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Trait and state of grit among middle school students in South Korea: the influence of peer, teacher, and parental variables

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Abstract
Psychological constructs encompass both stable traits and unstable state factors. This study investigates the stability of grit subfactors among middle school students, focusing on those experiencing poor developmental-stage-environment fit. Utilizing the trait-state-occasion (TSO) model, we delineate the consistency of interest (CI) level and perseverance of effort (PE) characteristics and statuses. Moreover, we introduce variables concerning peer, teacher, and parental relationships, recognized as significant influences on middle school students' development. Data from 2,380 middle school students from the Korean Children and Youth Panel Survey 2018 are analyzed. Results indicate that both CI and PE exhibit stable traits influenced by time-invariant characteristics. Additionally, CI and PE encompass both stable and changeable state aspects. Teacher relationships and parental autonomy support positively impact the trait and state of CI and PE, while peer relationships have a negative effect on CI and a positive effect on PE at specific state points. Our findings underscore the stability yet malleability of grit subfactors, with both CI and PE demonstrating nuanced responses to environmental influences. Our study also identified the positive impact of teacher relationships and parental autonomy support on both CI and PE trait and state, highlighting the important role of a supportive environment in fostering grit.

Keywords Grit, Middle school students, Trait-state-occasion model, Peer relationship, Teacher relationships, Parental autonomy support

Introduction

Grit, which refers to perseverance and passion for achieving long-term goals [1], encompasses two distinct subfactors, consistency of interest (CI) and perseverance of effort (PE) [2]. Although the differential impact of these two subfactors is debated, grit is generally recognized as a positive predictor of cognitive and affective domains such as academic achievement [3, 4], self-regulation [5], and well-being [6]. Initially conceptualized as a trait by [1], state-level variations in grit are increasingly recognized, suggesting the importance of considering both trait and state dimensions. Additionally [7], argued that state-level grit can vary among individuals in studies using the diary method [3] emphasizing the significance of state factors alongside trait factors. Furthermore, psychological constructs typically encompass both time-invariant and stable traits and time-variant and unstable state factors [8, 9], suggesting the necessity of integrating trait and state dimensions of grit rather than dichotomizing them. Therefore, in this study, we apply the trait-state-occasion (TSO) model [10, 11] capable of integrating trait and state levels, to identify the trait and state levels

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of grit subfactors. This approach lays the foundation for designing and applying effective educational methods to improve students' grit.

Prior research on grit stability falls into two primary categories. First, grit stability has been assessed through mean changes in the general population [12] or autoregressive coefficients [3, 7, 13–15], with most studies employing this method. Second [16], analyzed the factors influencing CI and PE, the subfactors of grit, categorizing them into genetic, shared environmental, and nonshared environmental factors utilizing the twin method with an average of 16-year-old twin children in the United Kingdom. Their results indicated that the proportion of nonshared environmental factors was high in both subfactors, with the genetic factor of PE being relatively higher than CI. This suggests that CI and PE encompass both traits and states, indicating potential differential levels of traits and states within CI and PE.

To summarize these studies, first, except for [16], most studies explored grit stability using the autoregressive coefficient, which has methodological limitations in clearly delineating grit's trait and state levels. Notably [7], found lower changes over a five-day period compared to studies with a time interval of more than six months [13, 17], suggesting grit's variability depending on environmental circumstances while maintaining stable characteristics. However, previous studies often overlooked these nuances. Second, although grit subfactors have distinct functions [18], all but a few studies [16, 19] have explored grit stability as a unified construct. While the factor structure of grit is controversial [20–22], considering it as a composite of two different but related subfactors directed toward long-term goals is essential for a comprehensive understanding [2]. Thus, analyzing both subfactors, not just grit as a whole, is crucial. Third, except for [13], most studies examining grit stability have focused on elementary school students or adults, neglecting middle school students. Middle school represents a developmental mismatch, marked by increasing desires for independence and autonomy amid a more competitive and controlling educational environment. In the stage-environment fit approach [23], referred to the middle school period as a poor developmental-stage-environment fit [24], which may affect students' motivation, family and teacher relationships, and the characteristics and status of grit, a non-cognitive domain. In particular, during the middle school years in Korea, 47.3% of students are worried about their academics [25], indicating that academic stress is high. And, in response to the lack of opportunities to develop long-term interest in their vocations and studies, the Free Semester System has provided students with opportunities to explore long-term goals, such as their future careers, since 2015. In other words, middle school students in Korea are at a stage where they need to sustain their interest and passion to achieve their vocational and academic goals [26]. It is also important to pay attention to the affective domain of middle school students, given that, in the Korean educational context, affective factors such as classroom attitudes and academic efficacy tend to decline from elementary to middle school [27]. Therefore, this study aims to identify the characteristics and status of grit among middle school students who experience differences in developmental stage and actual environment.

Humans inherently seek to cultivate positive and enduring interpersonal relationships [28] with relatedness considered a basic psychological need within the framework of self-determination theory [29]. Additionally, grit is influenced by our interactions with individuals and our surrounding environments, including parental and teacher influences [30]. Therefore, this study aims to examine how relationships with friends, teachers, and parents—the most significant figures for middle school students both in school and at home—impact both the trait and state of grit.

First, successful peer relationships in adolescence promote optimal psychological and social functioning [31] and help foster competence in the social domain [32]. Prior research has demonstrated that peer relationships in adolescence significantly impact grit levels during adolescence [33, 34].

For adolescent students, the relationship with their teachers is pivotal for their academic success [35], acting as a protective factor against underachievement [36], enhancing academic engagement [28], and facilitating school adjustment [37]. Previous studies have indicated a positive effect of teacher-student relationships on grit [17, 38]. Moreover, although students spend less time with their parents during middle school because of increased school commitments, parental influence remains significant [39]. Autonomy support from parents, acknowledging children's independence and respecting their choices [40], profoundly influences adolescents' cognitive [41] and definitional domains [42], rendering it as one of the most important variables explaining the parent-child relationship. Prior research has illustrated a static relationship between parental autonomy support and grit [43].

In summary, this study aims to identify the trait and state levels of CI and PE, the subfactors of grit, in middle school students with poor developmental-stage-environment fit [24]. Drawing on the understanding that all psychological constructs encompass both traits and states [8, 9], we apply the TSO model [10, 11] to analyze the trait and state levels of CI and PE. Based on the Latent State–Trait Theory [44], this model allows for the simultaneous estimation of trait and state proportions. Additionally, recognizing the fundamental human need for relatedness

[28, 29], we examine the influence of peer, teacher, and parent variables—important relationships for middle school students—on the traits and states of the two subfactors of grit. This comprehensive approach aims to identify the levels of grit traits and states among middle school students informing targeted educational interventions and environmental strategies to foster positive grit formation. The research questions guiding this investigation are as follows:

Research Question 1. What are the characteristics and status levels of the grit subfactors in middle school students?

Research Question 2. What are the effects of peer, teacher, and parent-related variables on the characteristics and status levels of the grit subfactors in middle school students?

Theoretical background

Grit stability

Grit is widely recognized as a personality trait variable [1]. However [45], argued that environmental factors significantly influence personality development, suggesting that grit can also be influenced by the environment [46]. From this perspective, studies that have examined the stability of grit can be divided into two main categories. First, studies that apply statistical analysis methods such as mean change, autoregressive coefficient, and latent growth curve model to examine grit stability in general individuals. For instance [12], investigated changes in latent mean over a time interval of more than one year in adults, observing an increase in the PE level, whereas CI remained stable at waves 1 and 2, and then increased at wave 3 [47]. analyzed weekly changes in grit among high school students, noting dynamic changes in both subcomponents of grit, with CI peaking approximately two months after PE.

A closer look at grit stability studies employing autoregressive coefficients indicates that [48] evaluated grit stability across 3 waves at 4-month intervals for elementary school students in the United States, reporting autoregressive coefficients ranging from 0.64 to 0.70. Similarly [15], measured grit stability across 2 waves per grade from 4th to 6th grade and 6 waves in total for elementary school students in China, with autoregressive coefficients ranging from 0.09 to 0.41, increasing with grade levels. Meanwhile [13], analyzed grit stability in middle school students in the United States across 4 waves at 6-month intervals, finding autoregressive coefficients of 0.59 to 0.72. In a study by [17] involving Chinese high school students in an English as a foreign language context, grit stability was assessed across 3 waves at 1-year intervals, yielding autoregressive coefficients of 0.41 to 0.50. Conversely [7], investigated 5-day changes in college students' grit, revealing an autoregressive coefficient of 0.23. Furthermore [14], examined the stability of domain-specific academic grit among Spanish fourth graders, reporting an autoregressive coefficient of 0.481 across 4-year intervals and 2 waves. In summary, except for [13], most studies have focused on elementary school or college students, overlooking middle school students, a phase characterized by poor developmental-stage-environment fit [24].

By contrast, some studies have analyzed latent growth curve models. For example [49], estimated the change in PE at five points in time for Japanese high school students, demonstrating that those with higher PE levels were more likely to exhibit an inverted U-shaped growth trajectory [50]. used a longitudinal confirmatory analysis-curve of factors model to assess language-domain-specific grit, finding relatively more significant changes among students with lower grit levels. Similarly [16], utilized the twin method to examine grit among 16-year-old twins in the United Kingdom, revealing that CI, a subfactor of grit, was 20% genetic, 5% shared environmental, and 75% nonshared environmental, while PE was 37% genetic and 63% nonshared environmental. In summary, these studies highlight the stable and time-invariant nature of grit, alongside its time-variant and context-dependent aspects. However, except for twin studies [16], limitations exist in precisely identifying the levels of trait and state of grit.

Association between grit and peer relationships, teacher relationships, and parental support for autonomy

In line with self-system processes [51], which denote enduring personal resources individuals develop through interactions with social contexts, relationships significantly influence individual behavior and are central to basic psychological needs [29]. Additionally, according to dynamic interactionism [52], individual development is related to the quality of important social relationships alongside personality and environment. From this perspective, examining the influence of peer, teacher, and parent-related variables—important social contexts surrounding students—on the traits and states of grit subfactors, is vital for shaping future educational strategies to promote grit.

Initially, during adolescence, peer relationships foster optimal psychological and social functioning, nurturing social competence [31–33]. profiled early adolescent students in China using the two grit subfactors, finding significantly higher levels of peer relationships among those with elevated levels of both subfactors, particularly PE [34]. investigated the impact of peer relationships on grit among Korean elementary school students, revealing a significant positive effect regardless of the relationship level with the teacher. Meanwhile [53], examined the relationship between peer attachment and grit among

college students, reporting a significant positive effect. These results suggest that peer relationships play a positive role in grit, although given [33] findings, the two subfactors may exhibit differential results.

Subsequently, adolescent students' relationships with teachers also significantly influence their academic journey [35, 36]. In a longitudinal study of Chinese high school students in an English language arts context [17], relationships with teachers exhibited notable effects on grit. Given these results, we expect that relationships with teachers positively affect both grit subfactors.

Finally [43], analyzed the relationship between parental autonomy support and grit among college students, observing that parental autonomy support positively influenced grit [54]. explored the effect of parenting style on grit among college students, finding that overparenting (i.e., excessive behavioral or psychological control such as helicopter parenting) adversely impacted grit, whereas parental acceptance/involvement, which can be considered a positive style, had a positive effect. Meanwhile [38], scrutinized the effects of peer, teacher, and parental relationships on grit among Filipino high school students using hierarchical regression analysis, indicating significant effects of teacher relationships on CI, PE, and overall grit, while parental relationships significantly affected CI and overall grit, with friendships exhibiting no significant effect.

In summary, barring a few exceptions, existing research demonstrates teacher relationships and parental autonomy support have an overall positive effect on grit, whereas friendship has mixed results. However, despite the potential differential functions of grit subfactors [18], aside from a few studies [33, 38], attention to grit subfactors' individual impacts on grit characteristics and states is lacking. Furthermore, only a limited number of studies have explored the three most important players in a student's social context—friends, teachers, and parents—as grit predictors.

Materials and methods

Participants

To investigate the longitudinal stability of grit subfactors among Korean middle school students and assess the influence of student, teacher, and parental variables on this stability, this study utilizes data from the first (2018, Year 1), second (2019, Year 2), and third (2020, Year 3) waves of the Korean Children and Youth Panel Survey 2018 (KCYPS 2018) conducted by the National Youth Policy Institute. The survey utilized multi-stage stratified cluster sampling, employing a tablet-assisted personal interview method to improve accuracy and efficiency. In 17 provinces, 131 schools were chosen according to region size, employing probability proportional to size sampling to select schools with at least two classes and a minimum of 50 students. Consequently, the final study cohort comprised 2,380 students. The gender distribution of the participants is presented in Table 1.

Table 1 Participants' gender distribution (%)

		Boys	Girls	Total
Administrative unit size Criterion: No. of schools	Large city	554 (43.5)	442 (40.0)	996 (41.8)
	Small-medium city	540 (42.4)	489 (44.2)	1029 (43.2)
	Rural districts	180 (14.1)	175 (15.8)	355 (14.9)
Total		1,113 (49.7)	1,127 (50.3)	2,380 (100)

Psychometric tools

Grit

To measure grit, we utilized the 8-Item Grit Scale-Children, validated by [55] with permission from Duckworth, the developer. The scale consists of eight items and is composed of two subfactors: CI (e.g., I find it difficult to concentrate when I am doing something and my mind wanders) and PE (e.g., I do not get frustrated when I encounter difficulties in solving a problem, and I recover from frustration faster than others). CI was reverse coded. The response scale comprises a 4-point Likert scale, with reliability coefficients (Cronbach's α) of 0.70, 0.70, and 0.71 for CI and 0.63, 0.61, and 0.63 for PE at waves 1, 2, and 3, respectively.

Peer relationship

To assess peer relationships, we utilized the Peer Relationship Quality Scale developed by [56] for middle and high school students. The scale comprises 13 items, with subfactors for positive relationships (e.g., I am good at telling my friends about myself) and negative relationships (e.g., I often disagree with my friends). Negative relationships were reverse coded. The response scale is a 5-point Likert scale and the reliability coefficients (Cronbach's α) were 0.69 at wave 1, 0.65 at wave 2, and 0.70 at wave 3.

Teacher relationship

To evaluate teacher relationships, we employed items from the Student-Teacher Attachment Scale developed by [57] for elementary and middle school students. The scale includes14 items and is composed of the following subfactors: trustworthiness (e.g., My teacher believes that I can do well in my future studies), sensitivity (e.g., My teacher can quickly recognize if I am thinking about something else in class), receptivity (e.g., My teacher patiently waits for me to answer questions), and accessibility (e.g., My teacher is the first person I want to approach when I have trouble with my studies or other problems). The response scale is a 4-point Likert scale

with reliabilities (Cronbach's α) of 0.91 at wave 1, 0.91 at wave 2, and 0.90 at wave 3.

Parental autonomy support

To measure parental autonomy support, we utilized the autonomy support item from [58] Parenting Attitudes Scale. This scale consists of four items (e.g., My parents believe in me). The response scale is a 4-point Likert scale, with reliability coefficients (Cronbach's α) of 0.88 at wave 1, 0.86 at wave 2, and 0.86 at wave 3.

Data processing

Analytical model

The TSO model, which can identify the traits and states of a psychological construct, has been empirically validated through various studies [11, 59, 60]. The model connects occasional factors between nearby points in time in autoregressive structures to capture the stability of occasions and has a low error rate [10]. Considering these advantages, the TSO model was employed in this study to identify the traits and state levels of grit [10] (Fig. 1). First, latent trait factors (e.g., CI T) refer to stable traits of an individual, and latent occasional factors (e.g., o1) refer to occasions that may affect an individual's current latent state (e.g., CI S1). Following the model setting of [10] and [11] and the understanding that psychological variables may include state variance in addition to trait variance [61], we assumed that latent trait variables equally influence latent state variables and fixed them at 1. We set an equality constraint on the autoregressive coefficients of latent occasional factors. Meanwhile, three observed indicators (CI11 ~ CI33, PE equal) were used to measure the latent state variables (S1 ~ S3) at each measurement point. The observed indicators of each latent variable were grouped into three sets of items using a factor algorithm that clusters items based on factor loadings derived from confirmatory factor analysis. This method has the advantage of yielding an appropriate set of measurement models regardless of sample size [62].

Data process

Mplus 6.1 [63] and SPSS 18.0 programs were used for the analysis. The proportion of variance explained by grit trait and occasional factors was derived to explore the influence of stable trait (T) and time-varying occasional factors (O) of grit. Additionally, the autoregression coefficient of occasional factors was calculated to assess their stability. Subsequently, we introduced variables related to friends, teachers, and parents to understand their influence on the traits and state of grit. Finally, the full-information maximum likelihood method was employed to estimate the TSO model parameters and evaluate the fit between the model and the data. However, to reflect the sample-sensitive characteristic of validation, we also complementarily utilized fit indices such as the Tucker–Lewis Index (TLI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). In this study, a threshold of TLI > 0.90, CFI > 0.90, and RMSEA < 0.08 was applied to evaluate the model fit [64].

Results

Descriptive statistics and correlation analysis

The descriptive statistics and correlation analysis results of the grit subfactors, friendships, teacher relationships,

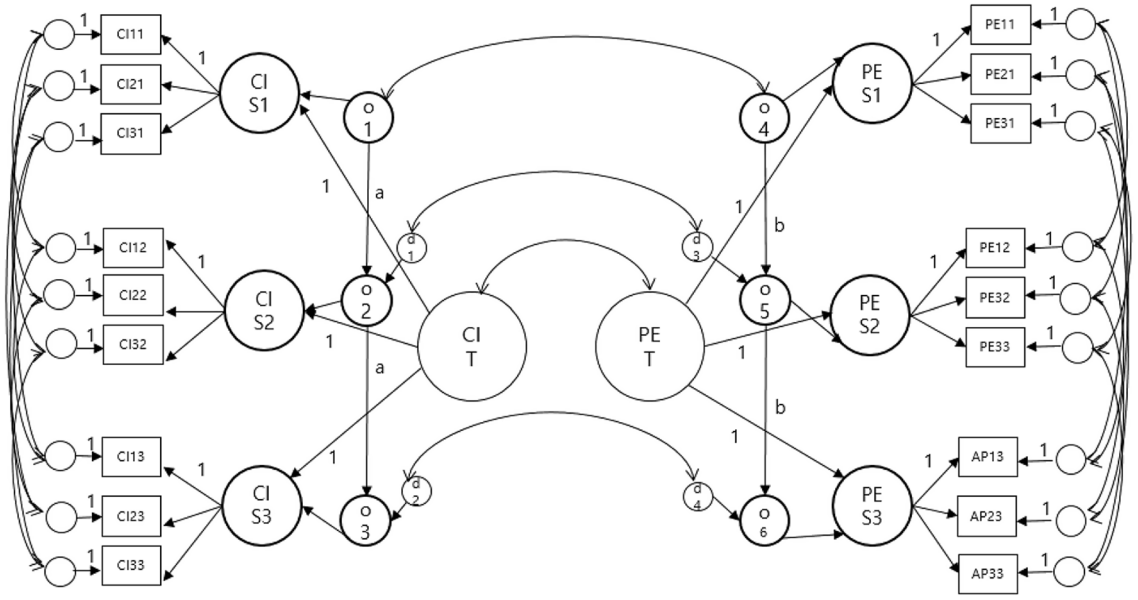

Fig. 1 TSO model of grit subfactors. Note. T: trait; S: state; o: occasion; d: residual variance of latent occasional factors; correlation set between error variances of the same metric at each measurement time point; number of observed variables: denoting item parceling at each time point of measurement

and parental autonomy support at each time point are presented in Table 2.

The correlations between grit and its subfactors exhibited significant positive correlations ranging from 0.211 to 0.822 (p <.01). An examination of the correlations of grit and its subscales with predictors reveals that friendships had a significant negative correlation of −0.054 with CI at wave 1 and Time 3 (p <.01), but not at wave 2. PE displayed a significant static correlation of 0.088 to 0.143 (p <.01), but not at wave 3, while grit had a significant static correlation of 0.052 with CI only at wave 1 (p <.05). Subsequently, teacher relationships demonstrated significant static correlations with CI ranging from 0.117 to 0.241 (p <.01), while PE and grit displayed significant static correlations with CI ranging from 0.136 to 0.384 (p <.01) and from 0.158 to 0.383 (p <.01), respectively. When examining the relationship between parental autonomy support and grit and its subfactors, we found significant static correlations ranging from 0.083 to 0.200 (p <.01), with PE ranging from 0.150 to 0.335 (p <.01) and grit ranging from 0.144 to 0.328 (p <.01). Mean levels of grit and its subfactors generally tended to decrease slightly over time.

Longitudinal grit stability

Longitudinal measurement equivalence verification

The validity of the longitudinal data was confirmed through the confirmation of configural and metric invariance [65]. Table 3 presents the results, indicating that the value for configural invariance, which judges the sameness of the constructs across measurement periods, x^2 was statistically significant (p <.001), although TLI and CFI were above 0.90, whereas RMSEA was below 0.08. Other fit indices met acceptable standards, supporting configural invariance. The results of the test for metric invariance, a model that imposed equality constraints on the factor loadings of the same measure at each time point, x^2 were statistically significant (p <.001). However, the relatively good fit compared to the model for form equivalence supported metric invariance (x^2 = 12.274, $\triangle$df = 8).

Goodness-of-fit of the TSO model

To check the middle school students' grit stability, the fit of the TSO model was verified. Table 4 presents the results, x^2 was statistically significant (p <.001). However, the TLI and CFI indices were above 0.90, whereas the RMSEA value was below 0.08, indicating a relatively good fit.

The Squared Multiple Correlation of the three observed variables at each time point of grit revealed that the CI ranged from 0.650 to 0.708 at time point 1, 0.634 to 0.732 at time point 2, and 0.668 to 0.701 at time point 3. PE ranged from 0.607 to 0.645 at time point 1, 0.581 to 0.617

Table 2 Descriptive statistics and correlation analysis

	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	0.318**	1										
3	0.822**	0.801**	1									
4	0.366**	0.223**	0.365**	1								
5	0.192**	0.362**	0.338**	0.287**	1							
6	0.352**	0.361**	0.439**	0.820**	0.783**	1						
7	0.321**	0.211**	0.329**	0.349**	0.251**	0.376**	1					
8	0.237**	0.295**	0.327**	0.232**	0.360**	0.365**	0.286**	1				
9	0.350**	0.313**	0.409**	0.365**	0.378**	0.462**	0.819**	0.784**	1			
10	−0.054**	0.143**	0.052*	−0.030	0.088**	0.033	−0.054**	0.026	−0.020	1		
11	0.241**	0.384**	0.383**	0.117**	0.200**	0.195**	0.119**	0.136**	0.158**	0.216**	1	
12	0.200**	0.335**	0.328**	0.117**	0.175**	0.181**	0.083**	0.150**	0.144**	0.157**	0.384**	1
M	10.466	10.793	21.259	10.368	10.673	21.041	10.134	10.440	20.574	34.181	39.230	13.403
(SD)	(2.199)	(2.090)	(3.482)	(2.107)	(1.940)	(3.248)	(2.175)	(2.008)	(3.356)	(4.318)	(6.995)	(2.305)

Note. 1: CI wave 1; 2: PE wave 1; 3: grit wave 1; 4: CI wave 2; 5: PE wave 2; 6: grit wave 2; 7: CI wave 3; 8: PE wave 3; 9: grit wave 3; 10: peer relationship; 11: teacher relationship; 12: parental autonomy support; M = mean; SD = standard deviation; * p <.05; ** p <.01

Table 3 Goodness-of-fit indices for the measurement models by measurement points in time

Model		df	TLI	CFI	RMSEA (90% CI)	(df)
Configural invariance	443.985***	102	0.948	0.965	0.038 (0.034–0.042)	12.274 (8)
Metric invariance	456.259***	110	0.951	0.965	0.037 (0.033–0.040)	

Note. df: degrees of freedom; TLI = Tucker–Lewis Index; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; CI = Confidence Interval; ***p <.001

Table 4 Goodness-of-fit of the TSO model

Model		df	TLI	CFI	RMSEA (90% CI)
	459.983***	109	0.950	0.965	0.037 (0.033–0.040)

Note. model = effect of trait factors on state factors and equality constraints on autoregressive coefficients of occasional factors; df: degrees of freedom; TLI = Tucker–Lewis Index; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; CI = Confidence Interval; ***p <.001

Table 5 Grit's TSO parameter estimates

	time point	trait→state	occasion→state	occasion→occasion
CI	1	0.623	0.782	-
	2	0.649	0.761	0.090
	3	0.635	0.772	0.081
PE	1	0.609	0.793	-
	2	0.660	0.751	0.070
	3	0.661	0.751	0.061

Note. Path values are standardized coefficients; p <.001

at time point 2, and 0.584 to 0.659 at time point 3, indicating that the observed variables at each time point are relatively good at explaining the state factor.

TSO model estimating parameters

The TSO model analysis of middle school students' grit revealed statistically significant variance for CI's trait ($\sigma^2 = 11.002$, p <.001) and occasion ($\sigma^2 = 11.483$, p <.001), as well as for PE's trait ($\sigma^2 = 10.036$, p <.001) and occasion ($\sigma^2 = 10.564$, p <.001). Table 5 presents the parameter values assessing the influence of characteristics and occasional factors on the variance of the grit state factor, while Fig. 2 illustrates the variance distribution of the grit state factor.

The standardized coefficients of CI's trait factors ranged from 0.623 to 0.649, while those of PE's trait factors ranged from 0.609 to 0.661. The amount of explanation of the trait factors for the state factor, as determined by the squared value of the standardized coefficient of the trait factor to the state factor, ranged from 38.81 to 42.12% for CI, with an average of 40.41%. PE ranged from 37.08 to 43.69%, with an average of 41.44% explained. Meanwhile, the standardized coefficients of CI's occasional factors ranged from 0.761 to 0.782, and those of PE's occasional factors ranged from 0.751 to 0.793, indicating that 57.91–61.15% of the variance in CI's occasional factors and 56.40–62.57% in PE's occasional factors were explained by circumstances, with an average of 59.33% and 58.46%, respectively.

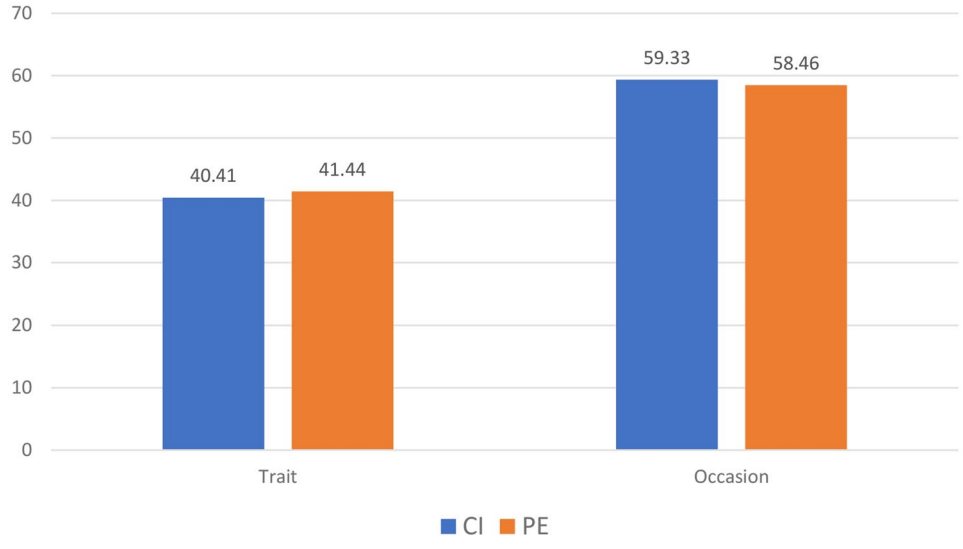

Fig. 2 Variance of grit state factors

Table 6 Predictor variables affecting the traits and state of grit subfactors

		CI			PE		
		B	**S.E**	***β***	**B**	**S.E**	***β***
Trait	PR	−0.013***	0.002	−0.176	0.003	0.002	0.051
	TR	0.014***	0.001	0.306	0.016***	0.001	0.412
	PAS	0.026***	0.004	0.190	0.037***	0.004	0.326
State1	PR	−0.018***	0.003	−0.142	0.006*	0.003	0.059
	TR	0.020***	0.002	0.266	0.025***	0.002	0.363
	PAS	0.038***	0.006	0.164	0.054***	0.005	0.261
State2	PR	−0.009**	0.003	−0.075	0.005	0.003	0.050
	TR	0.008***	0.002	0.118	0.012***	0.002	0.187
	PAS	0.023***	0.006	0.107	0.026***	0.005	0.139
State3	PR	−0.012***	0.003	−0.100	−0.002	0.003	−0.018
	TR	0.011***	0.002	0.146	0.008***	0.002	0.131
	PAS	0.013*	0.006	0.059	0.025***	0.005	0.139

Note. PR: peer relationship; TR: teacher relationship; PAS: parent autonomy support

***p <.001; *p <.05

Predictor variables affecting the traits and state of grit subfactors

In the TSO model, the fit of the conditional model to examine the influence of peer relationships, teacher relationships, and parental autonomy support on the traits and states of the grit subfactor was x^2= 334.206, df=109, CFI=0.953, TLI=0.934, RMSEA=0.044 (0.039~0.049), indicating an acceptable fit. Table 6 presents the results of the predictors' influence on the traits and states of grit.

Analyzing the impact of predictors on CI traits and states revealed a significant negative effect of peer relationships, ranging from − 0.018 to − 0.009 (p <.001), and a significant positive impact of teacher relationships, ranging from 0.008 to 0.020 (p <.001). Parental autonomy support also had a significant positive effect, ranging from 0.013 to 0.038 (p <.001). Similarly, examining the impact of predictors on PE traits and states showed a significant positive effect of peer relationships of 0.006 on state1 only (p <.05), and a significant positive effect of teacher relationships and parental autonomy, ranging from 0.016 to 0.025 (p <.001) and from 0.025 to 0.054 (p <.001), respectively.

Discussion

This study aimed to utilize the TSO model to identify the trait and state levels of grit subfactors among middle school students and determine the influence of peer relationships, teacher relationships, and parental autonomy support on the trait and state of grit. We summarize and discuss our findings as follows.

First, among the grit subfactors in middle school students, CI and PE had averages of 40.41% and 41.44% of the variance explained by trait factors, respectively, indicating that both subfactors are stable factors influenced by traits. These results align with previous studies employing autoregressive coefficients to characterize grit stability [13, 48, 1]. viewed grit as a personality trait factor, while [66] linked it more closely to trait variables such as conscientiousness, suggesting its stability. However, this study, focusing on middle school students, observed a relatively high self-regression coefficient compared to studies on elementary school students [14, 15]. Notably [48], study on elementary school students reported an even higher self-regression coefficient. These divergent results may partly stem from the dynamic nature of grit during childhood and adolescence [19]. Nevertheless, grit's level or stability may vary across age and cultural contexts [46, 66–68], warranting further exploration into its stability.

Second, the subfactors of grit exhibited both stable trait factors and changeable state factors, with varying effects of occasion observed on the two subfactors of grit. These results echo those of [16], who examined grit stability in twins, finding a relatively higher influence of environmental factors compared to genetic factors, along with discrepancies in the impact of the two subfactors. This suggests that while grit remains a stable variable, it is also susceptible to environmental influences [7, 45, 46], which could be partially interpreted to implying its teachability. Cultivating a penchant for sustained interest and long-term goal pursuit during adolescence can profoundly shape adulthood [16]., necessitating the development and implementation of diverse teaching methods. Moreover, CI demonstrated a somewhat stronger occasional influence compared to PE, akin to [3] findings on the stability of the self-regression coefficient, which reported a relatively high coefficient for PE. In early adolescence, people pursue multiple goals simultaneously while exploring their identity and interests [69], suggesting that CI's stability may diminish as individuals become involved in varied domains. However, the marginal disparity in the influence of occasional factors of the grit subfactor on

the state factor should limit the interpretation, warranting further investigation into the distinction between CI and PE.

Third, in terms of predictors of grit traits and states, the findings demonstrated that peer relationships negatively affect CI traits and states, while PE had a significant positive effect on only some states. These findings can be partly attributed to adolescent characteristics. Adolescents often prioritize peer expectations and opinions as adult supervision decreases, and their friendship groups are typically transient [70, 71]. This implies that frequent changes in friendship groups can lead to changes in interests, potentially exerting a negative effect on CI, a subfactor of grit related to sustained passion and interest. However, these results differ from other studies suggesting a static effect of peer relationships on grit [17] or no significant effect [38], warranting further investigation into the association between peer relationships and grit.

Furthermore, teacher relationships positively affected both the trait and state of grit subfactors. These findings echo previous studies [17, 38], suggesting that teacher relationships play a positive role in grit [72]. contended that creating a supportive environment is the first step in cultivating grit. Establishing supportive teacher-student relationships enhances students' sense of security and competence within the school environment [35], and students may perceive this relationship as part of a supportive environment at school, which positively affects grit. In addition to [73] study, which suggested strategies to promote grit across cognitive, affective, and behavioral dimensions, schools should also focus on teacher-student relationships to foster student grit. Meanwhile, parental autonomy support had a static effect on both the trait and state of the grit subfactor. These findings are consistent with those of prior studies [43, 54], suggesting that greater parental support for their children's autonomy correlates with higher overall grit levels. Parental support for autonomy fosters sustained effort and interest in tasks by nurturing children's internal motivational resources, offering explanations for task relevance, and increasing engagement [74, 75]. Notably [54], identified overparenting as detrimental to grit, emphasizing the importance of positive parenting behaviors in enhancing student grit.

Limitations and recommendations

This study has several limitations and avenues for future research. First, although this study is significant in identifying the traits and state levels of grit subfactors among middle school students, complementing this study by investigating grit traits and state levels across different school levels, considering previous findings indicating age-related differences in grit levels, is necessary [66]. Second, although this study analyzed peer, teacher, and parent-related variables as predictors of grit subfactors, further longitudinal studies are warranted to ascertain causal relationships between grit and its predictors, as identified in some studies [17]. Third, while this study focused on domain-general grit, the existence of domain-specific grit suggests potential variations in grit levels depending on the context, such as sports or school settings [14, 76, 77]. Thus, future research should explore grit traits and states in diverse contexts to provide a comprehensive understanding. Finally, while this study confirms metric invariance [65], some research [78] advocates testing for scalar invariance in longitudinal studies.

Conclusions

This study has significantly contributed to the understanding of grit subfactors by employing TSO analysis, shedding light on both their trait and state levels. Through our investigation into the influence of peer, teacher, and parent-related variables, we have unveiled intriguing insights into the dynamics of grit development among middle school students. Our findings underscore the stability yet malleability of grit subfactors, with both CI and PE demonstrating nuanced responses to environmental influences. Notably, while the trait consistently shaped both subfactors, CI exhibited relatively higher variability, suggesting a greater susceptibility to external factors. Moreover, our study elucidated the positive impact of teacher relationships and parental autonomy support on both the trait and state of CI and PE, underscoring the crucial role of supportive environments in fostering grit. Looking ahead, our study opens avenues for further research into grit stability, predictors, and interventions. Future studies could delve deeper into specific research questions or hypotheses derived from our findings, exploring the interplay between individual traits and environmental factors in shaping grit development. By embracing these future research directions and building upon the insights gleaned from this study, researchers can continue to advance our understanding of grit and its role in adolescent development, ultimately guiding interventions and initiatives aimed at promoting interest and perseverance among young individuals.

Abbreviations

TSO	Trait-state-occasion
CFI	Comparative Fit Index
CI	Consistency of interest
KCYPS	Korean Children and Youth Panel Survey
M	Mean
PE	Perseverance of effort
RMSEA	Root Mean Square Error of Approximation
SD	Standard deviation
TLI	Tucker–Lewis Index

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Data availability
For this study, we utilized public data from KCYPS 2018. KCYPS data are available to the public with consent.

Declarations

Ethics approval and consent to participate
For this study, we utilized public data from KCYPS 2018. Participant consent was obtained from the Korea Youth Policy Research Institute. KCYPS data is available to the public with consent.

Consent for publication
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Competing interests
The authors declare no competing interests.

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