ABSTRACT

Title of Thesis: EXPLORING LONELINESS THROUGH COGNITIVE PROFILES: UNDERSTANDING EXECUTIVE FUNCTION AND MENTALIZING IN AUTISTIC AND NON-AUTISTIC YOUTH

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Adolescence is a transitional period of development where rates of loneliness increase. Autistic youth are more likely to experience loneliness than their non-autistic peers, making adolescent youth on the spectrum particularly vulnerable to poor social outcomes. Difficulties with executive function (EF) and mentalizing are well-documented in autistic youth; these challenges may contribute to social difficulties. Given the heterogeneous presentation of autism symptoms, particularly executive functioning and mentalizing abilities, we conducted a latent profile analysis (LPA) to determine if distinct cognitive profiles emerge around 2 executive functioning and 2 mentalizing variables. We then examined whether these profiles are associated with loneliness outcomes. Results demonstrate that none of the 4 cognitive variables of interest: Flanker, DCCS, Faces, and STOMP are significantly related to loneliness when variance in age, overall IQ and diagnostic group are accounted for, thus suggesting the need for a heterogeneous approach to understand cognitive skills. LPA analysis revealed that a 3-profile solution best fits the data. The profiles were significantly related to loneliness outcomes, with the profile characterized by poor flexibility reporting the highest rates of loneliness. However, this result did not hold when we controlled for diagnostic group membership. When diagnostic group membership was accounted for, Profile 1 (the higher cognitive performance) and Profile 2 (the average cognitive performance) were marginally significantly different on loneliness outcomes. These results, although preliminary, demonstrate that a profiles approach to cognitive skills provides more explanatory power to loneliness outcomes compared to a linear approach.

EXPLORING LONELINESS THROUGH COGNITIVE PROFILES: UNDERSTANDING EXECUTIVE FUNCTION AND MENTALIZING IN AUTISTIC AND NON-AUTISTIC YOUTH

by

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Chapter 1: Introduction

Social Development in Autism Spectrum Disorder

Social communication challenges are a hallmark diagnostic feature of autism spectrum disorder (hereafter autism) (American Psychiatric Association [APA], 2013). Autism is considered a heterogeneous, dimensional condition, yet difficulties with social relatedness are observed across the continuum of cognitive and behavioral functioning for this disorder. Evidence demonstrates strong stability of autistic traits across the lifespan, with social difficulties manifesting differently at various points of the developmental trajectory (Fountain, Winter, & Bearman, 2012; Gotham, Pickles, & Lord, 2012; Venker, Ray-Subramanian, Bolt, & Ellis Weismer, 2014, Robinson et. al., 2011). In the general population, adolescence is a particularly tumultuous period of development as youth shift away from a family-centric relationship focus to an increased focus on peer relationships. Rates of loneliness tend to increase during adolescence (Qualter, et. al., 2015). Experiences of loneliness reported amongst autistic youth are significantly higher than their non-autistic peers, underscoring the particular susceptibility of adolescent youth on the spectrum to adverse social trajectories (Locke, et. al., 2010). While there is not a full understanding of the relationship between a lack of friendships and social interest, notably many autistic youth express the desire to form social bonds but have difficulty establishing such friendships and thus develop feelings of loneliness (Hawkley & Cacioppo, 2010; Bauminger, & Kasari, 2000; Cresswell et. al 2019). Chronic loneliness is associated with inflammation (Matthews et. al., 2024), poor mental health, and worse cardiovascular health (Leigh-Hunt et. al., 2017) in adulthood. Elevated rates of loneliness in autistic youth make this community particularly vulnerable to these poor outcomes. Sensitive periods of development, like adolescence, are particularly advantageous times to provide intervention and support for healthy social development to mitigate adverse outcomes. However, the field must deepen its understanding of the mechanisms driving loneliness development in adolescence, highlighting a critical gap in the literature essential for advancing developmental psychological theory and evidence-based intervention.

Execution Function and Mentalizing in Autism

Executive Functioning (EF) and mentalizing (also referred to as theory of mind (ToM)) challenges are well-documented in the autism population, with primary difficulties surrounding perseverative thinking and shifting between new concepts (Kenworthy, et. al., 2020). Examples of this in autistic youth include getting "stuck" on the same topic, which is sometimes referred to as inflexibility or fixed interests. In a social context, this could appear as an autistic child struggling to shift topics in conversation away from their topic of interest to that which their peers wish to discuss. Difficulties with these skills can adversely affect an autistic child's ability to navigate social situations and develop their social network.

Executive function has been proposed as the endotypic feature of autism to explain both mentalizing (Pellicano, 2007) and social difficulties (Leung et. al., 2016) in autism. Challenges in both EF and ToM are shown to be related to poor social outcomes (Jones et. al., 2018). One early theoretical conceptualization of loneliness (Weiss, 1974), links loneliness with the cognitive mechanisms related to difficulty in flexibility, shifting between others' perspectives, and taking on others' mental states. Greater cognitive flexibility has been shown to be correlated with improved social understanding (Bock et. al., 2015), and it stands to reason that challenges with this EF skill may be linked to social perception difficulties. However, this question has yet to be fully explored in autistic youth. In addition, autistic youth report fewer and lower quality social interactions with their peers in comparison to typically developing youth (Creswell et. al., 2019, Rowley et. al., 2012; Lord & Magill-Evans, 1995). Thus supporting the theory, the challenges with EF may be linked to forming friendships and maintaining social interactions. In order to fully understand the complex dynamic of social development in autistic youth, we must consider other developmental domains related to interpersonal skills.

Mentalizing encompasses one's ability to understand the thoughts, feelings, and behaviors of others around them. The process by which mental states are attributed to others, sometimes referred to as theory of mind, is a crucial aspect of social interaction. Difficulty with mentalizing is a feature associated with autism, and as such, is thought to be central for social interaction challenges experienced by autistic individuals. From this emerges the "mindblindness" theory: that the mentalizing challenges experienced by autistic youth give rise to poor socialization skills (Baron-Cohen et. al., 1985). The ability to read social situations is closely linked with forming social relationships and friendships. Mentalizing skills center on the ability to understand the feelings of those around them, and are important skills displayed in social interaction, which can be challenging for autistic people. However, recent work in the field reports conflicting findings regarding mentalizing in autism, with some research showing no group differences in either explicit (Nijhof et. al., 2018) or spontaneous (Alkire et. al., 2023) mentalizing between autistic youth and non-autistic peers. Futher, findings demonstrating a direct relationship between mentalizing and social skills are mixed. Some evidence shows that mentalizing is related to poor social behavior outcomes (Peterson, 2009), while other data indicates that there is no relationship between mentalizing and social skills (Alkire et. al., 2021). Such mixed findings could be the result of multifaceted approaches to quantifying mentalizing (Warnell & Redcay, 2019), phenotypic heterogeneity in autism (Altschuler et. al., 2018), or a combination of both these complex dynamics.

In addition to this mixed literature of group differences for both executive function and mentalizing difficulties, there are numerous discrepant findings regarding how these unique cognitive skills are related. For example, Kouklari et. al. (2018) reported that executive function skills predicted mentalizing ability in autistic youth, while Hemmers et. al. (2022) suggested that there is no link between EF and mentalizing in autistic youth. The wide spectrum of EF and mentalizing skills in autism is a major restricting factor in establishing a complete cognitive endophenotype in autism (Demetriou et. al., 2019). Meta-analyses suggest that heterogeneity observed in autism spectrum disorder is better suited to a subtype-based statistical approach (Kouklari, et. al., 2023). Initial work utilizing a profile or subtype approach to executive function challenges in autism has yielded promising results, demonstrating that distinct EF profiles may be a better predictor of outcomes than linear modeling (Dajani et. al., 2016; Kouklari et. al., 2023). However, to our knowledge, no studies to date have taken a profiles approach to both EF and mentalizing in autistic populations. Since the associations between these two key domains are divergent, this is a major gap in the literature that this study aims to fill.

This study will explore the relationship between mentalizing, EF, and loneliness. Given the heterogeneous nature of autism spectrum disorder and the range of cognitive skills, we will explore the links between different cognitive profiles and loneliness outcomes. It is crucial to understand the nuanced relationship between cognitive traits and real-world measures of loneliness to best support autistic youth's social well-being. The study aims to characterize the profiles of EF and mentalizing cognitive features in autistic and non-autistic youth. Upon identification of distinct EF and mentalizing profiles, we will explore the relationships between these profiles and social loneliness outcomes. Due to the complex and empirically discrepant relationships between mentalizing and executive functioning, there are no explicit hypotheses proposed in regard to the patterns of potential profiles and their relationship with loneliness. The findings from this research will unlock new avenues of social development support for autistic adolescents at risk for poor outcomes.

Chapter 2: Methods

Study Overview

This study leverages data collected from a longitudinal study of biopsychosocial predictors of loneliness in typical development and autism spectrum disorder. Data for the present study were collected at Timepoint 1. Data collection for Timepoint 1 began in March 2022 and concluded in July 2025. All participants and their parents/caregivers completed Timepoint 1 tasks and surveys in the Developmental Social Cognitive Neuroscience Lab at the University of Maryland, College Park. The Institutional Review Board at the University of Maryland, College Park approved the study. Informed consent was obtained from all parents/caregivers, and assent was obtained from participants.

Sample

The current completed sample comprises 195 eligible participants (Autistic (AUT), n=71; Non-Autistic (Non-AUT), n=124) between the ages of 11 and 14. Autistic youth were included based on a previous diagnosis of autism spectrum disorder, with enrollment confirmed by study team administration of the Autism Diagnostic Interview - Revised (ADI-R) (Lord et. al, 1994), a gold-standard measure for evaluating autism. The study team included a licensed clinician and clinical psychology graduate student who were both certified as research reliable on ADI-R administration. Co-occurring diagnoses such as attention-deficit-hyperactivity-disorder

(ADHD) and generalized anxiety disorder (ANX) were permissible for inclusion for all participants. Participants were excluded for MRI contraindication, Full Scale IQ below 80, or having a first-degree relative (biological parent or sibling) with a diagnosis of AUT or schizophrenia.

Measures

General Cognitive Ability

General Cognitive Ability was assessed by the proxy of intelligence quotient (IQ). IQ was estimated using the Kaufman Brief Intelligence Test, Second Edition (KBIT-2), an age-normed measure of verbal and nonverbal abilities. This measure is considered a valid and reliable estimate of intelligence for those aged 4-90 (Gray, 2013).

Executive Function

Domains of inhibition and shifting were measured using the NIH Toolbox Cognitive Battery (NIHTB-CB):

Dimensional Change Card Sort (DCCS) Test: This task (Zelazo, 2006) is a well-established measure of cognitive flexibility in children and adolescents. Participants are shown two target cards and instructed to sort the cards according to one of two dimensions (e.g., color or shape). Participants are instructed to select the appropriate card based on a single dimension. After several trials, the selection rule is changed, and participants must choose the correct target cards according to the new dimension.

Flanker Inhibitory Control (Flanker) Test: As a measure of inhibition, in this adaptation of the Eriksen Flanker task, (Eriksen & Eriksen, 1974), participants are instructed to indicate the orientation (left or right) of a centrally presented arrow (target arrow) while inhibiting attention to the surrounding flanker arrows. The trial consists of congruent flankers, in which the target arrow is oriented in the same direction as the surrounding arrows, and incongruent trials, where the target arrow is oriented in the opposite direction of the flanker arrows.

Mentalizing

The Face Task: This task measures participant response accuracy in labeling emotional states. Participants watch a looping brief video of an actor producing a facial expression. For each trial, participants are shown four possible emotional states (e.g. 1. Ashamed 2. Ignoring 3. Jealous 4. Bored). Possible emotion state selections are different for each video. Participants are presented with 27 randomized trials, with the stimuli at each trial presented for 8 seconds.

STOMP Mentalizing: Participants are shown a 2-minute scene, without audio, from the 1996 movie, *Matilda*. After viewing the emotionally charged film clip, the participants are instructed to "please describe what happened in the scene." Participants are prompted for additional information ("Can you say a little more?") if their response is of insufficient length. These participant responses are then transcribed and coded using a machine-learning approach to quantify the number of mentalizing phrases used. For the present analysis, we will use a residual score of mentalizing words, accounting for the overall number of words spoken. This will more robustly account for those who may not speak as much as others.

Social Outcomes

Loneliness was captured using a study-modified version of the Children's Loneliness and Social Dissatisfaction Scale (Asher, et.al., 1984). This 24-item scale includes constructs like "it's hard to get other kids to like me" and "I feel left out of things to quantify loneliness. Distractor (non-scored) items are included in the scale to improve scale validity. Participants' responses were coded along a 5-point Likert scale from "that's always true" to "that's never true," with higher scores indicating more loneliness. Internal consistency for this study was excellent (Cronbach's $\alpha = 0.94$).

Other Social Variables were captured using select NIHTB Emotional Battery surveys: (1) Emotional Support, (2) Friendship, (3) Hostility, and (4) Rejection. These surveys consist of developmentally appropriate measures of emotional health in each respective area. Normed scores for each index reflect reliable and clinically valid measures of socioemotional health (Paolillo et. al., 2019).

Analytical Approach

The first goal of this project is to explore whether distinct cognitive profiles of EF and mentalizing emerge across autistic and non-autistic youth. Current literature explores the relationship between EF and social cognition, and findings regarding the correlation of these skills are mixed. EF and social cognition are broadly umbrella terms that capture various nuanced cognitive skills; skills that seem to be theoretically distinct yet are often conflated. This study utilized a latent profile analysis (LPA) approach to explore various cognitive profiles in autistic and non-autistic youth using select EF and social cognitive domains. LPA is a statistical modelling approach used to identify subgroups of a sample based on groups of a set of continuous variables (Gana, et. al., 2022). Given the spectrum nature of autism and the wide heterogeneity of cognitive traits, a person-centered, LPA technique is well-leveraged to explore distinct cognitive profiles (Sterba, 2013). If distinct profiles emerge after LPA modeling, we will venture into the second goal of this project, which is to explore the relationship between the distinct profiles and loneliness outcomes. We hypothesize that linear relationships between cognitive domains and loneliness will not emerge and that distinct cognitive profiles will better explain the relationship between cognition and loneliness outcomes.

Analysis Plan

An LPA was conducted in Mplus Version 8.11 (Muthén & Muthén, 2012–2024). Four continuous variables of cognitive abilities were included in the model: Flanker Uncorrected Standard Score (Flanker), DCCS Uncorrected Standard Score (DCCS), percent accuracy on Faces Task (Faces), and residual mentalizing words on the STOMP task (STOMP). Age was modeled as a covariate predicting latent profile membership, given that non-age-corrected NIHTB-CB scores were used. Full information maximum likelihood (FIML) was used to handle missing data. For each model, starting values of 100 random sets and 50 optimizations were used. The best fit final model was selected based on a combination of fit statistics, including AIC, BIC, entropy, and theoretical interpretability. To compare models of the best number of classes, the AIC and BIC fit indices were used, with lower values indicating a betterfitting model (Nylund et al., 2007). Variance-covariance structure comparisons were reported for four structure models as indicated by Masyn (2013). Profile results for best fit class number were exported to R Version 2024.09.1+394 (Posit Software, PBC, 2024) for regression and ANOVA analyses.

Chapter 3: Results

Sample Characteristics and Descriptive Statistics

Results (Table 1) indicate that autistic adolescents experience more feelings of loneliness than their non-autistic peers (AUT $\bar{x}$ = 49.32, Non-AUT $\bar{x}$ = 37.84, $p<0.001$). We found that autistic youth performed significantly poorer on executive function measures of inhibition ($p<0.001$) and flexibility ($p=0.02$) compared to their non-autistic peers. In addition, autistic youth performed poorer on mentalizing measures of explicit mentalizing (Faces; $p<0.001$), but groups did not significantly differ in spontaneous mentalizing (STOMP). Diagnostic group remained significant in Flanker and Faces when controlling for overall IQ. DCCS and Stomp were not significantly different by diagnostic group when accounting for overall IQ.

Table 2 presents Pearson correlation results for all variables and covariates of interest. Age was significantly correlated with DCCS scores, with high performance on the measure of flexibility associated with older children ($r = .24$, $p < .01$). Overall IQ was significantly associated with higher performance on both measures of executive function (Flanker: $r = .34$, $p < .01$; DCCS: $r = .31$, $p < .01$) and measure of explicit mentalizing (Faces: $r = .35$, $p < .01$), demonstrating that an index of general cognitive ability is positively associated with executive functioning and mentalizing. Strong correlation was observed between DCCS and Flanker ($r = .55$, $p < .01$), and both measures of executive function demonstrated strong associations with Faces (Flanker: $r = .30$, $p < .01$; DCCS: $r = .36$, $p < .01$).

Associations Between Key Variables and Loneliness

A series of regression analyses was conducted to explore the unique contribution of each executive function and mentalizing domain individually on loneliness, controlling for age, diagnostic group, and overall IQ (Table 3). The covariate model included overall IQ, age, and diagnostic group. The overall model was significant (R^2=0.20; p<0.001), with age (β=0.17, p=0.01) and diagnostic group (β=0.41, p<0.001) explaining significant variance in loneliness. Findings indicate that adding none of the four cognitive variables of interest significantly improved model fit (Flanker: ΔR^2<-0.001; DCCS: ΔR^2=-0.01; STOMP: ΔR^2<-0.001; Faces: ΔR^2=0.02). None of the four variables of interest explains significant variance in loneliness when controlling for age, overall IQ, and diagnostic group (Flanker: p=0.35; DCCS: p=0.75; STOMP: p=0.39; Faces: p=0.17). Further, we explored the relationship between diagnostic groups and found no statistically significant linear relationships between the four cognitive variables of interest and loneliness in either the AUT or non-AUT groups (Table 4). In the covariate model for non-AUT, neither age (β=-0.04, p=0.68) nor overall IQ (β=0.14, p=0.13) explains significant differences in loneliness. For AUT, age (β=0.30, p=0.02) explained significant variance in loneliness, but not overall IQ (β=0.14, p=0.24).

LPA Results

Variance-covariance model comparisons across four structures are reported in Table 5. . The default modeling structure (Structure 1: Class-Invariant, Diagonal), classified by varying means, equal variances, and zero covariances, was used (Masyn, 2013). Modeling revealed that a three-profile approach best fit the data. Bayesian Information Criterion (BIC), and Bootstrap Likelihood Ratio Test (BLRT) indicated that the three-profile solution provided a significantly better fit than the two-profile model. The three-profile solution yielded an entropy value of 0.71, indicating acceptable classification quality (Clark, 2010). Although entropy did not exceed the typical threshold of 0.80, entropy <0.70 reflects an acceptable degree of classification certainty and is within the range reported in previous LPA studies (e.g., Nylund et al., 2007). The model shows significant improvement in fit indices, including the BIC, AIC, and BLRT. The three latent profiles are classified as Profile 1 (n=86): Higher Cognitive Ability (High-Cog), Profile 2 (n=97): Average Cognitive Ability (Avg-Cog), and Profile 3 (n=12): Low Flexibility (Low-Flex).

One-way ANOVA (Table 6) analysis revealed a significant effect of LPA profiles on loneliness scores ($F(2, 184) = 3.28$, $p = .040$). Profile 3 (Low-Flex) was significantly different from Profile 2 (Avg-Cog) ($\beta=0.18$, $p=0.02$), with mean loneliness scores being 10.47 points higher in Low-Flex compared to Profile 1 (High-Cog). Mean loneliness scores in the high cognitive ability profile were 2.69 points higher than average cognitive ability profile, and this difference was not statistically significant ($\beta=0.10$, $p=0.17$). The low flexibility profiles' mean loneliness score was

7.79 points higher than the mean score for the high cognitive ability profile, and this difference was marginally significant (β=0.13, p=0.08) (Table 7). Full characteristics of each profile are listed in Table 8.

A hierarchical multiple regression was completed to examine the relationship between the LPA profiles and loneliness when accounting for diagnostic group (Table 9). Diagnostic group accounts for significant variance in loneliness ($F(1,185) = 38.26$, $p < .001$)). Adding LPA group to the model did not improve the model fit ($\Delta F(2,183)=1.96$, $p=.14$) with LPA group not significantly contributing to variance in loneliness when accounting for diagnostic group ($F(3,183) = 14.2$, $p=0.14$). While the overall effect of LPA group on loneliness was not statistically significant when accounting for diagnostic group, linear regression was used to explore comparisons between LPA groups (Table 10). Analysis indicates that Profile Avg-Cog showed a marginally significant difference from High-Cog when controlling for diagnostic group (β=0.12, p=0.086). There was no difference between Profile 2 (High-Cog) and Profile 3 (Low-Flex) when accounting for diagnostic group (β=0.091, p=0.195). There was no interaction between the Profiles and diagnostic group ($F(2, 181) = 0.97$, $p = 0.32$).

Exploratory Analysis Results

Additional social outcomes

Exploratory analyses were conducted to explore the relationship between the LPA cognitive profiles and other social outcomes. Additional social outcomes were collected from select NIH Toolbox Emotion Surveys: (1) emotional support, (2) friendship, (3) hostility, and (4) rejection. We observed diagnostic group differences on emotional support ($p<0.001$) and friendship ($p<0.001$) (Table S1). The LPA profiles were significantly related to NIHTB emotional support ($p>0.004$) and none of the other three selected NIHTB socioemotional health outcomes surveys. This significant result survived the Bonferroni test of multiple comparisons (Table S2). To follow the same analytical procedure as loneliness analysis, we added a diagnostic group to the model (Table S3). We observed that the LPA groups explained significant variance in emotional support when controlling for diagnostic group ($F(3,175) = 6.99$, $p=0.02$). To explore this further, we used a hierarchical regression analysis to explore the relationship between emotional support and the LPA profiles, accounting for diagnostic group. We observed that the diagnostic group accounts for significant variance in perception of emotional support ($F(1,177) = 13.6$, $p < .001$). Adding LPA group to the model significantly improves the model fit ($\Delta F(2,75)=3.49$, $p=.03$). We observed that perception of emotional support scores significantly differs between Avg-Cog and Low-Flex ($\beta=-0.19$, $p=0.02$) as well as High-Cog and Low-Flex ($\beta=0.20$, $p<0.01$) when accounting for variance attributed to diagnostic group.

Co-Occurring Diagnoses

An exploratory analysis was conducted to investigate relationships between the LPA profiles and co-occurring diagnoses. We tested diagnostic group differences by differentiating groups with ADHD and Anxiety (ANX), respectively, at every Profile level. To enhance comprehensibility, typically developing (TD) indicates participants without a reported ADHD, ANX, or AUT diagnosis. In order to control for multiple comparisons, Bonferroni correction was used for reported pairwise comparisons, and Tukey's HSD adjusted p-values were used for within-profile ANOVAs.

ADHD. Of the sample included in the primary analysis, 51 have a diagnosis of both AUT and ADHD, 12 have a diagnosis of ADHD only, 20 have a diagnosis of AUT only (n=83 AUT and/or ADHD), and 112 are considered TD (Table S4.). Fischer's exact test for count data reveals significant differences between the distributions of diagnostic groups across the profiles (p=0.01). A marginally significant interaction was observed between profile and diagnostic group on loneliness ($F(3, 175) = 2.22$, $p = 0.054$), indicating that the effect of diagnostic group on loneliness varied by profile. Tukey's HSD revealed significant diagnostic group differences for Profiles 1 (p=0.010) and 2 (p<0.001), but not the Low-Flex profile. For Profile 2 (Avg-Cog) (Table S6), both AUT-only (p=0.003) and AUT & ADHD (p=0.006) were significantly more lonely, respectively, than TD. There was no difference between AUT-only and AUT & ADHD in reference to ADHD-only loneliness scores. For Profile 1 (High-Cog) (Table S5), the ADHD-only group had significantly lower loneliness scores than the AUT & ADHD group (p=0.006), with AUT & ADHD (p<0.001) reporting significantly greater loneliness than the TD group. There was no difference in loneliness AUT-only and TD groups for the High-Cog profile.

Anxiety. Of the sample included in the primary analysis, 50 participants are considered both AUT and ANX, 18 participants are ANX-only, 21 are AUT-only (n=89 AUT and/or ANX), and 106 are TD (Table S7). Fischer's exact test for count data reveals significant differences between the distributions of diagnostic groups across the profiles (p=0.02). A significant interaction was observed between profile and diagnostic group on loneliness ($F(5, 176) = 2.69$, $p = 0.02$), indicating that the effect of diagnostic group on loneliness varied by profile. In Profile 2 (Avg-Cog) (Table S8), both AUT-only (p=0.009) and AUT & ANX (p=0.010), respectively, were significantly more lonely than TD. ANX-only was significantly less lonely than AUT-alone (p=0.013), but not AUT & ANX. In Profile 1 (High-Cog) (Table S9), AUT & ANX were significantly more lonely than Non-AUT (p<0.001).

Chapter 4: Discussion

The goal of this study was to explore relationships between cognitive skills and loneliness in autistic and non-autistic youth. The varied profiles of autism symptoms make linear approaches to studying these cognitive domains difficult to interpret. The present study aimed to highlight flaws with a linear analysis of a heterogeneous sample, such as autism, to support the use of profile-centered approaches when analyzing samples with varied symptomology. Our results indicate that three distinct cognitive profiles best fit our data: globally strong cognition (High-Cog), average cognitive skills (Avg-Cog), and low flexibility (Low-Flex) (Figure 1). The Low-Flex profile was especially lonely, followed by the High-Cog profile, with the Avg-Cog group reported the lowest levels of loneliness (Figure 2). When we account for diagnostic group, we see a marginal difference with the globally strong cognition group being slightly more lonely than the average cognitive skills group. Overall, the autistic sample is substantially lonelier than their non-autistic peers, yet controlling for diagnostic group differences did not improve the model. There was no difference in loneliness for autistic youth by cognitive profile.

Our correlation results supported existing theory asserting a close association between executive functioning domains and general cognitive abilities (Liss et. al., 2001; Arffa, 2007) across the entire sample, with significant differences between the autistic and non-autistic participants on measures of general cognitive ability and executive function. Differences in executive function are well documented in autistic youth (Kenworthy et. al., 2022), but there is a lack of consensus on potential general cognitive ability differences between autistic and non-autistic youth (Wolff et. al., 2022). Evidence suggests that approximately half of autistic youth demonstrate an average or greater IQ (Katusic et. al., 2021). In our sample, both groups fell within one standard deviation of the population average, indicating that most participants fell in the clinically average range. This is notable in that although group differences indicate that the non-autistic participant significantly outperformed their autistic peers, the autism group scored within the average range on population-normed measures. While this difference is not clinically meaningful, it is relevant in interpreting profile differences. Further, neither executive function nor overall IQ was significantly correlated with loneliness in our sample, indicating that experiences of loneliness may not be explained alone by general cognitive ability (e.g., IQ).

Next, we explored relationships between each cognitive domain of interest and loneliness and accounted for variance in age, general cognitive ability, and diagnostic group. We found no relationship between any of the four cognitive domains of interest and loneliness scores. This is not consistent with some work in the field indicating that more loneliness and social isolation are linked with greater cognitive difficulties in youth (Jin & Hwang, 2024; Baumeister et. al., 2002; Fox et. al., 2011). Yet, to our knowledge, there has been no exploration of social isolation or loneliness and cognitive skills in autistic populations. Broadly, our results support the need for a profile-centered method to explore the relationship between executive function and mentalizing in autistic youth. The heterogeneous nature of autism is evident in these results and emphasizes the utility of a person-centered approach. Such methods may better capture the mechanisms by which unique profiles of EF and mentalizing contribute to loneliness outcomes in autistic youth.

Indeed, results indicate that the profiles are significantly related to loneliness, with the low flexibility profile being significantly more lonely than the balanced cognitive skills profile (Avg-Cog), and approaching statistical significance in reference to being different from the globally strong (High-Cog) cognitive profile. When we control for the variable in the diagnostic group in loneliness scores across the profiles, the overall effect of LPA Profile is overridden by the diagnostic group difference. This effect is likely impacted by the small sample size and the relatively high skew of autistic participants in the low flexibility profile. Although the small group size of this profile makes confidence in this result somewhat weak, there are existing links between poor cognitive abilities and social isolation regardless of neurodevelopmental diagnosis (Fox et. al., 2011). In taking the results of this lonely profile, independent of diagnostic group, the hallmark feature of poor flexibility linked to greater loneliness is worth future investigation. Animal modeling posits that social isolation causally drives impaired flexibility during adolescence (Schrijver & Würbel, 2001), while work in pre-teens and adolescents highlights that those who experience greater challenges with cognitive flexibility have more struggles with social competence and peer interactions (Ciairano, 2006). To support autistic youth in reaching their social goals, interventions targeting cognitive flexibility (Kenworthy et al., 2014; Memari et. al., 2013; de Andrade Varanda & Fernandes, 2015) have been empirically developed and implemented. Our results emphasize the continued support of interventions to support both non-autistic and autistic youth's flexibility skills in order to boost successful social interactions to mitigate adverse loneliness outcomes.

In our findings, ANOVA analyses revealed a marginally significant difference between the highest “globally strong” cognitive skills group and the moderate cognitive skills group when accounting for diagnostic group. Although this difference does not meet the threshold for statistical significance and should be interpreted cautiously, this result warrants additional investigation with a larger sample. While marginal, this result is especially interesting in that the cognitive skills of these profiles provide an interesting pattern of results in relationship to loneliness scores. When accounting for the diagnostic group, Avg-Cog group, the least lonely profile, was approaching a significant difference from High-Cog, the moderately lonely profile. This relationship between higher and moderate cognitive skills profiles and their mean loneliness scores is the inverse of what is observed between the lower cognitive skills and average cognitive skills profiles, without the consideration of the diagnostic group. Broadly, these results indicate that the cognitive extremes: those with the lowest cognitive skills and those with the highest cognitive abilities, may be more susceptible to loneliness than their average-cognitive ability peers. These findings could indicate a potential quadratic relationship between cognitive skills and loneliness: that those with the highest and lowest cognitive skills are at greater risk of loneliness. While there is evidence of high-cognitive-ability youth experiencing more loneliness than their average-cognitive-ability peers (Ramos et. al., 2024), no one has reported greater loneliness on both low and high ends of cognitive ability in one sample.

In addition, we were curious to look beyond outcomes of loneliness and explore other constructs of social experience. There is evidence that social support (Lasgaard et. al., 2010) and friendship (Mazurek, 2014) are associated with loneliness outcomes in autistic youth. Futher, experiences of rejection (Gurbuz et. al., 2024, victimization (Fisher & Taylor, 2015) and difficulty with peer interactions (Bauminger, 2003) make it difficult for autistic peers to initiate and maintain social bonds. Our exploratory analysis explored whether the cognitive profiles could be related to other social outcomes beyond loneliness. Our analysis revealed that autistic youth report having significantly fewer emotional support outlets than their non-autistic peers. We also noted significant differences in the availability of friends across AUT and Non-AUT groups. However, only emotional support was significantly associated with the cognitive profiles, controlling for diagnostic group. Mirroring our results with loneliness outcomes, youth in the Low-Flex profiles reported the lowest rating of perceived social network support. There was no difference between the High-Cog and Avg-Cog groups on emotional support outcomes. These results are preliminary, but indicate that future work should probe the distinct feature of having emotional support above simply having friends with whom to interact.

Lastly, an exploratory analysis investigated the role of co-occurring diagnoses on the relationship between the cognitive profiles and loneliness. We examined co-occurring ADHD and Anxiety in the sample, independently, in an effort to maximize sample size across the groups; although, small sample sizes remained a significant limiting factor in interpreting results. As expected, in general, co-occurring ADHD and/or Anxiety with autism seemed to be related to increased rates of loneliness compared to typically developing (TD) peers. (TD peers indicate individuals who are Non-AUT, Non-ANX, and Non-ADHD). Results demonstrated that the interaction between co-occurring diagnoses and cognitive profile was significant for the Anxiety model, and marginally significant for the ADHD model. Given that without co-occurring diagnoses, we did not observe a significant interaction between diagnostic group and cognitive profiles in relationship to loneliness, we can infer that considering co-occurring diagnoses is an important facet in capturing this complex dynamic between cognition and loneliness experiences. We follow up on this significant interaction result to explore for which profiles and co-occurring diagnosis pairs did loneliness outcomes differ. (See Figures S1 and S2). Neither those with Anxiety alone nor ADHD alone had elevated loneliness scores from their TD peers. For the average cognitive performers, we observed that those with AUT alone or AUT and a co-occurring diagnosis experience significantly more loneliness than those without AUT or either co-occurring ANX or ADHD. Yet those with AUT and co-occurring ADHD and Anxiety had a loneliness rating that trends higher than autistic participants without either co-occurring diagnoses. Interestingly, we do not see this same effect in the high cognitive performers: AUT-only participants do not differ significantly from their TD peers, and those with AUT and ADHD or Anxiety have the highest loneliness rates and significantly differ from their TD peers. This provides more evidence for the unique presentation of loneliness and social experiences for those at the higher extremes of cognitive ability.

Limitations and Future Directions

A primary limitation is the sample size of Profiles 1 and 2 compared to the small sample size of Profile 3. For the 3-profile solution, those included in Profile 3 also seemed to be those identified as one distinct profile in the 2-profile solution, leaving a highly skewed secondary group. This lack of theoretical fit is reflected in BIC fit indices comparing the 2 and 3 profile solutions. This, along with supported fit indices, provided theoretical justification for the utility of a 3-group solution, yet it also highlights the disadvantage of this project's small size for conducting an LPA. Further, as the classification quality for the 3-profile solution was in the moderate range, this further limits the interpretability of the profiles. Future directions include expanding the sample size by accessing NDAR and/or Simons available data to see if these relationships between cognitive skills and loneliness hold.

In addition, our sample reflects a narrow window of the spectrum of autism. While autism is heterogeneous, our sample overall tends to reflect autistic and non-autistic youth who scored in the average to high average range of performance across all measures. As the small-sized group, Profile 3, is characterized by lower performance on measures of cognitive skills, our sample does not robustly reflect the autistic community in this performance range. Expanding the sample to include a nationwide sample (e.g. NDAR and/or Simons), thus increasing the representation of lower cognitive skill youth, will allow us to explore whether our results generalize to a broader sample. Another direction we plan to explore is expanding the variables of interest in the profiles to include general cognitive ability and social reward. Leaders in the field have proposed that autistic individuals who find social interaction less rewarding may demonstrate decreased social motivation, which is linked with more difficulty with mentalizing (Chevallier, 2012). There is a key distinction here between motivation and cognition. Some youth may be highly motivated to engage, as reflected in strong evidence that autistic youth desire social bonds and friendships, yet struggle with the cognitive skills to develop these relationships. Other youth may not have the desire to forge social bonds and demonstrate cognitive skills that match their non-autistic peers. There is evidence that being more sensitive to reward is associated with higher rates of loneliness (Dziura et. al. 2023). Our future work will raise the question of the relationship between the ability and propensity to develop peer relationships in association with adverse loneliness outcomes.

Conclusion

Given the evidence of long-term adverse physical and mental health outcomes linked to loneliness, it is essential to understand factors that are linked to experiences of chronic loneliness in youth. Challenges with cognitive domains, including mentalizing and executive functions, have been frequently reported; however, work in recent years has questioned reported mentalizing difficulties in adolescence and adulthood. Autism symptoms present heterogeneously, making studies exploring links between cognitive skills like executive function and theory of mind, with social outcomes, difficult to deduce a clear consensus across the field.

Our work adds to the growing collection of literature raising concerns over the high rate of loneliness in autistic youth. These results indicate that there are qualities unique to the autism experience that are related to loneliness, which go beyond simply cognitive ability. We demonstrated, through an LPA profiling approach, 3 distinct patterns of executive functioning skills and mentalizing. We demonstrated that the profile characterized by flexibility difficulties was the loneliest. The highest cognitive skills group trends towards greater loneliness than their average cognitive ability peers, regardless of diagnostic group. These findings illuminate the field's understanding of the complex relationship between social experience and cognitive ability in autistic and non-autistic youth and highlight the unique contributions of executive function and mentalizing on loneliness in autistic adolescence.

Tables

Table 1. Participant Characteristics

	ASD n=71	Non-ASD n=124	
Age in Years	12.98 (1.0)	12.74 (1.2)	
Birth Sex (F:M)	7:64	63:61	***
Overall IQ	106.12 (16.9)	114.94 (12.5)	***
Loneliness Total	49.32 (15.8)	37.84 (9.6)	***
Flanker	94.35 (10.3)	99.51 (7.2)	***
DCCS	96.09 (15.9)	101.32 (8.8)	*
STOMP	-0.39 (2.0)	0.23 (2.3)	
Faces	0.60 (0.1)	0.72 (0.1)	***

*** indicates $p < .001$; * indicates $p>0.05$

Table 2. Means, standard deviations, and correlations with confidence intervals

Variable	*M*	*SD*	1	2	3	4	5	6
1. Age	12.85	1.16						
2. Overall IQ	112.21	13.11	-.03 [-.19, .12]					
3. Flanker	98.08	8.40	.10 [-.06, .25]	.34** [.20, .47]				
4. DCCS	99.91	11.45	.24** [.09, .38]	.31** [.16, .44]	.55** [.43, .65]			
5. STOMP	0.02	2.23	.03 [-.12, .19]	-.02 [-.18, .13]	.03 [-.13, .18]	.03 [-.13, .18]		
6. Faces	0.68	0.13	.09 [-.07, .24]	.35** [.21, .48]	.30** [.15, .44]	.36** [.22, .49]	.09 [-.06, .24]	
7. Loneliness	41.83	13.37	.21** [.06, .36]	.01 [-.14, .17]	-.01 [-.16, .15]	-.02 [-.18, .14]	.00 [-.16, .16]	-.22** [-.36, -.06]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$. ** indicates $p < .01$.

Table 3. Cognitive variables of interest predicting loneliness controlling for age, diagnostic group, and Overall IQ

	β	**SE**	**t**	**p-value**	$R^2(\Delta R^2)$
Diagnostic Group	0.41	1.93	6.03	<0.01	
Overall IQ	0.06	0.05	0.81	0.42	
Age	0.17	0.77	2.60	0.01	
Covariate Model Fit:					0.20***
Flanker	0.07	0.08	0.93	0.35	(<-0.01)
DCCS	-0.03	0.08	-0.32	0.75	(-0.01)
STOMP	0.06	0.07	0.87	0.39	(<-0.01)
Faces	-0.11	0.08	-1.38	0.17	(0.02)

*** indicates $p < .001$; β indicates standardized beta

Table 4. Associations between cognitive variables of interest and loneliness with age and IQ covariates by diagnostic group.

	β	SE	t	p-value	$R^2(\Delta R^2)$
			ASD Group		
Overall IQ	0.14	0.12	1.17	0.24	
Age	0.30	2.10	2.37	0.02	
Covariate Model Fit:					0.10*
Flanker	0.02	0.158	0.129	0.898	(<0.001)
DCCS	0.00	0.161	0.00	1.00	(<0.001)
STOMP	0.189	0.122	1.551	0.127	(0.004)
Faces	-0.08	0.151	-0.53	0.598	(0.01)
			Non-ASD Group		
Overall IQ	-0.04	0.07	-0.41	0.68	
Age	0.14	0.70	1.52	0.13	
Covariate Model Fit:					0.02
Flanker	0.10	0.10	1.01	0.31	(0.01)
DCCS	-0.11	0.10	-1.07	0.29	(0.01)
STOMP	-0.01	0.09	-0.13	0.90	(<0.001)
Faces	-0.18	0.09	-1.90	0.06	(0.03)+

* indicates $p>0.05$; + indicates $p>0.10$; β indicates standardized beta

Table 5. LPA Model Fit Indices

Structure Type	Number of Profiles	AIC	BIC	Entropy	BLRT p-value	LMLRT p-value
Structure #1	1	3907.074	3939.906	-	-	-
	2	3171.810	3217.632	0.96	<0.001	0.001
	3	3137.170	3202.630	0.71	<0.001	0.0649
	4	3125.370	3210.468	0.78	0.01	0.205
Structure #2	1	3907.074	3939.906	-	-	-
	2	3157.223	3216.137	0.69	<0.001	0.006
	3	3117.258	3208.902	0.68	<0.001	0.006
	4	3102.759	3227.133	0.81	<0.002	0.161
Structure #3	1	3825.749	3878.280	-	-	-
	2	3149.312	3214.772	0.96	<0.001	0.075
	3	3135.352	3220.450	0.70	<0.001	0.252
	4	3125.080	3229.816	0.79	0.01	0.086
Structure #4	1	3825.749	3878.280	-	-	
	2	3149.437	3234.535	0.97	<0.001	0.011
	3	3138.282	3262.656	0.68	1.00	0.342
	4	3127.113	3290.763	0.77	1.00	0.239

Note: Akaike Information Criterion (AIC); Bayesian Information Criterion (BIC); Bootstrap Likelihood Ratio Test (BLRT). Structure #1: Class-Invariant, Diagonal; Structure #2: Class-Varying, Diagonal; Structure #3: Class-Invariant, Unrestricted; Structure #4: Class-Varying, Unrestricted.

Table 6. Fixed-Effects ANOVA Results using loneliness as the criterion

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	partial η^2	partial η^2 90% CI [LL, UL]
(Intercept)	150994.27	1	150994.27	881.64	.000		
LPA Profiles	1121.78	2	560.89	3.28	.040	.03	[.00, .08]
Error	31512.67	184	171.26				

Note. LL and UL represent the lower-limit and upper-limit of the partial η^2 confidence interval, respectively.

Table 7. Regression results using Loneliness as the criterion

Predictor	Std. Beta	Std. Error	t value	p value	
Profile 1 – Profile 3	0.13	4.38	1.78	0.08	+
Profile 1 - Profile 2	0.10	1.97	1.36	0.18	
Profile 2 - Profile 3	0.18	4.35	2.41	0.02	*
Model Fit: R^2=0.03; p-value=0.04					

* indicates p>0.05; + indicates p>0.10

Table 8. Characteristics of Cognitive Profiles by Diagnostic Group

	Profile 1 High Cognitive Skills			Profile 2 Average Cognitive Skills			Profile 3 Low Flexibility		
Variable	ASD	Non-ASD	Total Sample	ASD	Non-ASD	Total Sample	ASD	Non-ASD	Total Sample
Flanker	102.35 (5.35)	103.75 (4.63)	103.30 (4.88)	91.83 (6.39)	95.71 (6.85)	94.43 (6.92)	80.90 (11.78)	93.00 (9.90)	82.92 (12.03)
DCCS	107.58 (4.88)	107.77 (5.67)	107.71 (5.40)	96.10 (8.92)	96.28 (4.31)	96.22 (6.18)	66.20 (10.34)	67.00 (0.00)	66.33 (9.35)
STOMP	-0.88 (1.76)	0.15 (2.39)	-0.20 (2.24)	0.16 (2.16)	0.27 (2.22)	0.23 (2.18)	-1.26 (2.01)	0.81 (2.23)	-0.74 (2.12)
Faces	0.69 (0.12)	0.75 (0.09)	0.73 (0.10)	0.57 (0.11)	0.69 (0.11)	0.65 (0.12)	0.43 (0.18)	0.65 (0.08)	0.48 (0.18)
Loneliness	52.05 (16.31)	38.76 (10.58)	42.77 (13.90)	46.87 (15.83)	36.57 (8.26)	40.08 (12.34)	50.63 (14.30)	50.24 (8.82)	50.55 (12.95)

Note: Scores listed as M(SD)

Table 9. Fixed-Effects ANOVA results using diagnostic group and loneliness as the criterion

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{partial}\eta^2$	$_{partial}\eta^2$ 90% CI [LL, UL]
(Intercept)	27596.01	1	27596.01	190.76	.000		
LPA Profiles	568.42	2	284.21	1.96	.143	.02	[.00, .06]
Diagnostic Group	5038.92	1	5038.92	34.83	.000	.16	[.09, .24]
Error	26473.75	183	144.67				

Note. LL and UL represent the lower-limit and upper-limit of the partial η^2 confidence interval, respectively.

Table 10. Regression results using Loneliness as the criterion controlling for diagnostic group

	Std. Beta	Std. Error	t value	p value	
Profile 1 – Profile 3	-0.11	4.14	0.53	0.595	
Profile 1 - Profile 2	0.12	1.81	-1.72	0.086	(+)
Profile 2 - Profile 3	0.09	4.10	0.53	0.195	
Diagnostic Group	0.40	1.90	-5.90	< 0.001	***
Model Fit: R^2=0.19; p-value<0.001					

Note: Regressions ran with alternating reference groups to calculate all profile combinations.
* indicates p>0.05; + indicates p>0.10

Table S1. Diagnostic Group Differences on NIHTB Emotion Survey Measures

	ASD		Non-ASD		
Variable	M	SD	M	SD	
Friendship	38.24	11.6	50.22	8.8	***
Emotional Support	45.52	9.9	50.63	8.1	***
Rejection	50.76	11.8	48.90	8.9	
Hostility	45.87	11.4	45.13	8.6	

Notes: Domains are calculated on a population normed t-score. *** indicates p>0.001

Table S2. Associations Between LPA Profile and NIH Survey Measures

	p-value	Bonforroni Adjusted p-value
Emotional Support	.004	0.016
Hostility	. 693	1.000
Rejection	. 886	1.000
Friendship	.115	0.460

Table S3. Fixed-Effects ANOVA results using NIHTB Emotional Support as the criterion controlling for diagnostic group.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	partial η^2	partial η^2 90% CI [LL, UL]
(Intercept)	92182.20	1	92182.20	1224.24	.000		
Group	682.28	1	682.28	9.06	.003	.05	[.01, .11]
LPA Profile	526.07	2	263.04	3.49	.033	.04	[.00, .09]
Error	13177.07	175	75.30				

Note. LL and UL represent the lower-limit and upper-limit of the partial η^2 confidence interval, respectively.

Table S4. Mean Loneliness Scores and Sample Size by Profile and Diagnostic Group including Co-Occurring ADHD

	Profile 1	Profile 2	Profile 3	Total
ADHD only	n=7 x̄=36.57	n=5 x̄=42.40	n=0 -	12
ASD only	n=6 x̄=43.00	n=9 x̄=51.38	n=5 x̄=57.33	20
ASD and ADHD	n=21 x̄=54.90	n=25 x̄=45.36	n=5 x̄=46.61	51
ASD and/or ADHD	n=34 x̄=48.66	n=39 x̄=46.26	n=10 x̄=50.63	83
TD	n=52 x̄=39.01	n=58 x̄=36.06	n=2 x̄=50.23	112

Note: TD refers to Non-ASD participants and participants who did not report a diagnosis of ADHD. x̄ indicated mean loneliness score.

Table S5. Tukey's HSD P-Values for Diagnostic Group Pairs in Profile 1

	ADHD	ASD	ASD+ADHD
ASD	0.78	-	-
ASD & ADHD	<0.01	0.17	-
TD	0.95	0.88	<0.01

Table S6. Tukey's HSD P-Values for Diagnostic Group Pairs in Profile 2

	ADHD	ASD	ASD+ADHD
ASD	0.51	-	-
ASD & ADHD	0.96	0.56	-
TD	0.63	<0.01	<0.01

Table S7. Mean Loneliness Scores and Sample Size by Profile and Diagnostic Group including Co-Occurring Anxiety

	Profile 1	Profile 2	Profile 3	Total
Anx Only	n=8 x̄=44.79	n=10 x̄=34.60	NA	18
ASD only	n=9 x̄=47.38	n=7 x̄=54.00	n=5 x̄=63.67	21
ASD & Anx	n=18 x̄=54.26	n=27 x̄=45.55	n=5 x̄=42.81	50
ASD and/or ANX	n=35 x̄=50.31	n=44 x̄=43.95	n=10 x̄=50.63	89
TD	n=51 x̄=37.79	n=53 x̄=36.95	n=2 x̄=50.23	106

Note: TD refers to Non-ASD participants and participants who did not report a diagnosis of Anxiety.

Table S8. Tukey's HSD P-Values for Diagnostic Group Pairs in Profile 2

	Anx	ASD	ASD & Anx
ASD	0.01	-	-
ASD+Anx	0.05	0.42	-
TD	0.93	0.01	0.01

Table S9. Tukey's HSD P-Values for Diagnostic Group Pairs in Profile 1

	Anx	ASD	ASD & Anx
ASD	0.97	-	-
ASD+Anx	0.30	0.57	-
TD	0.44	0.19	<0.01

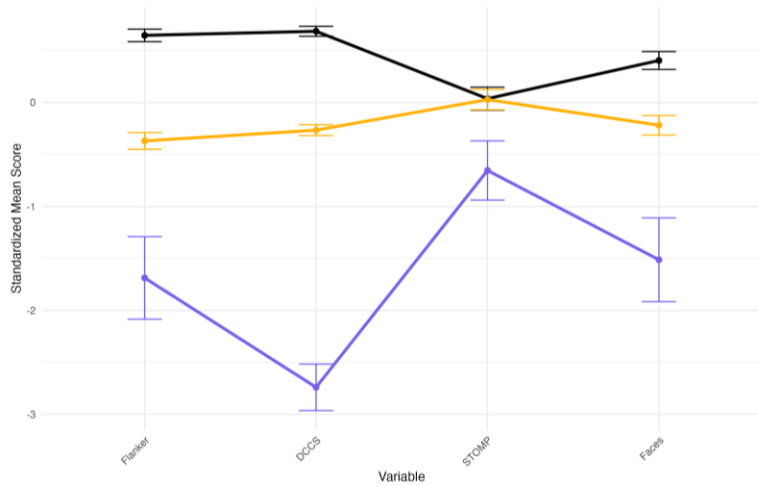
Table S10. Means, standard deviations, and correlations with confidence intervals

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10
1. Age	12.89	1.16										
2. Overall IQ	112.28	12.94	-.05									
			[-.21, .11]									
3. Emo. Supp.	49.04	9.22	-.01	.12								
			[-.17, .15]	[-.04, .28]								
4. Friendship	45.88	11.62	-.09	.04	.52**							
			[-.25, .07]	[-.12, .20]	[.40, .63]							
5. Hostility	45.44	9.62	.05	-.01	-.14	-.13						
			[-.11, .21]	[-.17, .15]	[-.30, .02]	[-.29, .03]						
6. Rejection	49.64	9.92	.12	-.10	-.27**	-.34**	.67**					
			[-.04, .28]	[-.25, .06]	[-.42, -.12]	[-.48, -.19]	[.58, .75]					
7. Loneliness	42.07	13.41	.21*	.01	-.51**	-.81**	.25**	.48**				
			[.05, .35]	[-.15, .17]	[-.62, -.38]	[-.86, -.74]	[.10, .40]	[.35, .60]				
8. Flanker	98.03	8.39	.13	.33**	.04	.15	.02	-.04	-.04			
			[-.03, .28]	[.18, .47]	[-.12, .20]	[-.01, .31]	[-.15, .18]	[-.20, .12]	[-.20, .13]			
9. DCCS	100.03	11.56	.24**	.29**	.21*	.10	.06	.02	-.04	.55**		
			[.08, .39]	[.14, .43]	[.05, .36]	[-.06, .26]	[-.11, .21]	[-.14, .18]	[-.20, .12]	[.43, .65]		
10. Faces	0.68	0.14	.07	.35**	.26**	.27**	.04	-.05	-.22**	.32**	.36**	
			[-.09, .23]	[.20, .49]	[.10, .40]	[.11, .41]	[-.12, .20]	[-.21, .11]	[-.37, -.06]	[.16, .45]	[.21, .49]	
11. STOMP	0.07	0.03	-.05	-.13	-.03	.08	.08	.08	.02	-.12	-.05	-.06
			[-.21, .11]	[-.29, .03]	[-.19, .13]	[-.08, .24]	[-.09, .23]	[-.09, .23]	[-.14, .18]	[-.28, .04]	[-.21, .12]	[-.22, .10]

Note. *M* and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). Emotional Support (Emo. Supp.). * indicates $p < .05$. ** indicates $p < .01$.

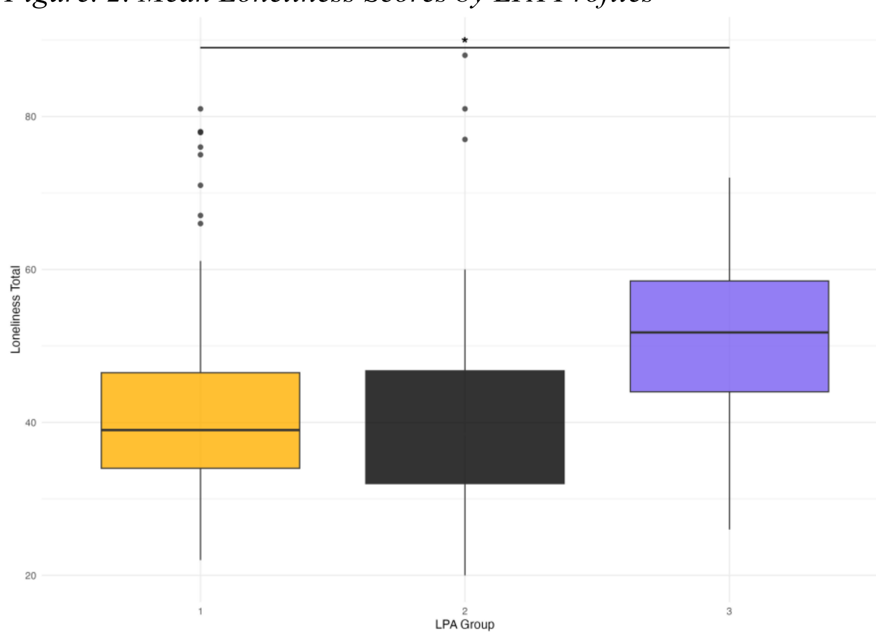
Figures

Figure 1. Profiles Plotted by Cognitive Variable of Interest



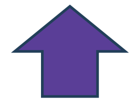
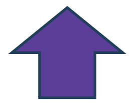
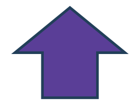
Note: To facilitate the readability and the comprehension of the graph, standardized z scores of the cognitive variables of interest are plotted.

Figure. 2. Mean Loneliness Scores by LPA Profiles



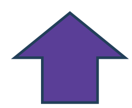
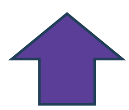
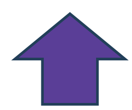
* indicates p<0.05

Figure S1. Difference in loneliness scores comparing diagnostic group with typically developing peers.

	ADHD	ASD	ASD + ADHD
Profile 1 (High-Cog)	Non-Significant Difference	Non-Significant Difference	
Profile 2 (Avg-Cog)	Non-Significant Difference		

Typically developing (TD) peer indicates participants with no reported ADHD nor ASD diagnosis. Upward arrow indicates significantly elevated loneliness score compared to TD peer.

Figure S2. Difference in loneliness scores comparing diagnostic group with typically developing peers.

	ANX	ASD	ASD + ANX
Profile 1 (High-Cog)	Non-Significant Difference	Non-Significant Difference	
Profile 2 (Avg-Cog)	Non-Significant Difference		

Typically developing (TD) peer indicates participants with no reported ADHD nor ASD diagnosis. Upward arrow indicates significantly elevated loneliness score compared to TD peer.

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