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Social goals in girls transitioning to adolescence: associations with psychopathology and brain network connectivity

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Abstract

The motivation to socially connect with peers increases during adolescence in parallel with changes in neurodevelopment. These changes in social motivation create opportunities for experiences that can impact risk for psychopathology, but the specific motivational presentations that confer greater psychopathology risk are not fully understood. To address this issue, we used a latent profile analysis to identify the multidimensional presentations of self-reported social goals in a sample of 220 girls (9–15 years old, $M = 11.81$, $SD = 1.81$) that was enriched for internalizing symptoms, and tested the association between social goal profiles and psychopathology. Associations between social goals and brain network connectivity were also examined in a subsample of 138 youth. Preregistered analyses revealed four unique profiles of social goal presentations in these girls. Greater psychopathology was associated with heightened social goals such that higher clinical symptoms were related to a greater desire to attain social competence, avoid negative feedback and gain positive feedback from peers. The profiles endorsing these excessive social goals were characterized by denser connections among social-affective and cognitive control brain regions. These findings thus provide preliminary support for adolescent-onset changes in motivating factors supporting social engagement that may contribute to risk for psychopathology in vulnerable girls.

Key words: social motivation; neurodevelopment; girls; transdiagnostic psychopathology; brain network connectivity

Introduction

As children transition to adolescence, they undergo a social reorientation characterized by increased motivation to socially connect with peers (i.e. social motivation) (Nelson *et al.*, 2005; Nelson *et al.*, 2015). This transition period entails rapid neurodevelopmental changes in the brain's social-affective and cognitive control networks (Crone and Dahl, 2012). These changes in social motivations and the brain are thought to contribute to risk for psychopathology (Nelson *et al.*, 2005; Rudolph *et al.*, 2013). Interestingly, increases in social motivation can 'cut both ways' (Hunt, 1979; Berens *et al.*, 2020) by driving positive experiences that facilitate healthy development but also by contributing to negative experiences that can lead to psychopathology. Indeed, individual differences in the specific social goals supporting social motivation—mastering social skills, avoiding social failure and attaining positive feedback—are associated with symptoms of anxiety and depression (Horst *et al.*, 2007; Mouratidis and Sideridis, 2009; Shim and Ryan, 2012).

Conceptualization of social goals

Social achievement goal theory proposes that motivation is driven by goals to achieve social competence (Ryan and Shim, 2006). These social goals include building competence through mastery of social skills and relationships (i.e. mastery) and demonstrating competence by avoiding peer disapproval and social failure (i.e. performance-avoidance) or by gaining peer approval and social

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status (i.e. performance-approach). The assessment of these goals generates broad information on why children and adolescents engage in social interactions (Pintrich, 2000; Ryan and Shim, 2006). Social goals are particularly relevant to the transition into adolescence—a time when adolescents become increasingly sensitive and attuned to their peers (Nelson *et al.*, 2005; Nelson *et al.*, 2015). These goals may also be particularly important to adolescent girls, based on data suggesting that girls experience heightened distress following interpersonal stress as compared to boys (Rose and Rudolph, 2006).

In most of the existing social goal literature, these three goal orientations—mastery, performance-avoidance and performance-approach—are evaluated separately from one another. One study adopted a multidimensional perspective of social goals and identified four social goal profiles in 391 high school students in Korea (mean age = 16; 56% female): one high in all three goals (mastery, performance-avoidance and performance-approach), one low in all three goals, one oriented toward performance-approach and one oriented toward both performance-approach and performance-avoidance (Lee, 2018). This prior study discusses several implications: first, findings suggest that some adolescents hold both performance goals, although it remains unclear whether these goals are held simultaneously or if goal orientations are switched depending on the context. Second, the implications of exhibiting low endorsement of all goals also remains unclear and may suggest a broad disinterest in goals for social interaction (Lee, 2018). This prior research indicates that the multidimensional approach warrants continued investigation; yet, it has received relatively limited attention, particularly in a clinically enriched sample.

Implications of social goals for psychopathology

Identifying social goal profiles is important for informing risk for psychopathology; during the transition to adolescence, changes to the goals driving social motivation provide opportunities for experiences that may increase risk for psychiatric disorders (Nelson *et al.*, 2005; Rudolph *et al.*, 2013; Rudolph, 2021). For example, adolescent changes in social motivation may relate to heightened social sensitivity, promoting altered processing of information within the brain that is associated with psychopathology (Nelson *et al.*, 2015). In support of this perspective, an increasingly large literature documents differential associations between social goals and a host of clinically relevant symptoms. For example, mastery goals are associated with prosocial behaviors and emotional well-being, whereas performance-avoidance and performance-approach goals are associated with loneliness, impulsivity, aggression, anxiety and depression (Horst *et al.*, 2007; Mouratidis and Sideridis, 2009; Rudolph *et al.*, 2011; Shim and Ryan, 2012; Rodkin *et al.*, 2013; Lee, 2018; Rudolph, 2021).

Social goals are thought to exhibit this differential association with psychopathology because mastery goals are based on internal standards or guidelines, while performance goals use external standards (Elliot and McGregor, 2001); therefore, performance goals can elicit maladaptive cognition, emotion, and behavior, particularly as a result of perceived social failure (Dweck, 1986; Rudolph, 2021). Together, this literature implicates social goal orientations as being related to general, transdiagnostic psychopathology symptoms, although this possibility has yet to be directly tested. Given existing data indicating that adolescents harbor simultaneous social goals (Lee, 2018), identifying the association between general psychopathology and multidimensional social goal profiles will generate a more ecologically valid and comprehensive understanding of how social motivation may relate to clinical symptomatology. Examining associations between psychopathology and multidimensional social goals will identify specific social goal profiles that are most at risk for the development of psychopathology. For example, profiles reporting conjointly held performance goals may experience more internal conflict, creating opportunities for increased psychopathology by way of dissatisfaction and perceived failure in social interactions.

Neural basis of factors supporting social motivation

Attempts to understand social motivation rely heavily on neurodevelopmental models, which indicate that puberty and age relate to social-affective processing and cognitive control (Crone and Dahl, 2012; van den Bos, 2013; Dahl *et al.*, 2018). Specifically, communication among social-affective [temporoparietal junction (TPJ)], ventral striatum, amygdala (AMY), insula, medial prefrontal cortex (mPFC) and cognitive control regions (e.g. anterior cingulate cortex and dorsolateral prefrontal cortex) are honed during adolescence (Dahl *et al.*, 2018; Gozdas *et al.*, 2019). Coinciding with these changes is increased motivations to seek out new experiences and connect with peers (Nelson *et al.*, 2005; Crone and Dahl, 2012; Dahl *et al.*, 2018). There are many studies of the relations between adults' neurobiological functioning and various related social processes including social observation, social cognition, and social interaction; findings generally implicate corticostriatal-limbic regions (Frith, 2007; Lieberman, 2007; Blakemore, 2008; Adolphs, 2009; Somerville *et al.*, 2013; Redcay and Schilbach, 2019). However, studies testing the association between social goal orientations and neurobiology are limited, particularly in adolescence, which is a period of rapid development of both the brain and social orientation.

Recent shifts in clinical neuroscience research identify associations between brain and behavior using a network approach, which provides a detailed mapping of the connections and interactions among brain circuitry (Bassett and Sporns, 2017). In contrast, existing social goal orientation research relies on functional magnetic resonance imaging (fMRI) to examine more general activation changes in regions as a result of a task. One existing study found that heightened performance goals are related to stronger co-activation among social-affective regions (Davis *et al.*, 2022). Expanding this work using a network approach will offer a closer inspection of the nature of these connections.

One area that has yet to be investigated is the average network degree, which represents the total number of edges or connections among regions divided by all possible edges (Fornito, 2016). The average network degree is a basic property of a network and can reflect the strength and interconnectedness among brain regions elicited through task-based fMRI. Given this context, it is possible that greater endorsement of several, possibly competing social goals will necessitate the recruitment of additional brain regions, resulting in a more densely connected brain network (i.e. one with higher average degree). Denser brain networks may be also be more vulnerable to insult (Wig, 2017; Chahal *et al.*, 2020), given the multitude of pathways erroneous signaling could exert influence, and thus relate to higher psychopathology. To date, however, no studies have examined such links between neurobiology, multidimensional profiles of social goal orientations, and psychopathology. Investigations of network degrees can tell us about the interconnectedness of a network as it relates to social goal profiles and psychopathology. This network

neuroscience approach will generate new insights into the brain mechanisms supporting the known relation between social goals and psychopathology.

Present study

In the present study, we first attempted to replicate existing work (Lee, 2018) by identifying multidimensional groupings of social goal orientations in a sample of girls enriched for internalizing symptoms. Consistent with prior research (Lee, 2018), we hypothesized that there would be four distinct profiles of social goals: one group high in mastery, performance-avoidance and performance-approach goals; another low in all three goals; one performance-approach oriented and the final oriented toward both performance goals. Second, we examined associations between social goal profiles and psychopathology. Based on existing research (Horst *et al.*, 2007; Mouratidis and Sideridis, 2009; Rudolph *et al.*, 2011; Shim and Ryan, 2012; Lee, 2018; Rudolph, 2021), we hypothesized that profiles high in performance-avoidance and performance-approach goals would exhibit higher general psychopathology. Third, we characterized patterns of brain network connectivity associated with social goal profile membership using an fMRI task requiring anticipation of social interaction (Somerville *et al.*, 2013; Miller *et al.*, 2019). We hypothesized that social-affective and cognitive control circuitry would be more densely interconnected in social goal profiles characterized by heightened performance-avoidance and performance-approach goals relative to their peers with lower performance goals. Finally, we tested associations between brain network connectivity and our measure of general psychopathology; we anticipated that more densely connected networks would correlate with higher psychopathology.

Method

Participants

The original sample included 230 adolescents assigned female sex at birth ($M = 11.8$, $SD = 1.81$; range 9–15 years old), but one participant did not have any usable data. Participants were recruited as part of a larger, longitudinal investigation into biological and behavioral responses to stress and risk for internalizing symptoms and self-injurious thoughts and behaviors in adolescent girls. Girls with a range of risk for internalizing psychopathology and suicidal ideation or attempts (e.g. history of life stress such as chronic peer problems, bullying and many changes in home/family; depressive symptoms and prior suicidal thoughts) were recruited from local community clinics, inpatient units, outpatient mental health agencies, high schools and the general community using flyers and mass email advertisements.

Exclusion criteria for the parent study included endorsement of pervasive developmental disorders, history of psychosis, intellectual disability, chronic medical disease (e.g. autoimmune disorder and diabetes) or certain factors limiting the ability to complete the study (e.g. English fluency and proximity to lab location). We chose to include the full age range from the parent study to capture the transition into adolescence. This choice was based on theoretical models, indicating that puberty onset influences social processes and brain connectivity of regions investigated in the present study (Dahl *et al.*, 2018; Pfeifer and Allen, 2021).

This study focused on the social goals experienced by adolescent girls. Based on data showing that girls experience social contexts differently from boys (Rose and Rudolph, 2006; Rudolph, 2021), individuals who identified their gender as male after screening into the study were excluded from the present analyses ($n = 4$). Additionally, participants who did not complete the social goal orientation scale ($n = 5$) were excluded resulting in a final sample of 220. This sample was used to test the first and second hypotheses involving social goal profiles and associations with psychopathology.

Participants self-identified their race and ethnicity, with the majority identifying as white ($n = 108$, 49%) followed by Black or African American ($n = 62$, 28%) and Hispanic/Latinx ($n = 34$, 15%). Roughly, 42% ($n = 92$) of the overall sample ($n = 200$) endorsed taking psychiatric medication. As a result, medication was tested as a covariate in all analyses involving this sample. A subsample of the 220 participants ($n = 138$, 63%) agreed to complete a subsequent fMRI scan visit. Participants who declined follow-up ($n = 1$), endorsed pregnancy ($n = 0$), were left-handed ($n = 13$), endorsed history of head trauma ($n = 0$) or had MRI contraindications ($n = 4$) were not eligible for the fMRI visit.

Within the scanned subsample, participants without social goal orientation data ($n = 2$) and those not meeting the imaging quality checks as described later ($n = 24$) were excluded. The four participants who identified as male were in the scanned subsample and, thus were again excluded from this subsample analysis, resulting in a final sample of $n = 108$ for the third hypothesis involving brain network connectivity. Approximately 43% ($n = 46$) of the 108 subsample endorsed taking a current medication, which was included as a covariate in all neuroimaging analyses. Participants' assent and caregiver consent was obtained according to the Declaration of Helsinki, and all consent and study procedures were preapproved by the University's Institutional Review Board.

Measures

Social goals

Social goal orientations were measured using the Social Achievement Goal Scale (Rudolph *et al.*, 2011) (see Supplementary material for example questions). The scale includes 21 items that require the participant to rate how true the statement is for them on a 5-point Likert scale. The scale is established as a valid measure of social goal orientations and had acceptable levels of reliability (α Mastery = 0.91, α Performance-Avoidance = 0.9, α Performance-Approach = 0.89).

Psychopathology

The following questionnaires were used to compute a general *P*-factor: the Youth-Self Report Aggressive Behavior Subscale ($\alpha = 0.86$; Achenbach and Rescorla, 2001), the Conners-3 Parent Report Attention-Deficit Hyperactivity Disorder Index ($\alpha = 0.93$; Conners *et al.*, 2011); parent and self-report on the Mood and Feelings Questionnaire to assess depressive symptoms (α parent = 0.94, α self = 0.94; Angold *et al.*, 1995; Messer *et al.*, 1995); and parent and self-report on the Screen for Child Anxiety Related Disorder to assess anxiety symptoms (α parent = 0.62, α self = 0.61; Birmaher *et al.*, 1997). The Mini Neuropsychiatric Interview for Children and Adolescents (Sheehan *et al.*, 2010) was administered to parents and girls separately to obtain total symptom count (not formal diagnosis) for conduct disorder, oppositional defiant disorder, major depression, generalized anxiety disorder, and posttraumatic stress disorder. See Supplementary material for more details regarding *P*-factor generation.

Pubertal status

Caregiver and self-report on the Pubertal Development Scale were used to assess physical development through the rating of five items on a four-point scale, which demonstrates good psychometric properties (α parent = 0.85, α self = 0.83) (Petersen *et al.*, 1988). Higher scores indicate more advanced pubertal status. Consistent with prior work, the average rating of the caregiver and participant report was utilized (Giletta *et al.*, 2015). Puberty and age were examined as covariates of interest in our analyses, based on data indicating that puberty and age influence brain development and social processes (Nelson *et al.*, 2005; Dahl *et al.*, 2018; Pfeifer and Allen, 2021). Given that a comprehensive investigation of these developmental factors is beyond the scope of this cross-sectional study, these analyses were conducted *post hoc* (see Supplementary material).

fMRI methods

fMRI task

Participants underwent a series of scanning protocols that included a social anticipation/evaluation task adapted from prior research (Somerville *et al.*, 2013). Participants were told that researchers were interested in how their brains responded to interacting with a peer for the first time. Therefore, the fMRI task required participants to passively view a blank screen after being told that a similar-aged, same-sex peer would be monitoring a video feed via camera and could see the participant's face in real-time whenever the screen indicated that the video was 'on'. Finally, they were told that since the technology was new, the camera may turn on and off because of the magnetic field. The resulting task was a block design format with two pseudo-randomly presented conditions that consisted of a resting period (indicated by a screen showing 'system off') and an evaluation condition ('video on'), for a total task time of 5 min and 45 s.

This fMRI task was selected for this study because it elicits activation related to trait motivation, which exists in the absence of specific external cues and represents a state of readiness (Wasserman and Wasserman, 2020). Trait, as opposed to state, motivation more closely aligns with our focus on social goal orientations, which are not tied to specific external stimuli. This task was also selected given the conceptualization that social evaluative contexts may be particularly salient for social motivation (Somerville *et al.*, 2013). Here, we conceptualized both task conditions as representing a period of anticipating social interaction where we could isolate activation related to trait social motivation; therefore, analyses for the present study were conducted across tasks.

fMRI preprocessing and postprocessing

Data were minimally preprocessed using fMRIPrep (Esteban *et al.*, 2019), which included intensity correction, skull-stripping, spatial normalization, segmentation, slice time correction, motion correction and co-registration. Following preprocessing, scans were corrected for nuisance variables, which included motion parameters and white matter, cerebrospinal fluid and global signal. Motion was accounted for by identifying and censoring time points with framewise displacement greater than 0.2 mm (see Supplementary material for more detail). A total of 24 participants were excluded for quality checks as follows: 9 participants were excluded from analyses due to scanner or task administration issues, and 15 participants were excluded because greater than 50% of their imaging data were missing as a result of censoring. The average number of frames censored within the remaining sample was 19 (14%).

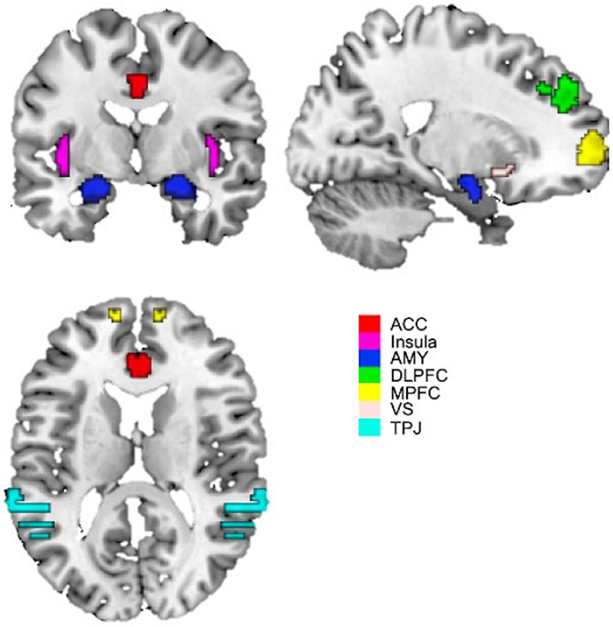

Fig. 1. Social-affective and cognitive control ROIs selected to identify brain network connections characterizing the social goal profiles (x = 20, y = −5 and z = 15).

Region of interest selection

From the preprocessed and nuisance-corrected images, regions of interest (ROIs) were extracted using FSLutils (Jenkinson *et al.*, 2012). These 13 ROIs were selected based on existing models of social motivation in adolescents (Crone and Dahl, 2012) (Figure 1). The present analyses focused on regions selected from available FSL-based atlases including Harvard–Oxford (Harvard-Center for Morphometric Analysis), Oxford–GSK–Imanova connectivity (Tziortzi *et al.*, 2014), Sallet (Sallet *et al.*, 2013), and Mars (Mars *et al.*, 2012). When possible, functional connectivity-based atlases were used (see Supplementary material). The average ROI signal was extracted across the fMRI task, resulting in a 13 × 138 matrix for each participant that was then used to model brain network connectivity as outlined later.

Analysis plan

Social goal profile identification

A latent profile analysis (LPA) in Mplus version 8.6 (Muthén and Muthén, 2017) was used to test the hypothesis that four latent social goal groups existed in this sample. Class enumeration decisions were based on existing research, indicating that there are four distinct profiles of social goals within adolescence (Lee, 2018); therefore, five classes/profiles were evaluated in accordance with existing LPA recommendations that state one more profile than anticipated should be generated (Vermunt and Magidson, 2002) (more detail provided in Supplementary material).

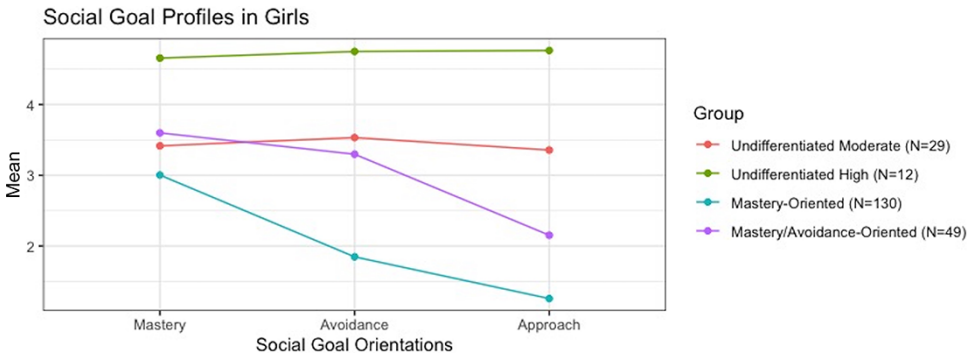

Fig. 2. Four social goal profiles within girls transitioning to adolescence identified using a LPA based on self-reported social goal orientations. All goal domains are significantly different across social goal profiles. Mean values for each social goal orientation are presented for each profile.

Association between social goal profiles and psychopathology

Our second hypothesis tested whether social goal profiles showed unique associations with psychopathology. To address this question, the latent class assignment for each participant was exported to use as the grouping variable. Primary analyses used two linear regression models with the lme4 package (Bates *et al.*, 2015) in R version 4.0.3 (R Core Team, 2020) to test the association between social goal profile and psychopathology, with psychopathology (hierarchical *P*-factor) as the outcome. Pairwise comparisons for all regression models were conducted using *emmeans* version 1.5.3 within R version 4.0.3 (Lenth, 2022), and a false discovery rate (FDR) correction was used to correct for multiple comparisons. Existing research shows differences in social processes associated with age and puberty (Nelson *et al.*, 2005; Crone and Dahl, 2012; van den Bos, 2013; Prendergast and Zucker, 2018; Pfeifer and Allen, 2021); therefore, additional *post hoc* regression models examined the association between social goal profiles and age, pubertal status and pubertal status with age, as well as the presence of psychiatric medication to identify potential confounds to result in interpretation.

Network connectivity

We next examined whether social goal profiles exhibit differential brain networks involving social-affective and cognitive control brain regions. We used the Group Iterative Multiple Model Estimation (GIMME) (Gates and Molenaar, 2012) program (Lane *et al.*, 2021) in R version 4.0.3 (R Core Team, 2020) to model task-based network connectivity associated with each social goal profile. GIMME capitalizes on structural equation modeling and multivariate autoregressive modeling approaches to identify both contemporaneous and time-lagged connectivity paths among ROIs (see Supplementary material for more details).

The present study uses a confirmatory subgrouping approach (Henry *et al.*, 2019) that generates directional network maps for each of the predefined social goal profiles. The connections are identified at the group, subgroup and individual levels. Group and subgroup connections are only identified if they exist for the majority of the sample. Identifying what is consistent across a subset of individuals has been shown to improve the recovery of true connections in simulation studies (Lane *et al.*, 2019). To test our hypothesis that the profile(s) with the higher endorsement of performance-avoidance and performance-approach goals would exhibit denser brain network connections, we calculated the average network degree for each participant (see Supplementary material). This average network degree value was used as a dependent variable in a subsequent linear regression model within R (Bates *et al.*, 2015) with social goal profile status as the categorical predictor. *Post hoc* tests evaluated specific profile contrasts using the emmeans package (Lenth, 2022) with the FDR correction. Significant findings were examined to test for potential influence of age, puberty, medication and motion.

Network connectivity and psychopathology

Our final analysis examined the association between the average network degree and *P*-factor score using one linear regression model. We also conducted *post hoc* analyses examining whether the relation between average degree and psychopathology was better accounted for by age, puberty, pubertal timing, medication or motion. Analyses for this project were pre-registered (https://osf.io/y8re2?view_only=ea910e3e5063411a8e80d81506571a33; see Supplementary material).

Results

Sample differences

The scanned sample ($n = 138$) was significantly different from the unscanned sample ($n = 91$) in reported racial identity ($\chi^2 = 11.78$ (5, 229), $P < 0.05$); however, *post hoc* tests did not reveal any significant between-group differences when accounting for multiple comparisons using FDR. The scanned sample also reported lower socioeconomic status ($t = 2.61$ (142.05), $P = 0.01$) and higher endorsement of suicidal behaviors ($\chi^2 = 5.7$ (1215), $P < 0.05$) relative to participants not scanned. No other demographic or clinical differences between the two subsamples of participants were observed.

Social goal profiles

Consistent with our hypothesis, the LPA conducted for Hypothesis 1 revealed four social goal profiles (Figure 2; Table 1; Supplementary Figure S2). Individuals in Profile 1 ($n = 29$) exhibited an 'undifferentiated moderate' pattern, which is indicated by relatively moderate levels of endorsement across all social goal orientations. Individuals in Profile 2 ($n = 12$) exhibited an 'undifferentiated high' profile with elevated endorsement of all social goal orientations. Profile 3 ($n = 130$) showed a 'mastery-oriented' pattern characterized by moderate mastery endorsement and low performance-avoidance and performance-approach. Lastly, Profile 4 ($n = 49$) had a 'mastery/avoidance-oriented' pattern with

Table 1. Fit statistics for LPA models estimating one to five latent classes

	Parsimony criteria						Clustering criteria	
Model	**AIC**	**BIC**	**B-LRT**	**LMRT**	**P**	**Smallest *n* (%)**	**CLC**	**Entropy**
1 Class	1986.90	2007.26	N/A	N/A	N/A	N/A	1974.90	N/A
2 Class	1798.07	1832.00	−987.45	188.11	0.003	24	1812.53	0.89
3 Class	1708.47	1755.98	−889.03	93.28	0.015	8.2	1726.87	0.90
4 Class	1652.39	1713.47	−840.23	61.25	0.003	5.5	1668.84	0.91
5 Class	1641.93	1716.59	−808.19	17.64	0.30	5.5	1731.77	0.81

Notes. AIC, Akaike information criterion; BIC, Bayesian information criterion; B-LRT, bootstrapped likelihood ratio; LMRT, Lo–Mendell–Rubin adjusted likelihood ratio test; CLC, collaborative label collection. A four-class solution was selected based on these results using the gold-standard criterion (Vermunt and Magidson, 2002; Nylund *et al.*, 2007). Model fit statistics compared $k-1$ class solutions.

Table 2. Social goal profile contrasts for mastery, performance-avoidance and performance-approach

Profile contrast	Estimate	SE	df	t	P
Mastery					
1–2	−1.24	0.34	216	−3.71	<0.001
1–3	0.41	0.20	216	2.06	0.049
1–4	−0.18	0.23	216	−0.80	0.423
2–3	1.65	0.29	216	5.62	<0.001
2–4	1.06	0.31	216	3.36	0.001
3–4	−0.60	0.16	216	−3.64	<0.001
Performance-avoidance					
1–2	−1.22	0.26	216	−4.78	<0.001
1–3	1.69	0.15	216	11.05	<0.001
1–4	0.24	0.17	216	1.35	0.178
2–3	2.90	0.22	216	12.96	<0.001
2–4	1.45	0.24	216	6.07	<0.001
3–4	−1.45	0.12	216	−11.65	<0.001
Performance-approach					
1–2	−1.41	0.10	216	−14.47	<0.001
1–3	2.10	0.06	216	36.06	<0.001
1–4	1.20	0.07	216	18.12	<0.001
2–3	3.51	0.09	216	41.01	<0.001
2–4	2.61	0.09	216	28.60	<0.001
3–4	−0.90	0.05	216	−18.85	<0.001

Notes. Contrasts corrected for multiple comparisons using FDR within mastery, performance-avoidance and performance-approach separately. Profile 1—undifferentiated moderate, Profile 2—undifferentiated high, Profile 3—mastery-oriented and Profile 4—mastery/avoidance-oriented.

moderate mastery and performance-avoidance goals, and yet low approach goals.

Social goal orientations were, for the most part, significantly discrepant among profiles, with performance-approach goals accounting for the greatest amount of variance among profiles (Table 2). However, there were no differences between the undifferentiated moderate and the mastery/avoidance-oriented profiles on performance-avoidance or mastery goals (Table 2). Age was significantly different across the social goal profiles (Table 3), with a specific contrast showing that the mastery/avoidance-oriented profile was significantly older than the mastery-oriented profile (estimate = 0.81, SE = 0.30, $t = 2.72$, $P = 0.04$). Similarly, pubertal status was significantly different across the profiles and was significantly higher in the mastery/avoidance-oriented profile compared to the mastery-oriented profile (estimate = 0.39, SE = 0.14, $t = 2.83$, $P < 0.05$) (Table 3). The social goal profiles continued to be significantly different from one another on goal levels when controlling for age, puberty and psychiatric medication (Supplementary Tables S1–S4).

Social goal profiles: differences in psychopathology

Overall, psychopathology was the highest in the undifferentiated high profile, followed by the undifferentiated moderate, mastery/avoidance-oriented and mastery-oriented profiles, respectively. Social goal profiles were significantly different in the hierarchical *P*-factor score (Table 3), with greater psychopathology in the undifferentiated moderate, undifferentiated high, and mastery/avoidance-oriented profiles relative to the mastery-oriented profile (Supplementary Table S5). There were no significant differences between the undifferentiated high, undifferentiated moderate, and mastery/avoidance-oriented profiles. When accounting for age and puberty, the finding of higher psychopathology in the mastery/avoidance-oriented profile relative to the mastery-oriented profile was no longer significant; all other results remained when accounting for potential confounds (Supplementary Table S6).

Brain network connectivity characterizing social goal profiles

Figure 3 shows all network edges, including those characterizing each social goal profile. As anticipated, the undifferentiated high and undifferentiated moderate profiles showed a denser pattern compared to the mastery/avoidance-oriented and mastery-oriented profiles. Tests examining the average network degree revealed that the average number of edges among all nodes was significantly different across profiles ($F = 9.36$, $R^2 = 0.19$, $P < 0.001$). *Post hoc* contrasts revealed that the undifferentiated moderate profile had a significantly higher average degree relative to the mastery-oriented profile (estimate = 0.01, SE = 0.003, $t = 4.62$, $P < 0.001$) and the mastery/avoidance-oriented profile (estimate = 0.01, SE = 0.003, $t = 4.32$, $P < 0.001$). The undifferentiated high profile also exhibited a significantly higher average degree relative to the mastery-oriented profile (estimate = 0.009, SE = 0.004, $t = 2.43$, $P < 0.05$) and the mastery/avoidance-oriented profile (estimate = 0.01, SE = 0.004, $t = 2.5$, $P < 0.05$). There were no significant differences in the average network degree between the undifferentiated moderate and undifferentiated high profiles, and similarly, no differences between the mastery/avoidance-oriented and mastery-oriented profiles (Table 4). Accounting for the potential confounds did not alter the average network degree findings.

Brain network connectivity and psychopathology

Analysis revealed that there was no significant linear association between the average network degree and *P*-factor score ($F = 0.002$,

Table 3. Sample characteristics

	Moderate, $n = 29$	High, $n = 12$	Mastery, $n = 130$	Mastery/avoidance, $n = 49$	F	R^2	P
Social goals							
Mastery	3.42	4.66	3	3.6	13.38	0.15	<0.001
Performance-avoidance	3.53	4.75	1.85	3.3	107.4	0.60	<0.001
Performance-approach	3.36	4.76	1.26	2.15	898.8	0.93	<0.001
Age	11.76	11.17	11.63	12.45	3.04	0.03	0.03
Puberty	2.87	2.52	2.68	3.07	3.17	0.03	0.03
P-factor	0.30	0.42	−0.19	0.13	6.5	0.07	<0.001
	Moderate, $n = 29$	**High, $n = 12$**	**Mastery, $n = 130$**	**Mastery/avoidance, $n = 49$**	**Total sample ($n = 220$)**		
Medication	7%	4%	20%	11%	42%		
Diagnoses							
MDD	17%	25%	12%	12%	14%		
GAD	48%	50%	31%	55%	40%		
ODD	59%	58%	28%	47%	38%		
CD	31%	33%	6%	8%	11%		
PTSD	21%	42%	12%	20%	16%		

Notes. Profiles were defined using a LPA based on reported social goal orientations. Mean values are reported. Social goal orientations are focused on mastery, performance-avoidance and performance-approach. Medication is the percentage of taking psychiatric medications. Diagnoses reflect approximate percentage of the sample meeting current DSM-5 diagnostic criteria (yes/no). MDD, major depressive disorder; GAD, generalized anxiety disorder; ODD, oppositional defiant disorder; CD, conduct disorder; PTSD, posttraumatic stress disorder.

$R^2 = 0.01$, $P = 0.97$). Accounting for potential confounds of age, puberty, medication and motions did not alter this finding.

Discussion

This study examined the multifaceted nature of social goals, and associations between social goals, brain connectivity and general psychopathology, in adolescent girls enriched for internalizing symptoms. Prior research has found that adolescents report several simultaneous social goals that are associated with functional outcomes such as peer relationship quality, aggression and anxiety (Lee, 2018). Our results extend this prior research and suggest that girls transitioning to adolescence who are at increased risk for psychopathology can be categorized into four distinct profiles of social goals based on their self-reported social mastery, performance-avoidance and performance-approach goals. Although performance-approach goals accounted for the greatest amount of variance among the four profiles, higher transdiagnostic psychopathology (when adjusting for age and pubertal status) and denser brain connections among social-affective and cognitive control regions were associated with greater endorsement of all three goals. Findings support the use of a multidimensional conceptualization of social goal orientation.

Adolescent girls exhibit four different social goal profiles

Consistent with prior research, the multidimensional characterization of social goals resulted in four profiles that varied in relative levels of self-reported mastery, performance-approach and performance-avoidance goals. These profiles included an undifferentiated high profile and an undifferentiated moderate profile (i.e. high or moderate endorsement of all three types of goal), a mastery/avoidance-oriented profile with moderate endorsement of both mastery and performance-avoidance goals and a mastery-oriented profile with low endorsement of the other goals.

One prior study of adolescents also identified four profiles in a sample of 391 adolescents (see Lee, 2018) but did not evaluate the age and pubertal differences among the profiles. We found that age and puberty were significantly different across the social goal profiles and that puberty and age were significantly higher in the mastery/avoidance-oriented profile relative to the mastery-oriented profile. The significant difference between these two profiles may be a result of higher power to detect effects in these profiles. Furthermore, it may be that a mastery-oriented profile is more evident in less mature girls relative to a profile that includes more performance-avoidance goals, as is the case in the mastery/avoidance-oriented profile. This latter interpretation aligns with developmental models that suggest increases in social sensitivity to peers with the transition into adolescence (Nelson *et al.*, 2005; Crone and Dahl, 2012; Nelson *et al.*, 2015; Crone *et al.*, 2020).

The existing study by Lee (2018) showed somewhat contrary results, likely a result of sample differences, as this prior study included older adolescent girls and boys from South Korea and did not enrich the sample for internalizing symptoms as done in the present investigation. Whereas we showed one profile with a preference for mastery and performance-avoidance, the prior study reported a profile with a preference for mastery and performance-approach (Lee, 2018). We also found a mastery-oriented group, whereas Lee (2018) found a group low in all goals. Lee (2018) also did not find both a high and moderate profile as we did, and instead, only discovered an overall high profile. We maintained both the moderate and high profiles in the present study based on the model fit metrics and the opportunity to explore whether there were meaningful differences between these two profiles. Research is needed to extend the present findings to a larger clinical sample of both boys and girls to accurately understand discrepancy in findings between the present study and prior work.

Notably, performance-approach goals (i.e. goals focused on seeking positive judgments and status) distinguished the social goal profiles most consistently. This finding suggests that, although many girls in our sample endorsed simultaneous mastery, performance-avoidance and performance-approach goals, it is the latter that may be particularly helpful in distinguishing motivation factors driving social interactions. Given the increasing focus on peer evaluation during adolescence, it

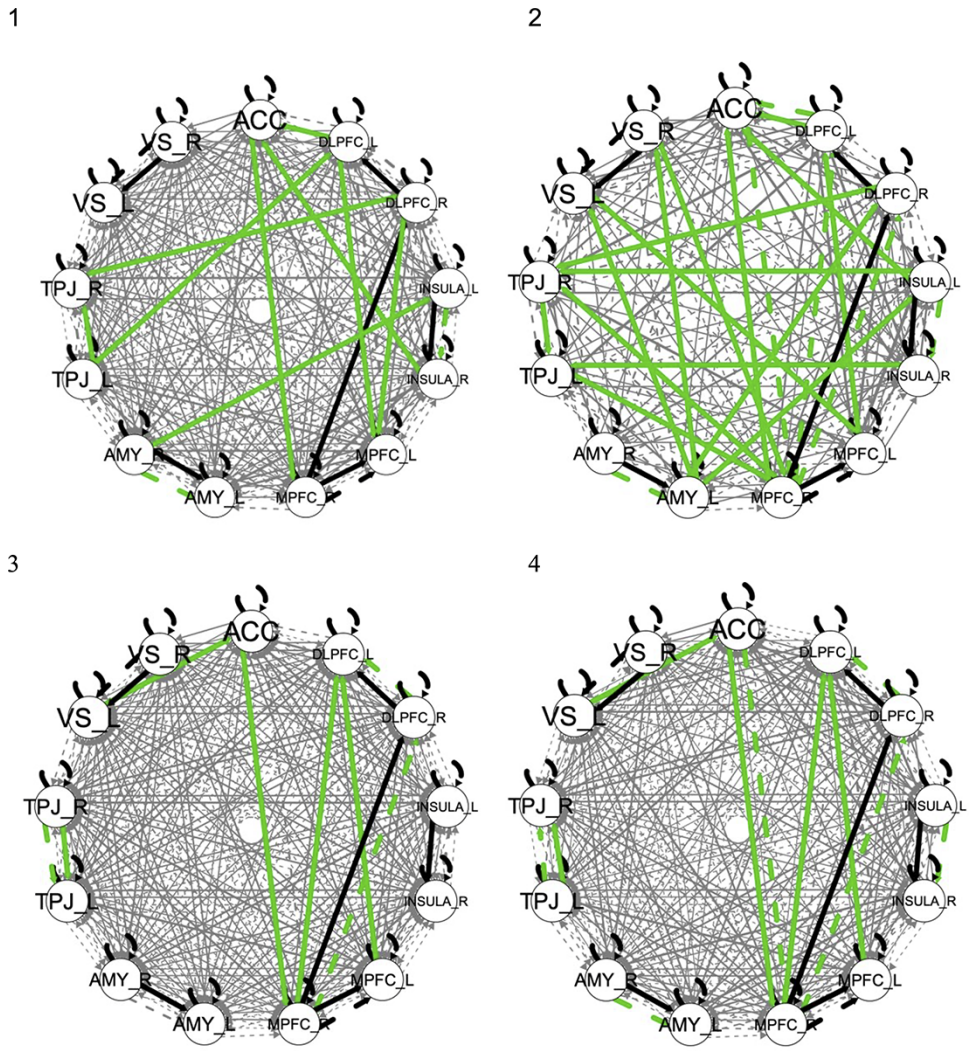

Fig. 3. Profile (black lines), subgroup (green lines) and individual (gray lines) connectivity edges identified for each of the four social goal profiles. Solid lines indicate contemporaneous connections, while dotted lines indicate lagged connections among social-affective and cognitive control regions. Profile 1—undifferentiated moderate, Profile 2—undifferentiated high, Profile 3—mastery-oriented and Profile 4—mastery/avoidance- oriented.

Table 4. Specific contrasts in the average network degree among social goal profiles

Profile contrast	Estimate	SE	df	t	P
1–2	0.003	0.004	104	0.61	0.65
1–3	0.01	0.003	104	4.62	<0.001
1–4	0.01	0.003	104	4.32	<0.001
2–3	0.009	0.004	104	2.43	0.03
2–4	0.01	0.004	104	2.50	0.03
3–4	0.001	0.002	104	0.42	0.67

Notes. Contrasts corrected for multiple comparisons using FDR. Profile 1—undifferentiated moderate, Profile 2—undifferentiated high, Profile 3—mastery-oriented and Profile 4—mastery/avoidance-oriented.

is developmentally normative for these performance-approach goals to be present (Nelson *et al.*, 2005). However, existing research indicates that the presence of these goals can be detrimental to girls by increasing retaliation designed to enhance social status (i.e. relational victimization), along with promoting disengagement from peers (Rudolph *et al.*, 2011; Rudolph, 2021). More concretely, performance-approach goals focused on seeking approval from peers may lead to instances of perceived social failure and subsequent social withdrawal, especially for girls. Therefore, performance-approach goals may warrant additional attention in future research given the potential to discriminate among different social profiles and implications for behavioral intervention.

Profiles with more social goals also show higher psychopathology

Profiles with moderate to high mastery, performance-avoidance and performance-approach exhibited more transdiagnostic psychopathology based on our *P*-factor score compared to the mastery-oriented profile. Initial results suggested that the mastery/avoidance-oriented profile was also significantly higher in psychopathology relative to the mastery-oriented profile. Notably, the psychopathology difference between the mastery/avoidance- and mastery-oriented profiles was better accounted for by the effects of age and puberty. A closer inspection of these two profiles indicates that the mastery/avoidance-oriented group was older, more advanced in pubertal status and exhibited higher rates of psychopathology. Together, these results suggest that differences in psychopathology between these two profiles are likely a result

of developmental differences, and not because one profile is more maladaptive than the other.

It is not surprising that the mastery-oriented profile showed was the lowest psychopathology; existing research indicates that mastery goals are adaptative and guided by internal standards, resulting in motivation to tackle the social challenges that dominate adolescence (Dweck, 1986; Rudolph, 2021). Contrary to performance goals, mastery goals are thought to result in less emotional arousal and cognitive distress (Rudolph, 2021). Our finding that profiles with excessive elevation in mastery, performance-avoidance and performance-approach exhibited the highest psychopathology was unanticipated, given prior studies indicating that mastery is associated with positive outcomes and may be protective against any harmful consequences associated with elevated performance goals (Lee, 2018). It may be that girls at risk for psychopathology who care deeply about developing social competence (i.e. mastery goals) may be highly sensitized to their social environment and thus experience aversive consequences when social goals are not met. It is also possible that adolescents at higher levels of risk for psychopathology may be less likely than unaffected peers to benefit from the potential buffer of mastery goals, although clinical and non-clinical profiles would need to be directly contrasted in future work to test this hypothesis.

Together, these findings suggest that, in girls transitioning to adolescence, the presence of performance-approach goals may be the key factor that distinguishes different social goal profiles, and yet, a shared focus on mastering social competence, gaining positive judgments and status and avoiding negative judgments is associated with higher transdiagnostic psychopathology. Continued clarification of the patterns of social goals and associated risk in girls could inform treatment targets and offset potential impacts of maladaptive social motivations. One potential example could be working to replace behavioral efforts to attain positive judgments with refinement of internal mastery goals.

Social goal profiles are uniquely associated with brain network connectivity

The four profiles also diverged in the density of their social-affective and cognitive control brain networks during the fMRI task where they anticipated a social interaction. The undifferentiated high and undifferentiated moderate profiles exhibited a significantly higher number of average connections among social-affective and cognitive control brain regions relative to the mastery/avoidance-oriented profile and the mastery-oriented profile. The average degree of a network reflects its interconnectedness and, in this context, the overall complexity of the organization of social-affective and cognitive control circuitry (Faskowitz *et al.*, 2022). Therefore, one interpretation of the present finding is that an abundance of social goals corresponds to a heightened sensitivity to anticipating social interaction and that this sensitivity allows for a greater amount of information to be communicated within social-affective and cognitive control regions.

Existing theoretical models suggest that alterations to typical neuromaturation are established in early childhood and with the onset of puberty as a result of heightened influence from the environment (Crone *et al.*, 2020). It is possible that the brain networks of the undifferentiated high and moderate profiles exhibited a greater number of connections relative to their peers as a result of these developmental periods and heightened sensitivity to social contexts. Future longitudinal research is needed to directly test the timing and cause of such network changes, which will help advance a better neurodevelopmental understanding of the motivating factors driving social engagement.

Greater network complexity, as indicated by higher average degree, could reflect maladaptive, compensatory and/or normative processes. In terms of maladaptive processes, heightened network complexity could increase risk of insult due to heightened vulnerability of that network (Wig, 2017) through multiple pathways for erroneous signaling to influence the brain. More specifically, a higher number of connections offers opportunity for a greater flow of information, and if there is any abnormality in signaling, an increased risk of harm to the system exists. A higher number of edges is also associated with more energy output and metabolic demand within the brain (Stiso and Bassett, 2018), implying a costly network structure (Faskowitz *et al.*, 2022). However, our data indicate that the network complexity examined here is not related to general psychopathology, suggesting that, in terms of the present study and network examined, higher average degree may not be maladaptive in terms of mental health. Instead, higher average degree associated with specific social goal profiles may reflect compensatory or normative processes. In other words, the average network degree may not be a mechanism accounting for the association between social goal profiles and psychopathology. This finding is in contrast to other work, showing that denser brain networks are associated with higher psychopathology (Chahal *et al.*, 2020). It is likely that future studies using longitudinal data, other brain network regions and metrics, additional measures of psychopathology and other behavioral outcomes would reveal brain–behavior associations other than what we have identified here.

Limitations and future directions

The present study represents an important initial characterization of multidimensional social goal profiles in girls transitioning to adolescence. Although our study benefited from using a well-established measure of social goal orientations and incorporating a validated network modeling technique, interpreting results would benefit from several considerations related to sample size. First, the undifferentiated high profile was much smaller than the other profiles, which calls into question the robustness of this profile and limits our ability to detect statistically significant differences. Furthermore, there may be some concern that brain network results in the undifferentiated high profile (Figure 3) are a result of the small sample size. Existing work with our network identification procedure shows reliable connection identification in sample sizes as low as 5 (Gates *et al.*, 2017). It is also important to note that the undifferentiated high profile was retained due to model fit metrics indicating improved fit with inclusion of this profile (Table 1) and prior literature in a larger sample showing a similar social goal profile (Lee, 2018). Future work with larger sample sizes will be needed to test the associations among social goal profiles, network degree and psychopathology.

Additionally, existing data simulations using our network modeling approach indicate that more connections are not discovered merely as a result of the small sample size (Gates *et al.*, 2017), lending support to our interpretation that this profile does indeed exhibit denser connections. Future research would benefit from increasing the sample size and examining the specificity of findings to specific diagnoses or symptom domains. Larger datasets like ABCD (Karcher and Barch, 2021) would be ideal to conduct analyses seeking to ascertain diagnostic specificity for the associations among social goals, brain functioning and psychopathology. Subsequent studies could also extend the present findings to include boys and probe the associations among race, ethnicity and social goal profiles. Further, studies could add additional measures of psychopathology and social motivation, such as

behavioral effort expenditure (Bos *et al.*, 2021) or questionnaires that directly assess effort and interpersonal withdrawal/pleasure (Llerena *et al.*, 2013; Gooding and Pflum, 2014; Abplanalp *et al.*, 2021). Also, as this investigation represents an initial step in characterizing the brain networks supporting different social goal profiles, subsequent research should incorporate ecologically valid social interaction tasks (Redcay and Schilbach, 2019) and test additional network metrics beyond average degree.

Conclusion

In conclusion, differences in social motivation can lead to experiences that increase risk of psychopathology, particularly for adolescent girls. The present data provide a novel characterization of the multifaceted social goals driving social motivation and support the use of a multidimensional consideration of social goals in girls. Specifically, we show that although performance-approach goals most strongly differentiate among four distinct motivation profiles, it is the heightened combination of mastery, performance-avoidance and performance-approach goals that are associated with the greatest report of transdiagnostic psychopathology. We also found that girls with an abundance of social goals exhibit more complex and interconnected brain networks relative to their peers reporting relatively less goals, although whether these connections represent maladaptive, compensatory or normative process remains to be seen. Nevertheless, these findings elucidate the association between altered social motivational factors, psychopathology and brain network connectivity during the transition to adolescence and identify several potential biobehavioral mechanisms that can be targeted to possibly reduce the risk of psychopathology in youth.

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Conflict of interest

The authors declared that they had no conflict of interest with respect to their authorship or the publication of this article.

Supplementary data

Supplementary data are available at *SCAN* online.

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