

The Network Structure of Positive Youth Development Attributes among Chinese Rural Adolescents

Abstract: Using psychological network analysis (PNA), this study explored the network structure of positive youth development (PYD) attributes of adolescents in rural China. A sample of 2,702 Chinese adolescents (47.7% girls, $M_{age} = 14.72$ year-old) participated in this study and completed the Chinese Positive Youth Development Scale (CPYDS). The study generated three major findings. First, most attributes of PYD were closely inter-related and formed a network structure of PYD. Second, cognitive competence, belief in the future, prosocial involvement, and self-determination were the central attributes, indicating that the four attributes stood out as the primary predictors of other attributes in the network. Third, resilience was an important central attribute in the PYD network of left-behind adolescents. The findings provide empirical support for the network structure of PYD attributes, offering new insights for future PYD interventions and research.

Keywords: Positive youth development, network structure, psychological network analysis, Chinese rural adolescents

Introduction

For a long period, scientific research on adolescent development has regarded adolescents as young people with problems (Qi et al., 2022). This view was challenged in the 1990s by the positive youth development (PYD) perspective (Shek et al., 2019; Lerner et al., 2019). The PYD perspective emphasizes adolescents' talents, strengths, interests, and future potential, shifting the focus away from the problems they may encounter during their development (Damon, 2004; Shek et al., 2012). Catalano and his colleagues (2004) proposed a PYD model including 15 attributes based on a systematic review of PYD intervention projects, including bonding, resilience, social competence, emotional competence, cognitive competence, behavioral competence, moral competence, self-determination, spirituality, self-efficacy, clear and positive identity, beliefs in the future, recognition for positive behavior, and prosocial involvement (Catalano et al., 2004, p.102). The definitions of each attribute are shown in Table S1 for details. Based on Catalano's 15 PYD attributes model, Shek and his colleagues developed PYD measurements in the Chinese context, contributing to the development of localized PYD attributes research in China (Shek et al., 2019; Shek & Dou, 2024; Zhu et al., 2024). Empirical studies on Chinese adolescents also supported Catalano's 15 PYD constructs model in Chinese culture (Shek, 2006a; Shek & Dou, 2024; Zhou et al., 2020). It is noteworthy that the structure of PYD attributes is complex, in that the attributes are numerous and inter-related (Fang et al., 2024). For example, a person with good emotional competence would most likely also be good at developing healthy relationships with family and friends. However, there is lack of research that systematically studies the complex relationship between PYD attributes.

Recent theoretical and methodological advances in network analysis (Borsboom & Cramer, 2013; Bringmann et al., 2022) may provide new perspectives facilitating our understanding of the relationships amongst PYD attributes. Early network analysis in the social science area primarily concentrated on "social network analysis" (SNA), which aimed to understand and analyze complex relationships between individuals (Brass, 2022). SNA visualizes individuals' interactions as networks and expresses them in the form of diagrams, with "nodes" representing individuals and "lines" representing the social relationships between them (Burt et al., 2013). In

contrast, with the expansion of network theory perspectives and developments in graph theory and computer technology, network analysis has been extended to various fields, such as Psychology, Information Science, Computer Science, and Geography (Boutyline & Vaisey, 2017; Fried et al., 2016; Riva et al., 2023; Xia & Ma, 2023). As Borsboom (2017) stated, network analysis offers numerous fields a theoretical framework to organize empirical evidence showing the interconnectedness and co-occurrence of human behavior and perceptions.

The value of network analysis has been demonstrated in several recent studies. Through analyzing the network of adolescent delinquent behaviors, Xia and Ma (2023) found that smoking and drinking were central delinquent behaviors among adolescents, which could further trigger other delinquent behaviors. Hence, prevention of juvenile delinquent behavior may focus on the prevention of smoking and drinking. Another example is the use of a network analysis lens to enhance our understanding of mental disorders by examining both the central symptoms and the co-morbidities between different disorders. Fried et al. (2016) identified that both DSM symptoms, such as sad mood, and non-DSM symptoms, like anxiety, are among the most central symptoms of depression. These studies can provide valuable insights for both theoretical research and clinical practice. Specifically, they can enhance clinical interventions for mental disorders. For instance, identifying central symptoms can assist clinicians to diagnose mental disorders and develop targeted intervention strategies more accurately. Additionally, understanding the comorbidities between different mental disorders can advance research on the etiology of mental disorders and improve intervention approaches (Borsboom, 2017; Cramer et al., 2010). The field of positive psychology can also adopt this strategy by employing network analysis perspective to identify the core factors that contribute to an individual's development and well-being and elucidate the relationships between these factors, thereby enabling the development of more effective intervention strategies. A study using a network perspective identified core nodes of development assets among adolescents, suggesting that school connectedness and agency thinking should be a focus in future interventions (Fang et al., 2024).

In the context of PYD, it is essential to explore the intricate relationships and co-occurrence among various PYD attributes. By identifying the central attributes of PYD, we may identify key targets for intervention. Although the network theory perspective and some empirical evidence suggest that PYD attributes may be a network, more research and empirical evidence are needed to validate this hypothesis. Previous studies mostly used two approaches regarding the structure of PYD constructs. The first is the cumulative approach, which regards different constructs equally and as additive (Zhou et al., 2022). Studies in this approach commonly add the scores together as an indicator of an individual's PYD level. However, the associations between different constructs have been ignored. In another approach, researchers have used structural equation modeling (SEM) to examine complex relationships in theoretical models (Marsh et al., 2014). In the SEM framework, PYD attributes are generally studied as latent variables by confirmatory factor analysis (Zhu et al., 2024). Unfortunately, this prevents us from exhaustively exploring the complex relationships between PYD attributes and the core attributes (Cramer et al., 2010). In contrast, psychological network analysis/ psychometrics network analysis (PNA), a network analysis method applied to psychometric scenarios, could be used to explore the structure and dynamics of psychological nexus (Borsboom et al., 2021; Epskamp, 2020). The PNA presumes that the interactions between variables can be understood as a network, which means the psychological symptoms/behaviors/traits can be regarded as nodes in the network, and causal relationships between them can be represented as the connections between the nodes (Borsboom, 2017). PNA provides a solution to analyze multivariate variables (nodes) by mapping the collections between the variables, and identifying the central nodes in the network (Chen et al., 2024; Liu et al., 2022).

It can be argued that PYD attributes are particularly amenable to psychological network analysis due to their highly intercorrelated nature (Zhou et al., 2022). It is hard to imagine adolescents with high social competence but an inability to build emotional attachment and commitment to social relationships with their family, peers, and community. Besides, extensive empirical evidence indicates that the PYD attributes are a bunch of character

strengths that are highly intercorrelated. For example, moral competence is associated with prosocial involvement (Lin & Shek, 2022), and cognitive competence is related to self-esteem (Catalano et al., 2004). Some studies have demonstrated that spirituality is a crucial source of resilience, providing adolescents with an invaluable asset for coping with adversity and life's challenges (Howard et al., 2023; Koenig, 2010). This multifactorial composition and the causal interconnections among different PYD attributes align with the principles of psychological network analysis, highlighting the complexity inherent in the psychological network of PYD (Borsboom, 2017; Shek, 2023). Finally, there are many studies using network analysis to look at developmental issues (Fang et al., 2024; Kwok et al., 2023; Pereira da Silva et al., 2024).

PYD research has faced criticism for its Western-centric orientation. A large number of PYD research has been conducted in Western, educated, industrialized, rich, and democratic countries (WEIRD), but few studies have been conducted in non-WEIRD areas (Hendriks et al., 2019). An increasing number of researchers recognize the importance of non-WEIRD samples in basic research (Sherman, 2024). Moreover, PYD attributes are significantly influenced by cultural backgrounds, necessitating an understanding of PYD models within diverse cultures (Shek, 2006b; Wiium & Dimitrova, 2019). Most child and adolescent studies based on strengths perspective in China were conducted in economically developed areas, with much fewer research in the rural and resource-limited areas (Zhou et al., 2022). This highlights the need for further research to improve our understanding of PYD in rural China.

The phenomenon of left-behind children in rural China has been extensively discussed in the literature. However, the left-behind children sample lacked representation in the PYD research. To enhance their economic opportunities, the parents of these children migrate to urban areas, leaving the children in the care of other family members, typically their grandparents (Ding et al., 2019). According to the latest statistics, there were 66.93 million left-behind children in China in 2020, of which 41.77 million were in rural areas (National Bureau of Statistics of China et al., 2023). The vast majority of studies have highlighted the challenges faced by left-behind children and indicated that left-behind children, due to a lack of parental care, tended to experience greater neglect (Wen et al., 2021), poorer mental health (Li et al., 2015), and more behavioral problems (Yang et al., 2022). A meta-analysis of 91 studies found that compared to children of non-migrants, left-behind children had a relative higher risk of depression (1.52), anxiety (1.85), suicidal ideation (1.70), substance use (1.24), wasting (1.13), and stunting (1.12) (Fellmeth et al., 2018). However, some studies argued that left-behind children possessed inherent strengths and resilience, which are usually overlooked by current research (Hu, 2019).

The present study

Using a PNA approach, this study examined the following questions with a sample from rural China: (1) What are the characteristics of PYD attributes among rural adolescents? (2) What is the network structure of PYD attributes, and which PYD attributes are core attributes with the highest potential to be linked to other attributes? (3) Are there differences in the network attributes between left-behind children and non-left-behind children?

Methods

Participants and Procedure

Data for this study is derived from the rural version of the Tin Ka Ping P.A.T.H.S. program, a PYD intervention program focused on the development of children and adolescents in rural mainland China (Shek & Dou, 2024). Data for this study were collected from two public middle schools situated in the rural area of China, where this county was classified as impoverished and underdeveloped. In 2022, the county's gross domestic product (GDP) per capita was US\$4,714.98, which remained significantly lower than the GDP per capita of US\$12,572.77 in the city where the county was located. Before data collection, oral and written consent was obtained from both the adolescents and their parents. During the data collection process, students were informed

about the principles of voluntary participation, their right to withdraw, and the assurance of anonymity in data analysis and dissemination. They were also told they could decline participation by leaving the questionnaire blank. Data collection occurred from May 16, 2022, to May 17, 2022, and received ethical approval from the Ethics Committee of the Research Institute of the first author. A total of 38 students chose not to participate. Out of the 2,702 adolescents invited, 47.70% were girls, with an average age of 14.72 years old ($SD = 1.06$), ranging from 13 to 17 years old.

Measures

PYD attributes

Based on Catalano et al.'s (2004) work, Shek and colleagues (2007) developed the Chinese Positive Youth Development Scale (CPYDS) to gauge the 15 positive attributes of Chinese adolescents, such as bonding, resilience, social competence, emotional competence, cognitive competence, behavioral competence, moral competence, self-determination, spirituality, self-efficacy, clear and positive identity, beliefs in the future, recognition for positive behavior, and prosocial involvement. The scale has been widely used to measure the PYD of Chinese adolescents. Numerous studies support the psychometric properties of this scale (Shek et al., 2007; Zhou et al., 2022; Zhu et al., 2024). The CPYDS was used to assess adolescents' self-perceived PYD attributes. Participants rated their perceived PYD attributes on a 6-point scale (1 = strongly disagree to 6 = strongly agree). Sample items included statements like "I know how to communicate with others" (reflecting social competence) and "When I need help, I trust my teachers will assist me" (indicating bonding). The Cronbach's α coefficient for the CPYDS in this study was 0.95, indicating high reliability.

Left behind status

Bureau of Statistics of China identified children with one parent away for six months or longer as left-behind children (National Bureau of Statistics of China et al., 2023). Several research studies on left-behind children in China adopted this definition (Ge et al., 2019; Zhu et al., 2020). Thus, in this study, adolescents whose one parent or both parents are outside the county for over six months within the past year were categorized as left-behind. Otherwise, they were categorized as non-left behind. In the study, there were 1,757 left-behind children and 936 non-left-behind children.

Control Variables

Similar to previous studies (e.g., Xia & Ma, 2023), several demographic and socioeconomic factors were controlled in the analysis. Gender was coded as female or male, and age was measured in years. As "Hukou" is a household registration system in China, "Hukou" status was categorized as agricultural or non-agricultural in this study. The categorization of hukou has to do with the distribution of state-provided socio-economic benefits received by individuals, not their place of residence (Chan & Buckingham, 2008). Additionally, family socioeconomic status was self-rated by asking respondents, "How was your family's economic status?" Responses were recorded on a five-point scale (1 = "very poor" to 5 = "very rich"). Fathers' and mothers' education levels were coded as primary and lower, junior high school, high school, professional training college, and undergraduate and above.

Data Analysis

First, a descriptive analysis was conducted to outline the profiles of participants' characteristics. Next, we employed PNA to analyze the network structure of PYD attributes. PNA offers a novel method for analyzing relationships between variables (Shek, 2023), capable of exploring co-morbidity among mental health issues, identifying central structures or behaviors within a network, pinpointing bridging symptoms and behaviors, and

comparing edges in different networks (Xia & Ma, 2023). Specifically, we used the R package *BGGM* to construct the Bayesian Gaussian Graph Model (BGGM) using non-regularized algorithms that could overcome limitations to estimate edges' standard errors or confidence intervals in low dimensional setting, where the sample size exceeds the number of variables (Xia & Ma, 2023). The BGGMs were estimated using Bayesian statistics, with a novel matrix-F prior distribution set at a scale of 0.50 and 5,000 posterior samples (Williams et al., 2020). In the BGGM, all key variables were represented as nodes, and partial correlations among variables were represented as edges, with thicker edges indicating higher correlations.

Finally, centrality analysis was conducted to identify the most central PYD attributes. Strength centrality measures were adopted, which can reflect the ability of a certain node to predict other nodes in the network and similar to degree centrality in SNA (Borsboom et al., 2021; Xia & Ma, 2023).

Results

Characteristics of PYD attributes among rural adolescents

[Table 1]

The descriptive statistics in Table 1 provide an overview of the socio-demographic profile and PYD attributes of the sample. Results showed that the majority of the adolescents (94.92%) had an agricultural Hukou. Regarding self-rated family socioeconomic status, 70.69% of participants categorized their family's economic position as medium, while only a small percentage rated their status as very poor (4.51%) or very rich (0.41%). Most parents of the adolescents had no education beyond high school, with 56.74% of mothers and 49.72% of fathers having only primary education or less.

PYD attributes assessed by the CPYDS showed an average score of 4.480 (SD=0.69). This suggests a relatively high level of perceived PYD attributes among adolescents. The highest average score was observed in "bonding" (M=5.00, SD=0.89), followed closely by "prosocial norms" (M=4.99, SD=0.83). The lowest average score was in "clear and positive identity" (M=3.94, SD=1.10).

A comparison between left-behind and non-left-behind children revealed that the mean values of PYD attributes were significantly lower for left-behind children ($t=2.32$, $p < 0.05$, Cohen's $d = 0.09$), but the effect size was small. Although half of the fifteen PYD attributes were significantly lower in left-behind children compared to non-left-behind children, the effect sizes were small and the remaining attributes showed no significant difference. Furthermore, the standard deviations of PYD attributes were larger among left-behind children compared to their non-left-behind counterparts, indicating a greater variability in PYD attributes within the group of left-behind children.

The network structure of PYD

Figure 1 presents the results of the PNA of the PYD attributes in the total sample, with the network models controlled for demographic and socioeconomic variables. Regression model results for each node within the network are reported in Table S2, and the coefficients for each edge are presented in Table S3. Figure 2 illustrates the node strength of the network model in the total sample, with detailed information on the value of node strength for PYD attributes available in Table S4. For clarity, only posterior distributions of estimated partial correlations significant at the 99% credible interval were retained for further discussion.

[Figure 1]

As shown in Figure 1, fifteen PYD attributes were significantly intercorrelated after controlling for socio-demographic variables. Out of 105 edges, 84 were positive (80%), and 21 were negative. The absence of a single central attribute among PYD attributes suggests a multicenter structure, indicating that PYD attributes form a

network. The three strongest associations were found from “clear and positive identity” (CPI) to “beliefs in the future” (BF, coefficient= 0.40), from “bonding” (Bo) to “recognition for positive behavior” (RPB, coefficient= 0.38), and from “cognitive competence” (CC) to “behavioral competence” (BC, coefficient=0.35). The negative correlations are unexpected, which require further considerations.

[Figure 2]

Further centrality analysis was conducted to identify the central attributes within the PYD network in the total sample. Figure 2 and Table S4 reveal that “cognitive competence” (CC, node strength= 1.19) had the highest strength value, suggesting it is the most central PYD attribute with the highest potential to predict other PYD attributes. The centrality analysis also showed that “belief in the future” (BF, node strength= 1.19), “prosocial involvement” (PI, node strength= 1.14), and “self-determination” (SD, node strength= 1.11) had strength values close to that of CC, indicating that these attributes could also be central in connecting other PYD attributes.

Differences between left-behind and non-left-behind children

Figure 3 presents the results of the PNA of the PYD attributes in the left-behind sample (Figure 3a) and non-left-behind sample (Figure 3b). Regression model results for each node within the network are reported in Table S5 and S8, and the coefficients for each edge are presented in Table S6 and S9. Figure 4 illustrates the node strength of the network model in the left-behind sample (Figure 4a) and non-left-behind sample (Figure 4b), with detailed information on the value of node strength for PYD attributes presented in Table S7 and S10. For clarity, only posterior distributions of estimated partial correlations significant at the 99% credible interval were retained for further discussion.

[Figure 3]

Consistent with the total sample, in both left-behind and non-left-behind participants, the three strongest associations were found from “clear and positive identity” (CPI) to “beliefs in the future” (BF), from “bonding” (Bo) to “recognition for positive behavior” (RPB), and from “cognitive competence” (CC) to “behavioral competence” (BC). These associations are illustrated in Figure 3, Table S6, and Table S9, indicating that there are similarities across the three networks.

[Figure 4]

Results based on centrality analysis revealed distinct differences in the core attributes of PYD between left-behind and non-left-behind children, as illustrated in Figure 4 and detailed in Tables S7 and S10. Among left-behind children, the attributes with the highest node strength values were “self-determination” (SD, node strength = 1.21), “resilience” (Re, node strength = 1.19), and “cognitive competence” (CC, node strength = 1.15). In contrast, for non-left-behind children, the attributes with the greatest node strength were “clear and positive identity” (CPI, node strength = 1.10), “belief in the future” (BF, node strength = 1.09), and “self-determination” (SD, node strength = 0.86). The finding underscores the variability in PYD attributes depending on the situation of adolescents, highlighting resilience as the core PYD attribute associated with being left behind.

Discussion

In this study, we argue that to better understand PYD attributes, it is essential to examine their interrelationships as a network because traditional research methods based on global scores are inadequate to provide a comprehensive picture of these relationships. Hence, this study adopted a network analysis (PNA method) perspective to investigate whether PYD attributes form a network and to identify which attributes serve as core components within this network.

The study identified two primary characteristics of PYD attributes among rural Chinese adolescents. Firstly, it was observed that these adolescents exhibited lower “clear and positive identity” compared to other PYD attributes. This finding underscores the necessity for implementing PYD intervention programs specifically tailored to rural Chinese adolescents to promote their self-identity because related programs have demonstrated effectiveness in enhancing PYD attributes, thereby reducing the risk of mental health issues and decreasing behavioral problems (Shek & Dou, 2024). Secondly, the PYD attributes of left-behind children were found to be slightly lower than those of non-left-behind children, with internal differentiation observed among the former group. Although left-behind children encounter more challenges and exhibit more developmental problems (Zhao et al., 2018; Zhuang & Wu, 2024), the small effect size values suggest that the difference in some PYD attributes between left-behind and non-left-behind children is not substantial. This finding suggests that left-behind children may possess the same positive developmental potential as their non-left-behind counterparts. Consequently, it implies that left-behind children may mitigate developmental barriers associated with parent-child separation through targeted PYD intervention programs.

The current findings suggest that as we hypothesized, there is a very tight and complex relationship between PYD attributes, meaning that PYD attributes form a network and the PYD attributes have strong correlations. These results underscore the importance of elucidating and emphasizing the relationships among PYD attributes in the PYD model. Furthermore, it is essential to recognize the strong correlations between PYD attributes in both intervention research and practice. When investigating the mechanisms of intervention, particular attention should be paid to the dynamic processes of change within PYD attributes and how their interrelationships influence intervention outcomes. These insights are critical for designing more effective intervention programs.

Nevertheless, while the vast majority of attributes are positively correlated with each other, there were some negative correlations, such as belief in the future and bonding. Since the study uses cross-sectional data for network analysis, the relationships between these concepts are primarily correlational rather than causal. Adolescents may excel in bonding (such as over-parenting of parents) while having low belief in the future (loss of autonomy under over-parenting). In other words, as suggested by the descriptive statistics, the adolescents in the sample are not achieving holistic development. This implies that PYD intervention programs are very important for Chinese rural adolescents (Zhou et al., 2022).

Besides, PYD attributes constitute a multicenter network, indicating that the core attributes of PYD attributes are not unique, but there are multiple core attributes. This suggests that PYD is multifaceted and can be intervened through multiple pathways, which is consistent with previous theoretical models and intervention research (Shek et al., 2019; Shek & Dou, 2024). PYD has garnered significant attention because it is a practice-oriented field that necessitates the development and implementation of effective interventions (Catalano et al., 2004; Ciocanel et al., 2017; Curran & Wexler, 2017; Durlak et al., 2011). Many intervention programs conduct pre-intervention surveys to gather information relevant to their focus and tailor the program accordingly (Zhuang & Wu, 2024). Interventions often focus on PYD attributes where participants perform poorly as shown by lower assessment scores. The mechanisms through which intervention programs influence PYD attributes are complex, and the aforementioned approach overlooks the correlations and interactions among these attributes. The study’s findings offer innovative approaches for analyzing pre-intervention survey data. Instead of merely focusing on the mean and standard deviation of PYD attributes, we can employ network analysis to gain insights into the network structure of these attributes among the intervention subjects as well as their changes.

Centrality analysis suggests that cognitive competence had the highest strength value, followed by belief in the future, prosocial involvement, and self-determination, indicating that these attributes were core attributes. The finding signals the importance of cognitive competence, belief in the future, prosocial involvement, and self-determination in the PYD attributes network. Cognitive competence has a profound impact on adolescents’

emotional and social development (Rodríguez-Negro et al., 2024) and is closely related to academic and future career achievement (Wallace & Russ, 2015). Especially in the era of highly developed artificial intelligence and information flooding, adolescents must have adequate cognitive competence to safeguard their positive development (McStay & Rosner, 2021). Beliefs in the future as an important psychological strength in adolescence are often thought to help individuals adapt to adversity (Ling et al., 2016). Compared with Chinese urban adolescents, rural adolescents face more difficulties in their growing up process, such as economic disadvantage, parent-child separation, and bullying in schools (Wen & Lin, 2012; Zhang et al., 2019), so it is particularly important to promote their belief in the future (Catalano et al., 2004). Social learning theory posits that adolescent behavior is largely shaped by environmental influences. Participation in socially sanctioned activities enables adolescents to receive praise and attention, fostering self-fulfillment (Lam, 2012). Evidence from several studies suggests that self-determination can help promote self-regulation, academic achievement, and well-being (Hui & Tsang, 2012), which are particularly important for Chinese adolescents and can influence parental feedback, as most Chinese parents hope their children can have a bright future (Lu et al., 2021).

Within the SEM framework, recent scholarly investigations have employed confirmatory factor analysis to delineate four higher-order factors of PYD attributes: cognitive behavioral competence, prosocial attribute, positive identity, and general PYD attributes (Shek & Ma, 2010; Zhu et al., 2024). The findings from centrality analysis demonstrate partial congruence with these higher-order factors, thereby substantiating their validity through the lens of network analysis. While confirmatory factor analysis contributes to the conceptualization of PYD primarily through a taxonomic approach, akin to Benson's classification of 40 developmental assets into internal and external categories (Benson et al., 2011), network analysis represents a significant methodological advancement. This approach transcends traditional analytical paradigms by elucidating the functional significance of specific attributes, thereby offering a more nuanced understanding of PYD constructs. We can use core constructs to facilitate changes across the network (Xia & Ma, 2023). Unfortunately, this has rarely been addressed in previous theoretical models and research of PYD. These empirical insights carry implications for PYD intervention strategies. Future programs, particularly those grounded in Catalano's 15 PYD constructs, should emphasize the identification and prioritization of core attributes, with particular attention to implementing targeted interventions. Special attention should be given to fostering adolescents' cognitive competence, belief in the future, prosocial involvement, and self-determination in the rural China context. These attributes may contribute to the overall effectiveness of the intervention.

Results based on centrality analysis also revealed distinct characteristics in the PYD attributes network of left-behind adolescents relative to non-left-behind children. Notably, the study highlights that resilience plays a particularly crucial role for left-behind adolescents in contrast to their non-left-behind counterparts. Resilience is composed of internal and external protective factors. Internal protective factors are intrinsic qualities that contribute to an individual's resilience, such as optimism, a sense of control, self-efficacy, a sense of humor, altruistic beliefs, and effective conflict management skills. External protective factors pertain to the supportive relationships and social networks that bolster resilience. These include maintaining positive relationships with parents, family, friends, and the community (Richardson, 2002). Parent-child separation can significantly undermine the external protective factors that contribute to adolescent resilience. A meta-analysis conducted on Chinese rural adolescents revealed that left-behind children exhibit notably lower levels of resilience compared to their non-left-behind counterparts (Dong et al., 2019). However, some studies suggest that a positive perception of parents' motives for working away from home can serve as a crucial protective factor for the resilience of left-behind adolescents. These adolescents were more resilient to navigate difficulties and challenges (Hu, 2019). In other words, bonding with parents is crucial for left-behind children, despite their parents' absence, highlighting the interconnectedness of PYD attributes. This is clearly shown in the diaries written by the students (Shek, 2024).

The current study generates several important research directions. Firstly, based on the Ecological Model, the development of an adolescent is closely related to the multiple environments in which he or she lives, such as the family, the community, and the school (Lai et al., 2015; Shek, 2006a; Shek et al., 2019). We can use a network analysis approach to examine the impact of adolescents' multiple life circumstances on the PYD attributes network and what factors bridge the gap between the two networks. Secondly, PYD attributes are protective factors against mental illness and problem behaviors in adolescents (Milot Travers & Mahalik, 2021). For example, longitudinal studies have shown that PYD attributes are effective in reducing depression among Chinese adolescents (Zhou et al., 2020). The process of influencing PYD attributes to reduce mental problems and problem behaviors has been consistently validated through traditional methods. Network analysis can better help us understand this process and facilitate the development of related intervention studies. Besides, the findings of this study are primarily exploratory, and network intervention researches are needed to clarify the pathways and dynamics of intervening PYD attributes (Fishbein et al., 2023).

Although the present study provides innovative insights into PYD attributes from the perspective of network theory, it has several limitations. The first limitation is that the participants in the present study were recruited from rural areas in Southwestern China, participants from different social and economic backgrounds should be included in the future to examine the generalizability of the findings in the present study (Wiium & Dimitrova, 2019). Second, the present study only included PYD attributes in the network, the link with other variables could also be examined in the future. Third, this study primarily relies on Catalano's 15 PYD constructs theoretical model without addressing other PYD models like Benson's 40 developmental assets, Lerner's 5Cs and 6Cs models (Lerner et al., 2005; Lerner et al., 2019), or Social Emotional Learning (Durlak et al., 2011). Future research should explore the network relationship of PYD attributes within these alternative theoretical frameworks. Fourth, as the present study is a cross-sectional study, the key dynamical properties of PYD attributes networks still need further examination (Finnemann et al., 2024). Compared with the cross-sectional survey used in the current study, longitudinal research should be employed to investigate the dynamic change of PYD attributes. Last but not least, the small effect size of the difference in PYD attributes between left-behind and non-left-behind children, combined with the large sample size of this study, suggests that there may not be a significant difference in PYD attributes between the two groups. Future research should focus on studying and intervening with left-behind children from the PYD perspective, emphasizing their strengths and potential, rather than solely emphasizing their "deficits".

Taken together, the results of the current study highlight the complexity of the PYD nexus, which may once again suggest the inadequacy of using traditional methods to understand the nexus. The complexity requires sophisticated methods that move forward and beyond linear relations. With the new development of network science, network-based approaches such as PNA allow researchers to embrace this complexity and have the potential to stimulate both theoretical and empirical efforts in future studies.

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Table 1 Descriptive Statistics

Variable	Category/Indicator	Total	Left-behind	Non-left-behind	T/ χ^2	Effect size
Bonding	Mean	5.00	4.78	4.84	1.48	0.06
	SD	0.89	0.91	0.83		
Resilience	Mean	4.64	4.62	4.69	2.00*	0.08
	SD	0.96	0.99	0.90		
Social Competence	Mean	4.38	4.38	4.39	0.06	0.00
	SD	1.08	1.10	1.06		
Recognition for Positive Behavior	Mean	4.41	4.41	4.45	0.83	0.03
	SD	1.01	1.04	0.96		
Emotional Competence	Mean	4.45	4.45	4.46	0.08	0.00
	SD	0.89	0.90	0.88		
Cognitive Competence	Mean	4.50	4.48	4.53	1.34	0.05
	SD	0.89	0.90	0.85		
Behavioral Competence	Mean	4.61	4.59	4.67	2.38*	0.09
	SD	0.84	0.87	0.78		
Moral Competence	Mean	4.40	4.38	4.44	1.90	0.08
	SD	0.85	0.86	0.81		
Self-Determination	Mean	4.39	4.35	4.46	3.00*	0.12
	SD	0.96	0.97	0.92		
Self-Efficacy	Mean	4.41	4.39	4.46	1.98*	0.08
	SD	0.97	0.99	0.93		
Clear and Positive Identity	Mean	3.94	3.90	4.04	3.07*	0.12
	SD	1.10	1.11	1.03		
Beliefs in the Future	Mean	4.38	4.34	4.48	3.29*	0.13
	SD	1.10	1.11	1.03		
Prosocial Involvement	Mean	4.55	4.53	4.58	1.25	0.05
	SD	0.97	0.97	0.97		
Prosocial Norms	Mean	4.99	4.98	5.02	1.19	0.05
	SD	0.83	0.86	0.76		
Spirituality	Mean	4.31	4.31	4.39	2.31*	0.09
	SD	1.23	1.24	1.21		
PYD Attribute	Mean	4.480	4.461	4.525	2.32*	0.09
	SD	0.694	0.707	0.661		
Hukou	Agricultural	2481 (94.95%)	1589 (95.37%)	852 (94.04%)	1.91	0.03
	Non-agricultural	132 (5.05%)	77 (4.62%)	54 (5.96%)		
Father's Education	Primary and Lower	1351 (49.72%)	862 (49.37%)	462 (49.95%)	11.17*	0.07
	Junior High	1186	774	396 (42.81%)		

	School	(43.65%)	(44.33%)			
	High School	153 (5.63%)	92 (5.27%)	59 (6.38%)		
	Professional Training College	14 (0.52%)	6 (0.34%)	8 (0.86%)		
	Undergraduate and above	13 (0.48%)	12 (0.69%)	0 (0.00%)		
Mother's Education	Primary and Lower	1511 (56.74%)	951 (55.36%)	536 (59.23%)	10.02 *	0.06
	Junior High School	990 (37.18%)	644 (37.49%)	330 (36.46%)		
	High School	128 (4.81%)	97 (5.65%)	31 (3.43%)		
	Professional Training College	13 (0.49%)	9 (0.52%)	4 (0.44%)		
	Undergraduate and above	21 (0.79%)	17 (0.99%)	4 (0.44%)		
Self-rated Family Socioeconomic Status	Very Poor	122 (4.50%)	61 (3.52%)	56 (6.02%)	12.81 *	0.07
	Poor	602 (22.21%)	372 (21.44%)	219 (23.55%)		
	Medium	1918 (70.75%)	1259 (72.56%)	629 (67.63%)		
	Rich	58 (2.14%)	35 (2.02%)	23 (2.47%)		
	Very Rich	11 (0.41%)	8 (0.46%)	3 (0.32%)		

Note: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. Cohen's d and Cramer's V /Phi coefficient were used to calculate effect size.

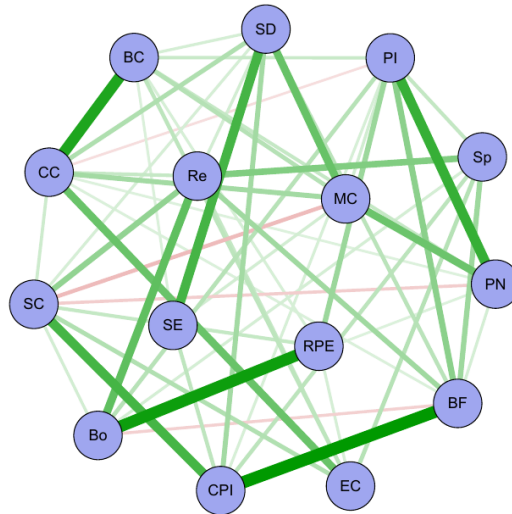


Figure 1 Network estimations for PYD attributes in total sample. Green edges denote positive partial correlations and red edges denote negative partial correlations. Thicker edges denote a higher partial correlation between two nodes after controlling other variables. Only partial correlations with 99% confidence intervals lower or higher than zero were summarized in the network estimations. The meaning of each node could be identified as follows: Bo (“Bonding”); Re (“Resilience”); SC (“Social Competence”); RPE (“Recognition for Positive Behavior”); EC (“Emotional Competence”); CC (“Cognitive Competence”); BC (“Behavioral Competence”); MC (“Moral Competence”); SD (“Self-Determination”); SE (“Self-Efficacy”); CPI (“Clear and Positive Identity”); BF (“Beliefs in the Future”); PI (“Prosocial Involvement”); PN (“Prosocial Norms”); Sp (“Spirituality”).

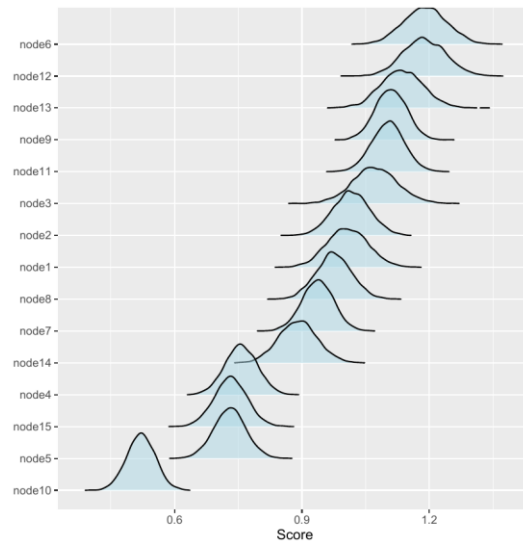
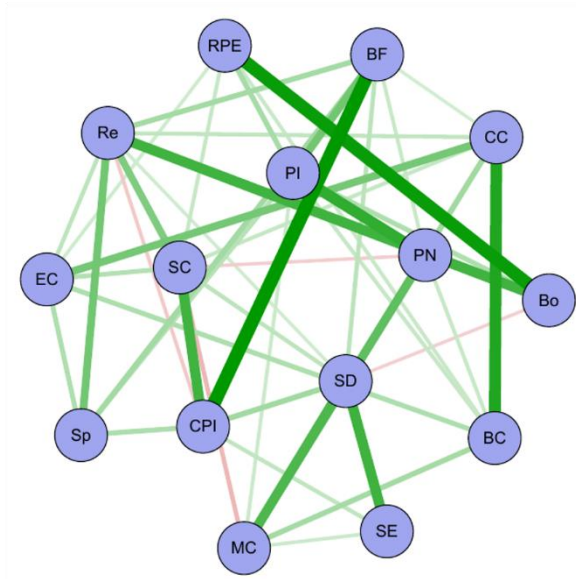


Figure 2 Results for node strength along with a 99% credible interval in the total sample. Numbers of each node could be identified as following: node1 (“Bonding”); node2 (“Resilience”); node3 (“Social Competence”); node4 (“Recognition for Positive Behavior”); node5 (“Emotional Competence”); node6 (“Cognitive Competence”); node7 (“Behavioral Competence”); node8 (“Moral Competence”); node9 (“Self-Determination”); node10 (“Self-Efficacy”); node11 (“Clear and Positive Identity”); node12 (“Beliefs in the Future”); node13 (“Prosocial Involvement”); node14 (“Prosocial Norms”); node15 (“Spirituality”).

(a) Left-behind



(b) Non- Left-behind

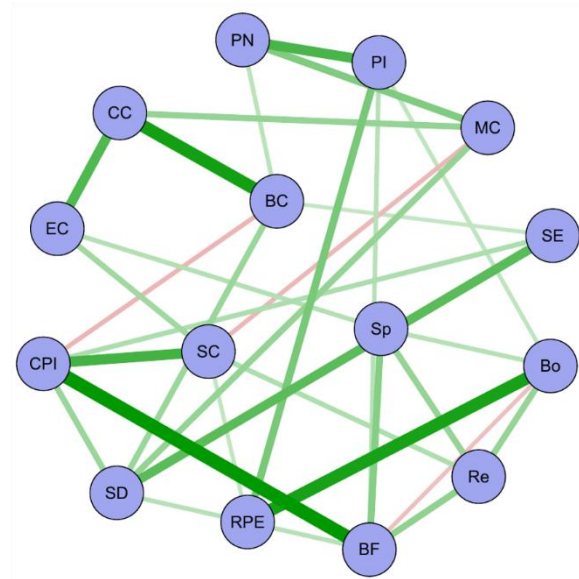


Figure 3 Network estimations for PYD attributes in left-behind and non-left-behind samples. Green edges denote positive partial correlations and red edges denote negative partial correlations. Thicker edges denote a higher partial correlation between two nodes after controlling other variables. Only partial correlations with 99% confidence intervals lower or higher than zero were summarized in the network estimations. The meaning of each node could be identified as follows: Bo (“Bonding”); Re (“Resilience”); SC (“Social Competence”); RPE (“Recognition for Positive Behavior”); EC (“Emotional Competence”); CC (“Cognitive Competence”); BC (“Behavioral Competence”); MC (“Moral Competence”); SD (“Self-Determination”); SE (“Self-Efficacy”); CPI (“Clear and Positive Identity”); BF (“Beliefs in the Future”); PI (“Prosocial Involvement”); PN (“Prosocial Norms”); Sp (“Spirituality”).

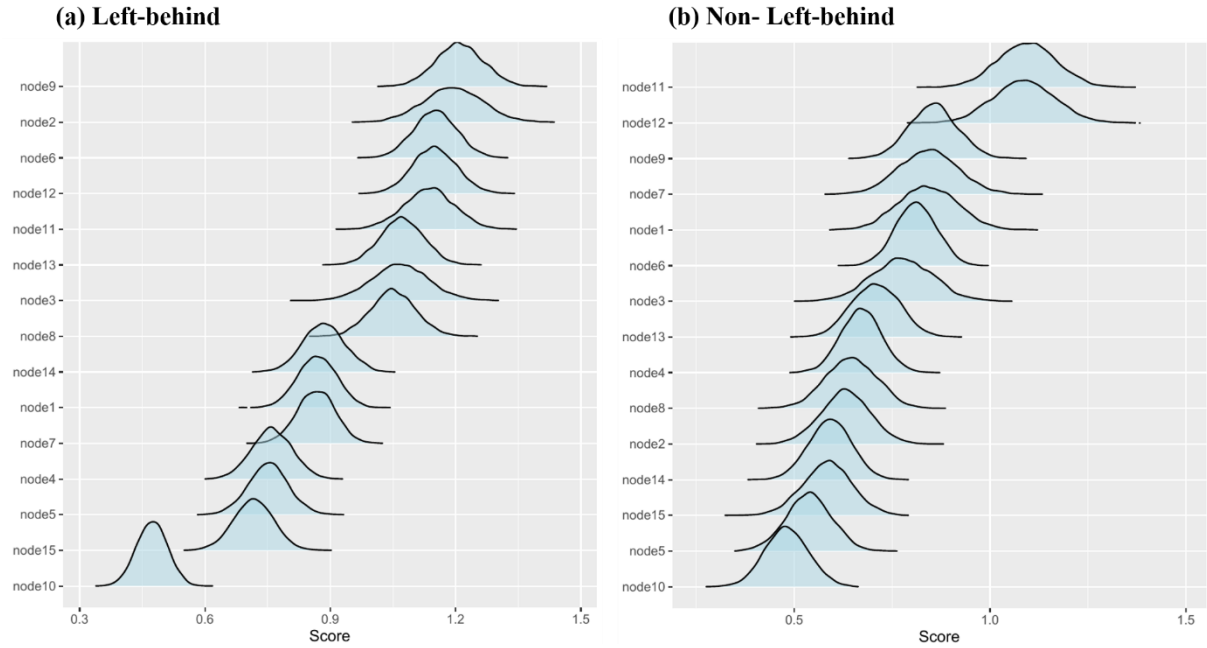


Figure 4 Results for node strength along with a 99% credible interval in left-behind and non-left-behind samples. Numbers of each node could be identified as following: node1 (“Bonding”); node2 (“Resilience”); node3 (“Social Competence”); node4 (“Recognition for Positive Behavior”); node5 (“Emotional Competence”); node6 (“Cognitive Competence”); node7 (“Behavioral Competence”); node8 (“Moral Competence”); node9 (“Self-Determination”); node10 (“Self-Efficacy”); node11 (“Clear and Positive Identity”); node12 (“Beliefs in the Future”); node13 (“Prosocial Involvement”); node14 (“Prosocial Norms”); node15 (“Spirituality”).