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Satisfaction with social connectedness is associated with depression and anxiety symptoms in neurodiverse first-semester college students

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Abstract

Social difficulties and mental health are primary behavioral health concerns in autistic young adults, perhaps especially during key life transitions such as entering college. This study evaluated how dissatisfaction with social connectedness may predict and/or maintain depression and anxiety symptoms in neurodiverse, first-semester, undergraduate students ($N = 263$; $n = 105$ with diagnosed or suspected autism). Participation included a baseline survey battery, a brief survey completed twice per week across 12 weeks, and an endpoint survey battery. Social dissatisfaction at baseline was prospectively associated with biweekly ratings of depression symptoms, when controlling for baseline depressive symptoms. Social dissatisfaction was synchronously related to elevated sadness, anhedonia, and anxiety throughout the semester. These relationships were generally consistent across levels of baseline social motivation; however, there was one significant moderation effect—the negative relationship between baseline social satisfaction and anxiety was strongest for more socially motivated participants. More autistic traits were related to lower social satisfaction at baseline and greater mood concerns across timepoints. In contrast, greater autistic traits at baseline were related to greater satisfaction with social connectedness throughout the semester. Results support ongoing efforts to address mental health in autistic college students by highlighting the importance of social satisfaction.

Lay abstract

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How satisfied people feel with their social connections and support is related to mental health outcomes for many different types of people. People may feel less socially connected at some times in their life—like when they start college. Feeling disconnected from others could lead to depression or anxiety. The transition to college may be especially difficult for autistic students as they are more likely to have difficulties adjusting socially. In our study, we asked 263 college students to answer questions about their emotions and social satisfaction twice per week during their first semester of college. We found that students who reported being less satisfied with their social connectedness (either at the beginning or throughout the semester) tended to express more symptoms of depression and anxiety. This relationship between social satisfaction and anxiety was even stronger for people who had a strong desire for social interaction (i.e. were more socially motivated). Students with more autistic traits tended to report more mood concerns, and they also reported being less satisfied with friendships at the beginning of the semester. This information may help to support ongoing efforts to better address mental health in autistic college students by encouraging efforts to improve social satisfaction.

Keywords

adults; anxiety; autism spectrum disorders; depression

Background

Upon entering their first semester of college, many students experience large shifts in their social support network, while also adjusting to new educational demands and increased independence. During their first year, undergraduates may experience the deterioration of previously close high school friendships and an initial decline in social well-being in these unfamiliar social environments (Conley et al., 2014). However, this social adjustment may be more challenging for some undergraduates than others. In recent years, there has been an increase in diagnosed autistic students entering college (Bakker et al., 2019), and many of these students appear to experience disproportionate mental health and social concerns (Bakker et al., 2020; McLeod et al., 2019; Sturm & Kasari, 2019; Van Hees et al., 2015). Understanding relationships between social dissatisfaction and internalizing symptoms during the transition to college may be a key step in better supporting autistic students.

Supporting the mental health of autistic young adults is a key clinical and research priority (Benevides et al., 2020; Crane et al., 2019; Pellicano et al., 2014). Meta-analytic and large survey research has shown that depression and anxiety are more prevalent in autistic adults than the general population (Hollocks et al., 2019; Hudson et al., 2019; Rosenau et al., 2023), resulting in numerous negative effects on health and functioning (Cassidy et al., 2018; Gillott & Standen, 2007; Grant et al., 2022; Joshi et al., 2013; Lawson et al., 2020; Park et al., 2019; Taylor et al., 2021; Williams & Gotham, 2021). Although there are many contributing factors to these high rates of mood disorders, general population literature strongly supports a link between social dissatisfaction or loneliness and negative health outcomes.

Satisfaction with social connectedness (SSC) is a subjective perception of how well one feels their need for belonging, involvement, and support are being met (Ambrey et al., 2017; Berry & Welsh, 2010). Instead of relying on objective measures such as the amount of time one spends with others, SSC reflects the understanding that two people can have the same amount of time with peers and yet still experience different senses of satisfaction and belonging from these interactions. In the general population, loneliness or a lack of SSC is associated with many negative physical and mental health consequences (Hawkley & Cacioppo, 2010), including an increased risk of suicide (Goldsmith et al., 2002) and depressive symptoms (Cacioppo et al., 2006; Wei et al., 2005). While relationships between depression and dissatisfaction with social connectedness are likely bidirectional (Segrin, 1999), there is evidence that loneliness predicts subsequent depression in 1-year intervals (Cacioppo et al., 2010). In these same intervals, depression does not predict increased loneliness (Cacioppo et al., 2010), potentially suggesting loneliness plays some causal role in the development of depressive symptoms.

Autistic individuals appear to be negatively affected by lack of social connectedness similar to—or more so than—the general population. As one might expect from the general population literature, cross-sectional evidence suggests that low social connection is related to loneliness and depression in autistic adults (Han et al., 2019; Mazurek, 2014). Autistic adults also tend to report more loneliness than their non-autistic peers (Ee et al., 2019). For autistic adults, loneliness may be affected by a variety of barriers to socialization, including bidirectional difficulties with social communication across neurotypes (e.g. the double empathy problem; Crompton et al., 2021; Milton, 2012), past negative interpersonal experiences, and environmental factors such as sensory stimuli (Ee et al., 2019).

Based on a systematic review, Smith and White (2020) suggest that it is the individualized and idiosyncratic discrepancies between desired and achieved social interaction that lead to loneliness and eventual depression in autistic adolescents and adults, rather than an objective ideal level of social connection needed to achieve social satisfaction. Under this social motivation model of depression, autistic individuals who have high social motivation and low social success may be at heightened risk of depressive symptoms due to increased loneliness (Smith and White, 2020). There is some supporting evidence for this; Han and colleagues (2019) found that autistic adults with high social motivation were more likely to be lonely if they had more autistic traits and greater social impairment. Loneliness, in turn, was the strongest predictor of depression in this study. However, this model (Smith and White, 2020) also hypothesizes that those with low social motivation would be less likely to develop loneliness. This has not been well-supported to this point: Autistic adults with low social motivation still tend to report high levels of loneliness, which are strongly related to depressive symptoms (Ee et al., 2019; Han et al., 2019). Further longitudinal research is needed to better investigate how social motivation—and matching versus discrepant social opportunities—may affect loneliness and depressive symptoms. Notably, autistic college students who feel less socially supported tend to report lower subjective well-being and greater difficulty balancing the demands of school (Bailey et al., 2020), so social connectedness may be particularly impactful for autistic students who are transitioning to college.

Objectives

In this study, we aimed to evaluate whether dissatisfaction with social connectedness predicts and/or maintains depression and anxiety symptoms in first-semester undergraduate students. We also evaluated whether the strength of the contributions of social dissatisfaction to depression and anxiety symptoms varied by self-reports of autistic traits. We additionally evaluated how effects of SSC on mood may vary by baseline social motivation (i.e. how highly social interaction is wanted). By understanding longitudinal relationships between SSC and internalizing symptoms, we may be able to inform future prevention and intervention efforts for depression and anxiety, particularly in the college transition context.

In line with previous research, the following a priori hypotheses were formed:

1. 1. SSC would prospectively and synchronously relate to depression and anxiety symptoms throughout the semester, such that participants who reported lower SSC would report greater depressive and anxiety symptoms, both at the same time as their low SSC and later in the semester. This relationship would be strongest for those with higher baseline social motivation (Smith & White, 2020).
2. 2. Given the similarities between general population and autism literature regarding social risk factors for depression (Han et al., 2019; Hawkley & Cacioppo, 2010; Mazurek, 2014), we hypothesized no difference in the model of this mechanism as a function of autistic traits (i.e. a lack of moderation by levels of autistic traits). However, we anticipated that students with higher autistic traits would exhibit lower SSC, as well as greater depression and anxiety scores, compared to those who endorsed fewer autistic traits.

Methods

Data were collected online across three waves (Fall 2020, Fall 2021, and Fall 2022) from four university systems (Rowan University, Montclair State University, Stony Brook University, and City University of New York). After eligibility was confirmed, participants completed a baseline questionnaire battery at the beginning of their semester, a brief survey twice per week throughout their first semester, and then an endpoint battery. Each survey battery is described in more detail below and in publications reporting on initial stages of data collection (McKenney, Brunwasser, et al., 2023; McKenney, Cucchiara, & Gotham, 2023).

Participants

Both autistic (formally diagnosed or self-identified) and non-autistic students were recruited via emails to student listservs, flyers posted on campuses, and invitations sent through institutional offices of disability services. Students who lacked a formal diagnosis but endorsed a history of self or others suspecting they were autistic were included in order to better represent historically underrepresented groups of autistic adults who have lower access to formal diagnoses (Huang et al., 2020; Wiggins et al., 2020); however, primary analyses of the effects of autistic traits relied on Social Responsiveness Scale, Second

Edition (SRS-2; Constantino & Gruber, 2012) scores, not this self-assigned autism status (see "Statistical Analyses" section). Higher SRS-2 scores are taken to represent more autistic traits. All eligible autistic students were enrolled. Non-autistic students were enrolled via one-to-one match, such that non-autistic students who closely matched autistic students on university, age, gender, and race/ethnicity were prioritized. All students were required to be 18 years or older and have no current psychosis, bipolar disorder, or significant substance use concerns (to avoid confounding influences on mood).

Following recruitment, the overall sample included $N = 263$ participants ($n = 41$ in Fall 2020, $n = 103$ in Fall 2021, and $n = 117$ in Fall 2022) who completed the baseline survey packet: 105 autistic participants ($n = 30$ reporting formal diagnoses) and 158 non-autistic participants (see Table 1). The average age was 19.35, standard deviation (SD) = 3.35. A substantial minority of participants identified as nonbinary or other (13%), and 46% self-described as women. The most commonly endorsed racial identities were white (61%), Asian (18%), and Black/African American (15%). In addition, 25% of participants endorsed Hispanic or Latino identity.

Participation at each biweekly survey ranged from 129 to 199 responses per timepoint (median = 167, interquartile range (IQR) = 146–173). In total, 176 participants then completed the endpoint packet. There were no significant differences in Beck Depression Inventory, Second Edition (BDI-II), General Anxiety Disorder 7 (GAD-7), SRS-2, Anticipatory and Consummatory Interpersonal Pleasure Scale (ACIPS), or NIH Friendship scores between those who completed the baseline and endpoint and those who only completed baseline ($p > 0.34$ and $r^2 \leq 0.004$ in all cases). We interpret this as indicating that attrition bias is likely of minimal concern. In addition, any missing data were treated as random. In the event that a participant completed part of a measure (e.g. part of the BDI-II) but not the full measure, pairwise deletion was used and their score on that measure was not included in analysis. To assess for potential historical effects, during the unique context of the COVID-19 pandemic, cohorts were compared across waves on primary measures of interest, resulting in findings that mental health appeared to be worsening somewhat in later years of data collection (see McKenney, Cucchiara, & Gotham, 2023 for full results).

Procedures

All components of participation, including informed consent, were completed electronically. Incoming undergraduates were first invited to complete a brief eligibility screener to assess eligibility and match participants groups. Enrolled participants then received the online baseline packet 1 week prior to their first week of classes and had approximately 3 weeks to complete it.

Participants who completed baseline were then texted a secure link to a survey that took approximately 2 min to complete twice per week for 12 weeks (approximately the remainder of the semester; see "Measures" section for more details). At the conclusion of the semester (13–15 weeks after baseline), participants were asked to complete a final battery of surveys, similar to baseline. Compensation was provided via virtual gift codes, totaling $75 per participant for full participation. This study and measures received approval from Rowan University School of Osteopathic Medicine Institutional Review Board, which was the IRB

of Record for most recruitment sites (study ID Pro2020001172), as well as Stony Brook University (IRB2021–00266). There was autistic representation on the research team, and autistic community members also informed aspects of broader study design, through a focus group.

Measures

All measures were distributed and completed online through Research Electronic Data Capture (REDCap), a survey and data management platform developed specifically for use in electronic acquisition and storage of sensitive data (Harris et al., 2009, 2019).

Baseline.—The initial battery of surveys was completed by participants within 3 weeks of the start of their semester and collected initial data on key constructs related to emotional, social, behavioral, and physical health, as well as demographics. Key measures for the current analyses included the SRS-2 (Constantino & Gruber, 2012) to assess autistic traits; BDI-II (Beck et al., 1996; Wang & Gorenstein, 2013; Williams et al., 2020) to assess recent depression symptoms; GAD-7 (Hull et al., 2021; Kroenke et al., 2010; Spitzer et al., 2006; Williams & Gotham, 2022) to measure recent anxiety symptoms; ACIPS (Gooding & Pflum, 2014) as a measure of social motivation, where higher scores are indicative of greater social motivation and/or pleasure taken from social interactions; and the NIH Toolbox Friendship Measure (Cyranowski et al., 2013) to assess baseline SSC. Internal consistency for all measures was strong: SRS-2 Cronbach's $\alpha = 0.93$, BDI-II Cronbach's $\alpha = 0.94$, GAD-7 $\alpha = 0.90$, ACIPS $\alpha = 0.91$, and NIH Friendship $\alpha = 0.91$.

Brief biweekly survey.—The brief 12-to15-question survey (depending on year of study), texted to participants twice per week for 12 weeks, was developed by the senior and first authors' lab to track changes in key constructs (e.g. sadness, anhedonia, anxiety, SSC) throughout each participant's semester. Most items used 1–5 Likert-type scales, from 1 ="Almost Never" to 5 ="Almost Always." Likert-type scale responses to "How often have you been feeling down, sad, or empty?" were used to reflect sadness; anhedonia was operationalized via responses to "How often have you been feeling low interest or little pleasure in doing things that you usually enjoy?" These items were conceptualized as reflecting components of depression that are related but distinct processes and were thus considered separately (Fried & Nesse, 2015). Anxiety was captured by responses to "How often have you been feeling nervous, anxious, or on edge?" SSC was reported via a visual analogue scale, where participants rated satisfaction with their "level of social belonging or closeness" from 0 (extremely dissatisfied) to 100 (extremely satisfied).

Endpoint.—Finally, the endpoint survey battery was a somewhat shortened retest of baseline measures. To support feasibility and retention, demographic and diagnostic history questions were not repeated.

Statistical analyses

Analytic methods were similar to that used in related research by the same study team (McKenney, Brunwasser, et al., 2023). In brief, generalized least squares regression (GLS; Pinheiro & Bates, 2000) with a first-order autoregressive correlation structure (AR_1) was

used for all primary analyses using the *rms* (Harrell, 2022) and *nlme* (Pinheiro et al., 2022) packages in R. GLS AR_1 model assumes that repeated measurements from an individual would be correlated with one another, and the strength of the correlation weakens with increasing distance between the measurements (i.e. time 1 is less related to time 10 than time 2). Importantly, the AR_1 models used account for the effect of the independent variable on the outcome at prior timepoints, meaning that the relationship between SSC and sadness at the second timepoint is adjusted for the sadness at the first timepoint, and so on. Effect sizes were calculated as f^2 and interpreted such that 0.02 is considered a small effect, 0.15 medium, and ≥0.35 large (Lorah, 2018; Selya et al., 2012).

Relationships between SSC and each mood construct (sadness, anhedonia, and anxiety) were assessed in three primary ways: we examined the long-term relationship between baseline characteristics and semester biweekly ratings, the short-term predictive relationship between SSC at one timepoint and mood constructs at the next, and the synchronous relationship between SSC and mood constructs. In each of these primary analyses, time (based on survey number) was included as a fixed predictor to capture the underlying symptom trajectory. Outcome trajectories were permitted to take a flexible, nonlinear shape by modeling the effect of time (survey number) using a restricted cubic spline approach with three knots placed at the 0.10, 0.50, and 0.90 quantiles. In addition, baseline BDI-II scores were held constant, to allow for estimation of effects of satisfaction with social connection on symptom outcomes accounting for the potential confounding effect of initial symptom severity.[1]

As previously described, there was also interest in whether an interaction effect may be present such that social motivation may affect relationships between SSC and mood. This was assessed in two ways for each mood construct. First, we added an interaction effect to the previously noted GLS regression equations comparing the synchronous relationships between SSC and biweekly mood scores. Through the addition of an interaction term, we sought to evaluate whether there was an interaction effect between social motivation at baseline (ACIPS) and SSC on biweekly mood scores (sadness, anhedonia, anxiety). Similarly, we evaluated baseline, cross-sectional interactions between NIH Friendship and ACIPS scores on baseline mood measures (BDI-II and GAD-7) via general linear models, to determine whether social motivation moderated the relationship between baseline SSC and baseline mood.

Differences by autistic trait status.—In our transdiagnostic, neurodiverse sample, we anticipated that those with greater self-reported autistic traits (SRS-2 scores) would endorse higher sadness, anhedonia, and anxiety, and lower SSC, compared to participants who reported fewer autistic traits. This was evaluated in baseline and biweekly data: We evaluated the cross-sectional relationship between baseline measures of SRS-2 scores and baseline mental health measures (BDI-II, GAD-7) in general linear models. As an exploratory post hoc analysis, we evaluated which subscale(s) of the SRS-2 may be

[1]·Analyses were also repeated with Social Responsiveness Scale, Second Edition (SRS-2) held constant, instead of Beck Depression Inventory, Second Edition (BDI-II) scores, to limit potentially confounding effects of autistic traits as a contributor to both SSC and mood symptoms; the pattern of results was largely the same when SRS-2 was added to the model as when BDI-II was held constant. These results are depicted in Supplemental Table I; primary analyses holding BDI-II constant are focused on in main results.

driving these relationships most strongly (Social Awareness, Social Cognition, Social Communication, Social Motivation, and/or Restricted Interests and Repetitive Behavior). Multicollinearity was evaluated and the variance inflation factor (VIF; O'brien, 2007) was found to range from 1.99 to 5.42, with all but Social Communication being below 5. Thus, all VIF values are well below the guideline of 10 for serious multicollinearity concerns and are taken to be acceptable in this exploratory context.

Following baseline analyses, we evaluated the relationship between SRS-2 scores and biweekly reports of SSC, sadness, anhedonia, and anxiety using GLS regression with time-held constant. As an additional exploratory analysis, differences in these variables of interest by dichotomous autism groups (i.e. those who report a history of autism diagnosis/suspecting or hearing from others that they may be autistic vs those with no history of autism) were evaluated. Due to the relatively low sample size of formally diagnosed participants, we consider these results to be preliminary.

Results

SSC and sadness

Baseline SSC (via NIH Toolbox Friendship Measure) was negatively associated with later sadness endorsement across the semester's twice-weekly survey: A one-unit decrease in baseline SSC was associated with a 0.019 units increase (95% CI: −0.03 to −0.01, $f^2 = 0.02$) in subsequent sadness levels, holding constant linear effect of time (survey number) and baseline BDI-II scores (see Table 2 for results from all primary analyses).

When testing the lagged relationship between biweekly SSC and sadness (i.e. SSC from the previous biweekly survey as a predictor of subsequent timepoint sadness), prior timepoint SSC did not significantly predict subsequent timepoint sadness when controlling for BDI-II and time ($b = 0.001$, 95% CI: −0.00007 to 0.002 $f^2 = 0.007$). However, there was a significant synchronous relationship between SSC and sadness within a timepoint ($b = -0.015$, 95% CI: −0.02 to −0.01, $f^2 = 0.13$).

Finally, we assessed whether there may be a significant interaction effect between baseline social motivation (ACIPS) and biweekly SSC on synchronous, biweekly sadness levels. No interaction effect was found ($b = 0.000$, 95% CI: −0.00002 to 0.0002, $f^2 = 0.001$). The interaction between baseline SSC and ACIPS scores on BDI-II scores at baseline was similarly non-significant, $F(1, 254) = 1.43$, $p = 0.23$ (see Figure 1).

SSC and anhedonia

The relationship between SSC and anhedonia appears similar: there was a significant negative relationship between baseline SSC and biweekly reports of anhedonia, such that a one-unit decrease on the NIH Friendship measure was associated with a 0.015-unit increase (95% CI: −0.03 to −0.004, $f^2 = 0.01$) in subsequent anhedonia levels, holding constant time and baseline BDI-II scores. The predictive relationship between biweekly SSC at one timepoint and subsequent anhedonia was not significant ($b = -0.0004$, 95% CI: −0.002 to 0.0007, $f^2 = 0.002$). However, the synchronous relationship within one timepoint was significant ($b = -0.014$, 95% CI: −0.02 to −0.01, $f^2 = 0.12$).

Finally, we assessed for an interaction effect between baseline ACIPS scores and biweekly SSC on self-reported anhedonia. No interaction effect was found ($b = 0.000$, 95% CI: −0.00006 to 0.0001, $f^2 = 0.0007$).

SSC and anxiety

Contrary to expectations, the relationship between baseline SSC and biweekly reports of anxiety was not significant, when controlling for BDI-II scores ($b = -0.008$, 95% CI: −0.02 to 0.002, $f^2 = 0.003$).[2] The predictive relationship between biweekly SSC and subsequent anxiety was also not significant ($b = 0.0008$, 95% CI: −0.0003 to 0.002, $f^2 = 0.009$). However, the synchronous relationship within one timepoint was significant ($b = -0.011$, 95% CI: −0.01 to −0.01, $f^2 = 0.08$).

We assessed for a significant interaction effect between baseline social motivation and biweekly SSC on biweekly anxiety, controlling for baseline BDI-II scores. A statistically significant ($p = 0.008$) interaction effect was found ($b = 0.0001$, 95% CI: 0.00004 to 0.0002, $f^2 = 0.003$). When examining the baseline interaction between SSC and ACIPS scores on baseline anxiety (measured via GAD-7), there was a significant interaction found, $F(1, 254) = 5.77$, $p = 0.02$, such that a negative relationship between friendship endorsement and anxiety was present and strongest for those in the highest tertile of baseline social motivation (see Figure 2).

Predictive utility of autistic trait levels

In cross-sectional baseline analyses, SRS-2 scores and NIH Friendship scores were significantly related, such that students who endorsed higher levels of autistic traits tended to endorse less frequent support from friendships over the last month, $F(1, 256) = 73.46$, $p < 0.001$, $r = 0.22$. As an exploratory post hoc analysis, we evaluated which subscale(s) of the SRS-2 may be driving this relationship most strongly (Social Awareness, Social Cognition, Social Communication, Social Motivation, and/or Restricted Interests and Repetitive Behavior). We found that Social Communication ($\beta = -0.29$, $p = 0.0006$), Social Motivation ($\beta = -0.27$, $p = 0.005$), and Restricted Interests and Repetitive Behavior ($\beta = 0.17$, $p = 0.04$) were significantly associated with Friendship satisfaction.

In baseline cross-sectional analyses, SRS-2 scores and ACIPS scores were also significantly negatively related, $F(1, 256) = 113.06$, $p < 0.001$, $r = 0.31$, indicating that greater autistic traits were associated with lower social motivation. Upon post hoc analysis of individual SRS-2 subscales, we found that Social Cognition ($\beta = -0.532$, $p = 0.01379$), Social Communication ($\beta = -0.485$, $p = 0.00115$), Social Motivation ($\beta = -0.715$, $p < 0.0001$), and Restricted Interests and Repetitive Behavior ($\beta = 0.725$, $p < 0.0001$) were significantly associated with ACIPS scores.

Higher SRS-2 scores were significantly positively related to both BDI-II, $F(1, 259) = 157.16$, $p < 0.001$, $r = 0.38$, and GAD-7 scores, $F(1, 259) = 117.55.26$, $p < 0.001$, $r =$

[2]This is the primary variation between models that hold BDI-II score constant and models that instead hold SRS-2 scores constant (see Supplemental Table). When holding SRS-2 score constant and not BDI-II, the relationship between baseline friendship scores and biweekly anxiety is significant ($b = -0.018$, 95% CI: −0.03 to −0.007, $f^2 = 0.01$).

0.31, at baseline; as hypothesized, participants with more autistic traits tended to report greater depression and anxiety symptoms. As an exploratory, post hoc analysis, a regression model was conducted to determine which subscales of the SRS-2 were most associated with mood symptoms at baseline. The results indicated that Social Cognition (β = 0.53, $p = 0.003$) and Social Motivation (β = 0.38, $p = 0.007$) were the components most significantly related to BDI-II scores. Social Awareness (β = −0.24, $p = 0.04$), Social Motivation (β = 0.30, $p < 0.0001$), and Restricted Interests and Repetitive Behavior (β = 0.28, $p < 0.0001$) appeared most related to baseline anxiety symptoms. Group differences by dichotomously self-assigned cohort are shown in Table 1, as a comparison to dimensional analyses described in text.

GLS regressions indicated that students who reported greater autistic traits at baseline endorsed higher sadness ($b = 0.0097$, 95% CI: 0.007 to 0.01, $f^2 = 0.06$; see Table 2), anhedonia ($b = 0.0098$, 95% CI: 0.007 to 0.01, $f^2 = 0.06$), and anxiety ($b = 0.008$, 95% CI: 0.006 to 0.01, $f^2 = 0.04$) on average throughout the semester as well. Contrary to expectations, there was also some evidence of a relationship between SRS-2 and biweekly SSC scores, such that students who endorsed a higher SRS-2 score at baseline tended to endorse greater satisfaction with their social connectedness on biweekly surveys ($b = 0.09$, 95% CI: 0.02 to 0.15, $f^2 = 0.007$). This relationship persisted, when controlling for baseline SSC ($b = 0.16$, 95% CI: 0.10 to 0.23, $f^2 = 0.02$).

We evaluated whether there was evidence of an interaction between SRS-2 scores and SSC on biweekly mental health outcomes. In almost all cases, the models (both synchronous and lagged from one survey to the next, as described previously) without the interaction effect were preferred over those including it, as indicated by non-significant likelihood ratio tests and smaller Bayesian information criterion values. The exception to this was our lagged SSC and anxiety model. We investigated this full model further using the simple slopes approach, finding that while the directionality of the relationship between SSC at one timepoint and anxiety at the next was somewhat different by SRS-2 scores (at low SRS-2 scores, there was a slight positive relationship with anxiety, this relationship was slightly negative at high SRS-2 levels), it was not significant at any of the points tested (10th, 25th, 50th, 75th, or 90th percentile). Thus, it was decided that there is not compelling evidence of clinically meaningful moderation of autistic traits (measured by the SRS-2) on the relationship between SSC and mood.

Discussion

The first semester of college is often characterized by unfamiliar social environments marking a shift in students' social support and perceived connectedness. This shift may particularly affect autistic students, who seem to disproportionately experience social dissatisfaction and mental health concerns. However, little longitudinal research has evaluated the temporal relationship between SSC, social motivation, and mood in autistic young adults. In this study, SSC and mental health were evaluated transdiagnostically in a neurodiverse sample ($n = 105$ self-identified or formally diagnosed autistic; $n = 158$ non-autistic) of first-semester college students.

We found that lower SSC was related to greater depression symptoms, when controlling for baseline depression scores; this was observed both over longer periods of time (with baseline SSC predicting cross-semester mood ratings) and via synchronous biweekly and baseline measures of SSC and depressive symptoms. Lower SSC was also related to anxiety symptoms synchronously (both within baseline measures and within biweekly survey timepoints). Surprisingly, when controlling for baseline depression symptoms, baseline SSC did *not* significantly predict anxiety ratings later in the semester. Also contrary to expectations, SSC from the prior biweekly timepoint (i.e. several days previously) did not predict depression or anxiety symptoms reported on the subsequent biweekly survey. Similar to non-significant findings for a lagged relationship between repetitive thinking and mood concerns within a subset of this sample (McKenney, Brunwasser, et al., 2023), it is possible that predictors of mood are more likely to have lasting effects when they accrue over extended periods of time, rather than in discrete instances. Current evidence of a significant relationship between baseline SSC—in which participants report a general tendency toward unsatisfying friendships over the last month via the NIH Toolbox Friendship measure—and later biweekly mood may additionally suggest a longer-term relationship between social satisfaction and mood that persists across environments (including across social changes expected to be associated with starting college). The temporal nature of this relationship should continue to be assessed longitudinally and with robust measurement tools in large neurodiverse or neurodivergent samples.

As hypothesized, relationships between SSC and mood symptoms did not differ by levels of autistic traits, and thus the mechanism appears to persist across neurotypes. Also as hypothesized, we observed main effects by autistic traits in our primary variables of interest, such that higher SRS-2 scores were related to higher ratings of depression and anxiety and lower social motivation and SSC at baseline. This and similar findings in previous work (McKenney, Brunwasser, et al., 2023) support the idea that high rates of depression among autistic adults may stem from greater prevalence of common risk factors for depression among the autistic population (e.g. less SSC, more negative rumination, as well as likely social risk factors such as increased risk of discrimination and trauma; Peterson et al., 2019), rather than from autism-specific risk factors—though both common and idiosyncratic mechanisms may be at play (see Smith & White, 2020 for examples of autism-specific risk factors for depression).

Of interest, we observed that higher SRS-2 scores at baseline—though related to lower SSC at baseline, in line with our hypothesis—unexpectedly were related to *greater* SSC in biweekly reports throughout the semester, even after controlling for baseline SSC. It is possible that the transition to college has the potential to be a particularly positive influence on SSC for autistic students—it may be the case that for at least some of these individuals, starting college was one of the first opportunities to find friends who are neurodiversity-affirming and/or autistic themselves, which led to greater increases in perceived SSC. Future work is needed to disentangle which aspects of college life may be beneficial versus deleterious for mental health within the autism spectrum. It is also possible that this unexpected finding was influenced by differences in which aspects of social interaction and support autistic and non-autistic college students consider when they complete their biweekly SSC ratings. For example, certain forms of social interaction (e.g.

virtual interactions that became prevalent in response to COVID-19) have been found to be rated as more satisfying by autistic versus non-autistic students (Maljaars et al., 2023; Stewart et al., 2023). In this study, only perceived social belonging was assessed, without queries on how this social belonging was achieved, so future work may explore the context and frequency of satisfying social interactions.

The role of social motivation

In this study, greater motivation for social interaction, as operationalized by the ACIPS, did *not* significantly moderate the relationship between ratings of SSC (whether baseline or biweekly) and cross-semester depression ratings (anhedonia and sadness) when controlling for baseline depression scores; social motivation *did* significantly moderate the relationship between SSC ratings and cross-semester *anxiety* ratings. In addition, this relationship between baseline depression and biweekly anxiety was only significant with the interaction effect of ACIPS (no main effect). Previous research has suggested differing ways social motivation may influence the relationship between SSC and mental health outcomes in autistic individuals: While the social motivation model of depression suggests that those with both greater desire for social connection and lower social communication skills would be at greatest risk for depression (Smith & White, 2020), other evidence has suggested autistic individuals with lower levels of desire for social connection still experience high levels of loneliness and corresponding negative impacts on mental health (Han et al., 2019; Umagami et al., 2022). This study's depression findings are in line with the latter body of evidence—dissatisfaction with social connectedness was related (both synchronously within timepoints and prospectively from baseline) to higher depression ratings, *regardless of* social motivation. However, as previously stated, ACIPS scores *did* moderate relationships between baseline SSC and anxiety (both synchronously and prospectively), such that lower baseline SSC was more strongly associated with higher anxiety among those reporting higher social motivation. This may speak to a profile of social anxiety, which is likely to be associated with both greater desire for positive social interactions and greater social difficulties (Spence & Rapee, 2016). More research is needed to better understand the directionality and scope of this relationship over extended time periods.

Taken together, lower SSC is associated with greater depression symptoms in autistic and non-autistic college students regardless of social motivation, and the addition of greater social motivation may be associated with heightened anxiety risk. These findings contradict the harmful and long-standing myth that autistic individuals do not benefit from or desire friendships (see Bennett et al., 2018 for description of the history of this myth). This myth has historically influenced intervention priorities and beliefs about autism in ways that may be detrimental to supporting autistic people's mental health across the lifespan (Bennett et al., 2018). Present findings warrant a re-evaluation of intervention priorities, adding to a body of recent evidence that dispels these historical notions by affirming not only that many autistic people do explicitly report desire for social connection, but that one's SSC influences the development of depressive symptoms regardless of the level of this desire. Behavioral activation, a standard treatment for depression (Bal et al., 2022; Dimidjian et al., 2014), relies on increasing healthful and meaningful activities irrespective of motivation. Current findings suggest social activities support the mental health of autistic

college students, and thus increasing social activities may be a valuable treatment target to prevent or treat depression, a prevalent condition in both the autistic and college student populations.

Limitations

As explained in previously reported findings from a subset of this sample (McKenney, Brunwasser, et al., 2023), this study opted to operationalize autism traits dimensionally based on SRS-2 scores rather than as a categorical group. While the dimensional approach allowed for greater statistical power than would categorical approaches, the lack of comparison between (formally diagnosed) autistic and non-autistic groups may limit the generalizability of findings, especially as it obscures the possible role of the social *identity* of being autistic in relationships between SSC and mental health. On the other hand, it is quite possible that the inclusion of non-formally diagnosed autistic adults in the sample might actually improve the representativeness of this sample, since autistic adults from historically underserviced/under-recognized groups may reach adulthood and experience autism-related social and mental health difficulties regardless of formal diagnosis. Future research could benefit from evaluating whether predictors of mood may vary by intersecting marginalized identities.

Moreover, the generalizability of the present findings may be influenced by the short-term design of the study. Although this study was longitudinal, it collected sample data during a relatively brief, specific time frame (i.e. the first semester of college); this time frame is advantageous in encapsulating key developmental and social transitions that can have a lasting impact on autistic youth as they emerge into adulthood and beyond. However, longer-term data will be needed to further confirm and disambiguate the relationships between SSC and mental health suggested by this study's findings.

While the current findings suggest that ACIPS moderates baseline friendship satisfaction's relationship with anxiety but *not* its relationship with depression, it is possible that this is an artifact of the measurement, which may not fully capture all social interactions that neurodiverse students would find pleasurable, or confounding variables. For example, findings could be confounded by high-anxiety participants endorsing low pleasure from anxiety-inducing activities listed in the ACIPS (e.g. "I am excited when a friend I haven't seen in a while contacts me to make plans"). Future longitudinal research in social motivation would benefit from more objective measures of this construct (Hay et al., 2023).

Conclusion

As hypothesized, present findings add to growing evidence that autism status and higher levels of autistic traits are associated with mood concerns during the transition to college. These results suggest that fostering social connectedness could be one key strategy to promote mental health in autistic college students (Hedley et al., 2018; Hymas et al., 2022). Present findings also demonstrate that low social connectedness may prospectively contribute to increased anxiety and depression in autistic adults, with low social motivation exacerbating the impact of social connectedness on anxiety. Unexpectedly, higher levels of autistic traits predicted higher levels of social satisfaction throughout the semester,

although greater research is needed to determine whether this is related to differences in conceptualizations of social satisfaction across neurotypes. Nonetheless, these findings provide empirical evidence for mental health risks in autistic adults transitioning to college and the potential risk-buffering effect of social connectedness. These findings contribute to ongoing efforts to call attention to mental health in autistic transition-age youth and present potential pathways (e.g. social support) through well-being can be supported in an understudied, underserved population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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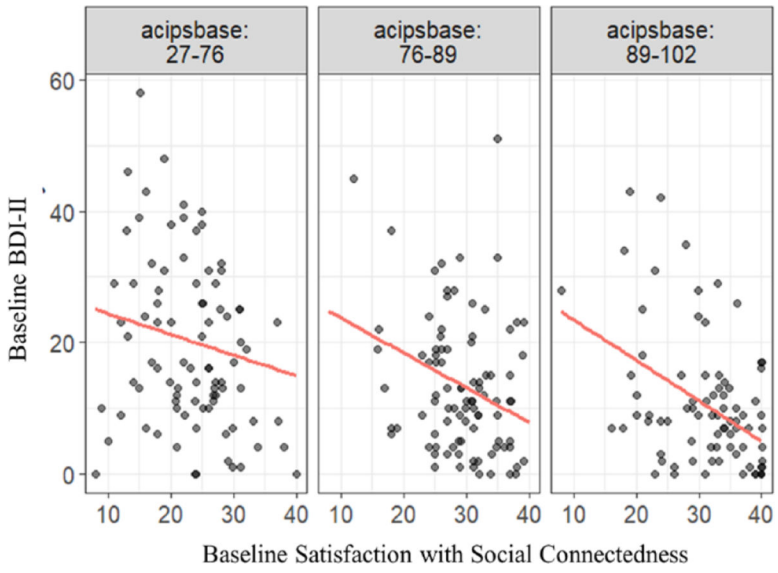

Figure 1.

Relationship between baseline satisfaction with social connectedness (NIH Toolbox Friendship Measure) and BDI-II scores, depending on ACIPS score.

NIH Friendship = NIH Toolbox Friendship Measure (Cyranowski et al., 2013); BDI-II = Beck Depression Inventory, Second Edition (Beck et al., 1996); ACIPS = Anticipatory and Consummatory Interpersonal Pleasure Scale (Gooding & Pflum, 2014).

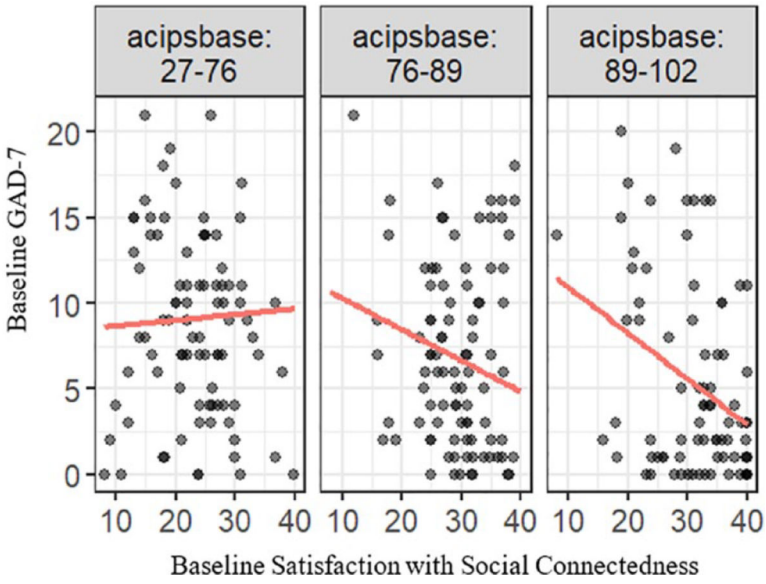

Figure 2.

Relationship between baseline satisfaction with social connectedness (NIH Toolbox Friendship Measure) and GAD-7 scores at baseline, depending on ACIPS score.

NIH Friendship = NIH Toolbox Friendship Measure (Cyranowski et al., 2013); GAD-7 = Generalized Anxiety Disorder 7 (Spitzer et al., 2006); ACIPS = Anticipatory and Consummatory Interpersonal Pleasure Scale (Gooding & Pflum, 2014).

Table I.

Baseline demographics and comparisons of autistic and non-autistic participants.

Mean (SD) Range	Entire sample *N* = 263	Non-autistic n = 158	Autistic (clin, dx or self ID) n = 105	Group differences
Age in years	19.35 (3.35)	19.29 (3.23)	19.44 (3.57)	$F(1, 261) = 0.12$
	18—43	18–39	18—43	p = 0.73, d = 0.001
Gender				$X^2(3, N = 263) = 6.56, p = 0.09$
% Women	46	48	43	
% Nonbinary or Other	13	9	18	
% Men	41	43	39	
Race/ethnicity				% Asian: $X^2(1, N = 263) = 6.23,$
% Native American	4	3	7	$p = 0.01^{\pm}$
% Asian	18	22	10	
% Black	15	19	10	
% White	61	57	67	
% Other	10	8	14	
% Hispanic/Latino	25	27	22	
Least educated parent				$X^2(7, N = 263) = 13.35$, p = 0.06
% HS or less	42	38	49	
% Some college	17	16	18	
% Associate degree	7	8	6	
% Bachelor's degree	25	26	22	
% Graduate degree	6	8	4	
SRS-2 *T*-scores	59.45 (11.93)	55.03 (11.23)	66.03 (9.76)	$F(1, 262) = 67.48, p < 0.001$ ***, $d = 1.03$
	39–89	39–89	45–89	
BDI-II	14.30 (11.65)	11.43 (9.93)	18.50 (12.71)	$F(1, 257) = 25.20, p < 0.001$ ***, $d = 0.64$
	0–58	0—45	0–58	
GAD-7	6.97 (5.52)	5.58 (5.21)	9.02 (5.36)	$F(1, 256) = 26.49, p < 0.001$ ***, $d = 0.65$
	0–21	0–21	0–21	
ACIPS	80.41 (14.67)	81.2 (14.4)	79.1 (15.0)	$F(1, 256) = 1.22, p = 0.27, d = 0.14$

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Mean (SD)	Entire sample	Non-autistic	Autistic (clin, dx or self ID)	Group differences
Range	***N* = 263**	**n = 158**	**n = 105**	
	27–102	27–102	37–102	
NIH Friendship	27.79 (7.45)	28.00 (7.72)	27.40 (7.02)	$F(1, 256) = 0.42$, $p = 0.52$, $d = 0.08$
	8–40	8–40	10–40	

SRS-2 = Social Responsiveness Scale, Second Edition (Constantino & Gruber, 2012); BDI-ll = Beck Depression Inventory, Second Edition (Beck et al., 1996); GAD-7 = Generalized Anxiety Disorder 7 (Spitzer et al., 2006); ACIPS = Anticipatory and Consummatory Interpersonal Pleasure Scale (Gooding & Pflum, 2014); NIH Friendship = NIH Toolbox Friendship Measure (Cyranowski et al., 2013).

$^{\pm}$Categories of race/ethnicity were not mutually exclusive, such that some participants selected multiple categories. As assessed by chi-square and asymptotic significance, only the differences in percentages of participants endorsing Asian identity were significant between groups at the $p < 0.05$ level.

$^{*}p < 0.05$;

$^{**}p < 0.01$;

$^{***}p < 0.001$.

Table 2.

Relationships between hypothesized predictors and biweekly outcomes of interest.

Hypothesized predictor	Outcome	Estimate (95% CI)	Estimated standard error	*t* Value (df)	Pr(>|*t*|)	f^2
SRS-2	SSC	0.09 (0.02 to 0.15)	0.031	2.77 (5, 3844)	0.006 *	0.007
SRS-2	Sadness	0.0097 (0.007 to 0.01)	0.001 3	7.71 (5, 3847)	<0.001 ***	0.06
SRS-2	Anhedonia	0.0098 (0.007 to 0.01)	0.0013	7.77 (5, 3846)	<0.001 ***	0.06
SRS-2	Anxiety	0.008 (0.006 to 0.01)	0.001	6.45 (5, 3847)	<0.001 ***	0.04
Baseline friendship[a]	Sadness	−0.019 (−0.03 to −0.01)	0.006	−3.40 (6, 3785)	<0.001 ***	0.02
Baseline friendship[a]	Anhedonia	−0.015 (−0.03 to −0.004)	0.006	−2.59 (6, 3784)	0.01 *	0.01
Baseline friendship[a]	Anxiety	−0.008 (−0.02 to 0.002)	0.006	−1.51 (6, 3785)	0.13	0.003
Lagged SSC[a]	Sadness	0.001 (−0.00007 to 0.002)	0.0006	1.84 (6, 3461)	0.07	0.007
Synchronous SSC[a]	Sadness	−0.015 (−0.02 to −0.01)	0.0008	−19.18(6, 3831)	<0.001 ***	0.13
Lagged SSC[a]	Anhedonia	−0.0004 (−0.002 to 0.0007)	0.0006	−0.70 (6, 3460)	0.48	0.002
Synchronous SSC[a]	Anhedonia	−0.014 (−0.02 to −0.01)	0.0008	−17.59 (6, 3830)	<0.001 ***	0.12
Lagged SSC[a]	Anxiety	0.0008 (−0.0003 to 0.002)	0.0006	1.36 (6, 3461)	0.17	0.009
Synchronous SSC[a]	Anxiety	−0.011 (−0.01 to −0.01)	0.0008	−14.29 (6, 3831)	<0.001 ***	0.08
ACIPS: SSC[a]	Sadness	0.000 (−0.00002 to 0.0002)	0.0001	1.61 (8, 3780)	0.1 1	0.001
ACIPS: SSC[a]	Anhedonia	0.000 (−0.00006 to 0.0001)	0.0001	0.78 (8, 3779)	0.44	0.0007
ACIPS: SSC[a]	Anxiety	0.0001 (0.00004 to 0.0002)	0.0001	2.65(8, 3780)	0.008 *	0.003

SSC = satisfaction with social connectedness.

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$.

[a] Variable was included in a model covarying baseline BDI-II scores. A separate model was also evaluated covarying SRS-2 scores, with most results following a similar pattern of significance; see supplemental materials. Effect sizes are described by f^2 and interpreted as follows: 0.02 is considered a small effect, 0.15 is considered medium, and & ≥35 is large.