

Optimism as a Mediator of the Relationship between Adolescents' Stress and Intelligence: Using the K-WISC-V*

청소년기 스트레스와 지능 간의 관계에서 낙관성의 매개효과: K-WISC-V를 중심으로

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Abstract The current study focuses on adolescent intelligence and its relationship with stress and optimism. We aim to examine the mediating role of optimism in the association between stress and intelligence. We conducted a cross-sectional study among 665 South Korean adolescents aged 12-16 years ($M = 14.3$; $SD = 1.4$; 47.4% female). Intelligence was assessed by K-WISC-V subtests, and we derived Full-Scale Intelligence Quotient (FSIQ) and five primary index scores (e.g., VCI, VSI, FRI, WMI, PSI) for analyses. Stress and optimism were also measured by self-report questionnaires. Through correlation and mediation analysis, we attained the following results. Stress did not significantly predict intelligence in general, while optimism positively predicted intelligence. Also, optimism mediated the association between stress and FSIQ and the association between stress and primary index scores except for PSI, after controlling for sex and region. The current study is the first empirical attempt to clarify the pathway from stress to intelligence among adolescents by revealing that stress indirectly affects intelligence through optimism. In this way, we provide direction for further discussions on how to protect and enhance adolescent intelligence.

Keywords stress, optimism, intelligence, adolescence, mediating effect

국문초록 본 연구에서는 청소년들을 대상으로 스트레스, 낙관성, 지능 간 관계를 알아보았으며, 특히 스트레스와 지능 간 관계를 낙관성이 매개하는지 살펴보았다. 이를 위해 만 12세에서 16세의 남녀 한국 청소년 665명 (평균 연령=14.3세)을 대상으로 K-WISC-V를 실시하고, 전체 IQ (FSIQ)와 5개의 기본 지표점수 (언어이해지표, VCI; 시공간지표, VSI; 유동추론지표, FRI; 작업기억지표, WMI; 처리속도지표, PSI)를 산출하여 횡단 분석에 사용하였다. 또한 스트레스와 낙관성을 측정하기 위해 설문조사를 실시하였다. 상관분석과 매개효과 검증 결과, 스트레스는 전반적으로 지능을 유의하게 예측하지 않은 반면 낙관성은 지능을 정적으로 예측했다. 또한 매개효과를 검증했을 때, 처리속도지표의 경우만을 제외하고 낙관성은 스트레스와 지능 간 관계를 매개하는 것으로 나타났다. 본 연구는 스트레스가 높을수록 낙관성은 낮아지고 이는 지능 감소로 이어지는 경로를 살펴본 첫 실증적 연구이며, 청소년의 지능 보호 및 향상에 대한 논의 방향을 제시하였다는 의의가 있다.

주요어 스트레스, 낙관성, 지능, 청소년기, 매개효과

1. Introduction

Intelligence could be defined as “a confluence of the abilities to understand complex ideas and use experience and reasoning to solve problems and adapt to the environment” (Duggan & Garcia-Barrera, 2015). It is discussed as a concept consisting of multiple factors in

modern theories of intelligence (Watkins & Canivez, 2022), including the Cattell-Horn-Carroll (CHC) theory, one of the most strongly supported perspective that asserts the three-stratum structure of intelligence (Duggan & Garcia-Barrera, 2015). This concept of intelligence could predict desirable behaviors and achievement in various areas of life (Bergman, Corovic, Ferrer-Wreder, & Modig,

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2014). Especially, intelligence in adolescence is known to be associated with one's academic achievement (Caemmerer, Maddocks, Keith, & Reynolds, 2018) and career success in adulthood (Bergman et al., 2014). While adaptive outcomes predicted by adolescent intelligence have been studied as such, potential factors that could affect intelligence during this time of transition and the mechanism of how has not yet been sufficiently explored.

However, considering the malleability of intelligence during adolescence (Rinaldi & Kamiloff-Smith, 2017), exploring the factors that could affect it are important and thus more developmental studies regarding it are needed. Intelligence is considered stable over the life span (Kaufman, Kaufman, & Plucker, 2013), but fluctuations still occur since it is rather an adaptive quality that undergoes development than a completely fixed entity. Especially, in times of adolescence, intelligence turned out to be less stable than in adulthood (Rinaldi & Kamiloff-Smith, 2017). This could be due to major structural changes that occur in the central nervous system as an adjustment to new experiences during this period (Dow-Edwards et al., 2019). These changes were in fact correlated with changes in verbal and non-verbal intelligence of adolescents (Ramsden et al., 2011). Based on this evidence showing the malleability of adolescent intelligence, we could draw an idea that exploring its possible determinants would be a necessary step to help elaborate intervention for adolescents' intellectual ability. Accordingly, we explored some variables that could influence intelligence in adolescence as follows.

Stress is one of the potential risk factors of intelligence (Shields, Sazma, & Yonelinas, 2016). And although other age groups also experience daily stress, adolescents experience stress more frequently because adolescence is a transitional period when rapid environmental and physical changes occur (Cho, 2010; Rahdar & Galván, 2014). Adolescence is also a period when mental dis-

orders related to stress exposure develop throughout (Dow-Edwards et al., 2019). Regarding these unique features, adolescent stress needs to be examined distinctively from stress in other stages of life. Also, rapid intervention is needed to prevent its detrimental effect brought on to adulthood (Park & Lim, 2021).

One possible explanation of how stress could affect intelligence is suggested through the arousal-biased competition theory (Mather & Sutherland, 2011). According to the theory, arousal from stress could bias perception and attention. In particular, arousal biases one's information processing towards the current stressor during stressful situations, and thereby executing cognitive tasks irrelevant to the stressor could be distracted (Shields et al., 2016). Although such mechanism was discussed, findings still vary across studies on the stress-intelligence relationship. There were results that found a negative association between stress and cognitive abilities (Eskildsen, Andersen, Pedersen, Vandborg, & Andersen, 2015; Gagnon & Wagner, 2016; May, Bauer, & Fincham, 2015; Shields et al., 2016). On the other hand, there were some results revealing a positive association (Lewis, Nikolova, & Chang, 2008; McCullough & Yonelinas, 2013). Finally, there also were results that suggested no significant association in between (Horvat & Tement, 2020; Lukasik et al., 2019; Oosterholt et al., 2014). Since prior studies showed conflicting results as such, reconsideration through empirical research is needed. Based on the theoretical mechanism discussed above, the current study assumed that stress may negatively affect adolescent intelligence.

It could be additionally assumed that the inconsistency in prior study results were due to moderating or mediating effect of stress-related variables. In particular, personality traits related to stress-coping and emotion regulation were recently suggested as important factors that determine the effect of stress (Plieger & Reuter, 2020). To be more specific, personality traits such

as coping behavior could interact with stress effects on cognitive control performance (Plieger & Reuter, 2020). Regarding this, we focused on the role of optimism, a personality trait related to adaptive coping and stress buffering (Boselie, Vancleef, Smeets, & Peters, 2014; Nes & Segerstrom, 2006), in the relationship between stress and intelligence. Optimism is defined as a generalized expectation that positive outcomes will happen, and it has been regarded as a stable trait (Carver & Scheier, 2014). However, an alternative view on optimism was provided as the social-cognitive perspective on the nature of personality, which considers personality as cognitive processes that could be determined by environmental factors, gradually gained support (Atienza, Stephens, & Townsend, 2004; Tetzner & Becker, 2019). Following this perspective, it was suggested that the level of optimism could be influenced by external elements. Optimism particularly appears malleable during the times of life transition, when people undergo significant changes. According to the developmental task theory by Havighurst (1972), failure or stressors that adolescents face during the pursuit of developmental tasks could decrease their optimism (Tetzner & Becker, 2019). Given this, stress in adolescence may have negative influence on optimism.

Besides stress, optimism is another factor that could affect intelligence. Optimism has been studied as a resource that has positive impact on various outcomes, such as social relationship, physical health, and mental health (Carver & Scheier, 2014). However, research on its benefits in the intellectual domain is not as plentiful, suggesting the need for further studies. A relatively small number of studies showed a positive association between optimism and intellectual development outcomes (Bjorklund, Gaultney, & Green, 1993; Kim & Kwak, 2011; Shin, Bjorklund, & Beck, 2007). Additionally, while such a correlation between optimistic trait and high in-

telligence was demonstrated, most of these studies focused on young children only. Therefore, the association also needs to be examined on other age groups. Especially adolescence, when optimism could function as an important protective resource that buffers stress, could be the focus of interest.

The possible mechanisms by which optimism could positively affect intelligence are as follows. First, optimism motivates one to continue additional efforts of producing new strategy during the phases of cognitive strategy development (Bjorklund, 2009; Miller, 2000). Second, optimism is closely related to self-efficacy. This positive belief of one's control and ability are known to facilitate effective intellectual performance and new learning attempts (Bjorklund, 2009). Third, according to the broaden-and-build theory by Fredrickson (1998), positive emotions frequently derived from optimism could expand one's range of thoughts and acts. Such broadened thought-action repertoires help accumulate various personal resources, including intellectual capacity (Fredrickson, 1998). Based on these, the current study assumed that optimism of adolescents may positively affect their intelligence.

1. The Current Study

From what we reviewed so far, most studies on the stress-intelligence relationship were carried out with a small sample of adults in a laboratory setting. However, since stress is an important factor related to intelligence development in adolescence (May et al., 2015; Rinaldi & Kamiloff-Smith, 2017), we suggest that adolescents should also be considered as important target population. Therefore, the current study attempted to explore the relationship between stress and intelligence among adolescents. Taken previous studies into account, we used a self-report method to effectively measure stress among a

large sample of adolescents (Rahdar & Galván, 2014; Wu et al., 2021). In addition, it should be considered that intelligence is a multidimensional concept consisting of several distinct factors, as we discussed earlier (Watkins & Canivez, 2022). With regards, a meta-analysis study revealed that stress affected each distinct core executive function in different ways (Shields et al., 2016). This may partly account for the conflicting prior results about the stress-intelligence relationship. Hence, when reconsidering the relationship, we need to investigate multiple cognitive abilities comprehensively instead of only one. For this reason, a standardized intelligence test battery was utilized in this study to examine how adolescent stress could affect each index reflecting different cognitive abilities.

In particular, we would like to focus on the mediating role of optimism in the relationship between stress and intelligence. Optimism is a personality trait that could be impaired by stress experiences during adolescence (Tetzner & Becker, 2019). As for the relationship between intelligence and optimism, there were a few studies demonstrating a positive association (Bjorklund et al., 1993; Kim & Kwak, 2011; Shin et al., 2007). However, most of these studies were focused only on young children so research needs to be extended to other age groups. Especially, we suggest that more studies should be conducted on adolescents, whose optimism is addressed as important resource in relation to stress

during this period. Considering these associations that optimism have with stress and intelligence, this study aimed to examine whether optimism works as a mediator in the relationship between stress and intelligence among adolescents. Consequently, we raised three research questions as follows:

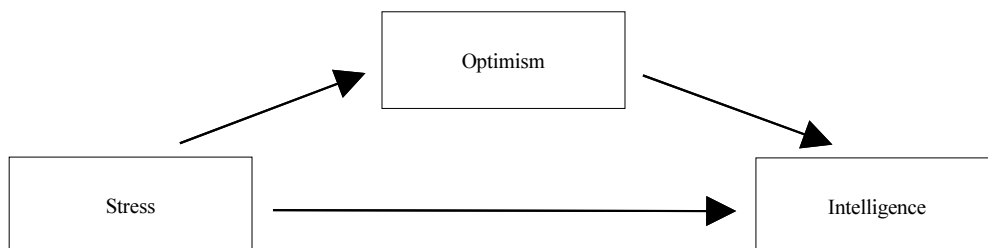
1. Does stress predict intelligence of adolescents?
2. Does optimism predict intelligence of adolescents?
3. Does optimism mediate the relationship between adolescent stress and intelligence?

Based on these questions, the hypothetical framework of this study is presented in Figure 1. This is the first empirical attempt to investigate the mediating role of optimism between adolescent stress and intelligence. Through this investigation, we expect to expand the existing knowledge base on intelligence and suggest direction for future discussion on ways to protect adolescent intelligence.

II. Method

1. Participants

Data for this study is drawn from the WISC-V Korean standardization sample (Wechsler, 2014; Kwak & Jang, 2019) of participants aged from 6 to 16 years.



Note. In the current study, intelligence was represented by the Full-Scale Intelligence Quotient (FSIQ) and five primary index scores (e.g., VCI, VSI, FRI, WMI, PSI) derived from the Korean Wechsler Intelligence Scale for Children-Fifth Edition (K-WISC-V; Kwak & Jang, 2019).

Figure 1. Hypothetical Framework for the Mediation Model

Of the original sample ($N = 2,200$), we used the subset of middle and high school adolescents for this study. Participants with Full-Scale Intelligence Quotient (FSIQ) that falls 2 standard deviations below ($FSIQ < 70$) or above ($FSIQ > 130$) the mean was excluded from analyses to avoid confounding effects. Our final sample consists of 665 adolescents (350 male and 315 female) aged from 12 to 16 years ($M = 14.3$, $SD = 1.4$). Participants were sampled in 10 provinces across South Korea, and most of the participants resided in Seoul (49.3%) and Gyeonggi (18.5%) province.

2. Measures

1) Stress

Stress was measured by the Daily Hassles Scale for Children in Korea (Han & Yoo, 1995). This 42-item self-report scale measures daily stress experienced by the respondents. Among the six subscales, subscales measuring parent-related stress (8 items) (e.g., “I am dissatisfied because my parents do not respect my thoughts or opinions”), home environment stress (7 items) (e.g., “I feel unhappy because my family doesn’t care about me”), and academic stress (7 items) (“I am anxious and nervous every time I take a test”) are used in the current study. Inclusion of these subscales are due to previous literature regarding adolescent stress (Kim, Kwak, & Kim, 2022). Each item is rated on a 6-point Likert type scale ranging from 1 (Strongly disagree) to 6 (Strongly agree), and higher score on this scale indicates higher level of perceived stress. The Cronbach’s alpha was .85 in Han and Yoo’s (1995) study, and .89 in the current study. In particular, Cronbach’s alpha was .87 for parent-related stress, .82 for home environment stress, .79 for academic stress respectively in the current study.

2) Optimism

Optimism was measured by the Korean version of the Life Orientation Test-Revised (LOT-R) (Scheier et al., 1994; Shin et al., 2005), a scale assessing generalized future expectation. This 10-item self-report scale consists of 3 positively worded items (e.g., “In uncertain times, I usually expect the best”), 3 negatively worded items (e.g., “I hardly ever expect things to go my way”), and 4 filler items. Each item is rated on a 5-point Likert type scale ranging from 1 (not at all like me) to 5 (very much like me). The negatively worded items were reverse coded so that higher total score on this scale reflects greater optimism. The Cronbach’s alpha was .73 in Shin’s (2005) study, and .69 in the current study.

3) Intelligence

Among modern theories of intelligence, one of the most robustly supported perspective is the Cattell-Horn-Carroll (CHC) theory, which describes the three-stratum structure of intelligence (Duggan & Garcia-Barrera, 2015). Stratum III consists of a single factor called general intelligence that shows the most general level of intellectual ability. Below that, stratum II consists of several group factors called broad abilities that represent more specific domains of mental ability. These are further subdivided into narrow abilities in stratum I (Kaufman et al., 2013). CHC theory is well reflected in most intelligence tests used today, including the Wechsler Intelligence test. The Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V) (Wechsler, 2014), one of the most widely used intelligence test battery for children and adolescents, produces a Full-Scale Intelligence Quotient (FSIQ) that represents general intelligence and five primary index scores (e.g., VCI, VSI, FRI, WMI, PSI) that represent several broad abilities (Caemmerer

et al., 2018).

Considering above, intelligence was assessed in the current study with the Korean Wechsler Intelligence Scale for Children-Fifth Edition (K-WISC-V) (Kwak & Jang, 2019), an individually administered intelligence test battery for school aged children and adolescents between 6 and 16 years of age. K-WISC-V consists of 16 subtests, and we used 10 of them for data analyses. 10 subtest scaled scores ($M = 10$, $SD = 3$) were combined and converted to produce standard scores ($M = 100$, $SD = 15$) of FSIQ and primary indexes. FSIQ is considered as a measure of general intelligence and is generated from seven subtests: Similarities, Vocabulary, Block Design, Matrix Reasoning, Figure Weights, Digit Span, and Coding. The primary index scores (VCI, VSI, FRI, WMI, PSI) are considered as measures that reflect five broad abilities. Verbal Comprehension Index (VCI), a measure of crystallized intelligence, is generated from Similarities and Vocabulary. Visual Spatial Index (VSI), a measure of visual processing ability, is derived from Block Design and Visual Puzzles. Fluid Reasoning Index (FRI), a measure of fluid reasoning ability, is composed by Matrix Reasoning and Figure Weights. Working Memory Index (WMI), a measure of short-term memory, is generated from Digit Span and Picture Span. Processing Speed Index (PSI), a measure of processing speed, is derived from Coding and Symbol Search. When interpreting the test result, it is encouraged to consider not only the FSIQ but also these primary index scores in order to describe and evaluate one's intelligence comprehensively (Wechsler, 2014). Therefore, we used the FSIQ and five primary index scores together for data analyses in the current study.

4) Covariate

Preliminary analysis was conducted with demographic

variables to identify potential covariates. Among the demographic variables, sex and region were significantly correlated with dependent variables so they were controlled for in the subsequent mediation analyses. Sex was coded as male = 1 and female = 0. Region was each category dummy-coded for the 10 provinces that the participants were from. Inclusion of these covariates was also due to previous literatures demonstrating associations between intelligence and sex (Chen & Lynn, 2020) and intelligence and region (Bakhiet & Lynn, 2015).

3. Procedure

Prior to this study, all procedure and measurement tools used were reviewed and approved by the Institutional Review Board of a university in South Korea. After the participants were informed about the purpose of the study and storage of data, they signed the consent form. Participants were first tested for their intelligence using K-WISC-V. The test was carried out in a quiet room and in a one-to-one setting by trained test administrators, who were trained through administration manual provided in advance. Administration lasted for approximately 90-120 minutes. Then, the participants were asked to complete questionnaires including items measuring perceived stress and optimism. After the data collection, standard scoring procedures were applied and intelligence index scores were derived from the Korean WISC-V norms. Total score of stress and optimism was each derived by summing the ratings from the items.

4. Data Analysis

Statistical analyses for the current study were conducted using the Statistical Package for Social Science version 25 (SPSS 25). We first calculated the means,

standard deviations, and range of the primary variables (stress, optimism, and intelligence). Pearson's correlation analysis was also conducted to examine the association between stress, optimism, and intelligence. To examine the mediating effect of optimism on the relationship between stress and intelligence, we used PROCESS macro version 3.5 (Hayes, 2017) and applied Model 4. Region and sex were dummy coded and were entered as covariates. The statistical significance of the indirect effect was tested with a bootstrapping approach.

III. Results

Descriptive statistics of the study variables are presented in Table 1. The mean of stress was 54.3 ($SD = 15.8$), with the score range of 22 to 97. The mean of each subscale was as follows: parent-related stress ($M = 17.7$, $SD = 7.5$), home environment stress ($M = 12.6$, $SD = 5.3$), and academic stress ($M = 24.0$, $SD = 7.0$). In terms of optimism, the mean score was 21.4 ($SD = 3.5$), with the score range of 12 to 30. Finally, with regard to intelligence, the mean of FSIQ was 100.8 ($SD =$

11.6), with the score range of 70 to 128. The mean of each primary index score was as follows: VCI ($M = 100.9$, $SD = 12.6$), VSI ($M = 100.3$, $SD = 12.5$), FRI ($M = 100.8$, $SD = 13.1$), WMI ($M = 100.6$, $SD = 13.6$), and PSI ($M = 100.3$, $SD = 14.2$)

Correlations among the study variables are presented in Table 2. One of our main findings was that stress did not show any significant correlation with the intelligence index scores, except for PSI ($r = -.08$, $p < .05$). Similar results were observed at the subscale level of stress. There was no significant correlation in general, other than the negative association between parent-related stress and PSI ($r = -.08$, $p < .05$) and positive correlation between academic stress and VCI ($r = .11$, $p < .01$). Optimism was positively correlated with every intelligence index score. FSIQ ($r = .14$, $p < .001$), VCI ($r = .09$, $p < .05$), VSI ($r = .12$, $p < .01$), FRI ($r = .09$, $p < .05$), WMI ($r = .12$, $p < .01$), and PSI ($r = .10$, $p < .05$) all revealed positive correlation with optimism. On the other hand, stress was negatively correlated with optimism ($r = -.37$, $p < .001$).

We tested whether the relationship between stress and intelligence was mediated by optimism among adolescents, after including region and sex as covariates.

Table 1. Descriptive Statistics of Stress, Optimism, and Intelligence

($N = 665$)

Measure	<i>M</i>	<i>SD</i>	Minimum	Maximum	Skewness	Kurtosis
Stress	054.3	15.8	22	0 97	-.20	-.62
Parent	017.7	07.5	0 8	0 39	-.53	-.62
Home environment	012.6	05.3	0 7	0 28	-.85	-.07
Academic	024.0	07.0	0 7	0 41	-.16	-.47
Optimism	021.4	03.5	12	0 30	-.15	-.26
FSIQ	100.8	11.6	70	128	-.10	-.32
VCI	100.9	12.6	71	132	-.03	-.43
VSI	100.3	12.5	70	130	-.02	-.45
FRI	100.8	13.1	65	135	-.02	-.33
WMI	100.6	13.6	64	139	-.01	-.22
PSI	100.3	14.2	65	135	-.04	-.23

Note. *M* = mean; *SD* = standard deviation; Stress = adolescent stress; Parent = parent-related stress subscale; Home environment = home environment stress subscale; Academic = academic stress subscale; Optimism = adolescent optimism; FSIQ = Full-Scale Intelligence Quotient; VCI = Verbal Comprehension Index; VSI = Visual Spatial Index; FRI = Fluid Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index

Table 3 shows the test result of the mediating effect of optimism in between stress and intelligence. The path from stress to optimism was significant, showing that adolescent stress had negative direct association with optimism ($B = -.08, p < .001$). The path from optimism to each intelligence index score was significant in general, with PSI as the only exception ($B = .30, p > .05$). Significant path coefficients that indicated positive direct association between adolescent optimism and intelligence were as follows: FSIQ ($B = .53, p < .001$), VCI ($B = .41, p < .01$), VSI ($B = .42, p < .01$), FRI ($B = .37, p < .05$), and WMI ($B = .51, p < .01$). In addition, as we could see from Table 3, neither the direct effect nor the total effect was significant in each analysis with FSIQ, VCI, VSI, FRI, and WMI as dependent variable. However, the direct effect ($B = -.08,$

$p < .05$) and total effect ($B = -.10, p < .01$) of stress on PSI was significant.

We also applied bootstrapping to test the significance of the mediating effect. 95% confidence intervals were yielded from 5,000 bootstrap samples. As presented in Table 4, the mediating effects of optimism between stress and the following intelligence index scores were significant: FSIQ (bootstrap 95% CI = $-.07 \sim -.02$), VCI (bootstrap 95% CI = $-.06 \sim -.01$), VSI (bootstrap 95% CI = $-.06 \sim -.01$), FRI (bootstrap 95% CI = $-.06 \sim -.01$), and WMI (bootstrap 95% CI = $-.07 \sim -.02$). On the other hand, there was no significant mediating effect of optimism between stress and PSI (bootstrap 95% CI = $-.05 \sim .00$).

Table 2. Correlations between Stress, Optimism, and Intelligence

($N = 665$)

	1	2	3	4	5	6	7	8	9	10	11
1. Stress	1	.88***	.76***	.74***	-.37***	.01	.04	-.03	.02	.01	-.08*
2. Parent		1	.65***	.43***	-.31***	.01	.02	-.00	.03	.02	-.08*
3. Home environment			1	.27***	-.33***	-.05	-.05	-.02	-.04	.02	-.07
4. Academic				1	-.26***	.06	.11**	-.06	.04	-.02	-.04
5. Optimism					1	.14***	.09*	.12**	.09*	.12**	.10*
6. FSIQ						1	.70***	.59***	.72***	.64***	.45***
7. VCI							1	.25***	.31***	.37***	.15***
8. VSI								1	.44***	.29***	.22***
9. FRI									1	.40***	.09*
10. WMI										1	.24***
11. PSI											1

* $p < .05$. ** $p < .01$. *** $p < .001$. (two-tailed)

Table 3. Test Result of the Mediating Effect of Optimism in the Relationship between Stress and Intelligence

Dependent Variable (DV)	Effect of Stress on Optimism				Effect of Optimism on DV				Direct Effect				Total Effect			
	<i>B</i>	β	<i>SE</i>	<i>p</i>	<i>B</i>	β	<i>SE</i>	<i>p</i>	<i>B</i>	β	<i>SE</i>	<i>p</i>	<i>B</i>	β	<i>SE</i>	<i>p</i>
FSIQ	-.08	-.37	.01	.000	.53	.16	.13	.000	.03	.04	.03	.276	-.01	-.02	.03	.671
VCI	-.08	-.38	.01	.000	.41	.11	.15	.005	.04	.05	.03	.189	.01	.01	.03	.779
VSI	-.08	-.38	.01	.000	.42	.12	.15	.004	-.01	-.01	.03	.804	-.04	-.06	.03	.156
FRI	-.08	-.38	.01	.000	.37	.10	.15	.015	.03	.04	.03	.312	.00	.00	.03	.914
WMI	-.08	-.38	.01	.000	.51	.13	.16	.001	.03	.04	.04	.350	-.01	-.01	.03	.774
PSI	-.08	-.38	.01	.000	.30	.08	.16	.053	-.08	-.08	.04	.034	-.10	-.11	.03	.002

Note. DV = dependent variable in a mediation model with optimism as the mediator and stress as the independent variable; *B* = unstandardized coefficient; β = standardized coefficient; *SE* = standard error.

Table 4. Bootstrap Test of the Mediating Effect of Optimism

Dependent Variable (DV)	Indirect Effect				
	<i>B</i>	β	<i>Boot. SE</i>	95% CI	
				LL	UL
FSIQ	-.04	-.06	.01	-.07	-.02
VCI	-.03	-.04	.01	-.06	-.01
VSI	-.04	-.05	.01	-.06	-.01
FRI	-.03	-.04	.01	-.06	-.01
WMI	-.04	-.05	.01	-.07	-.02
PSI	-.03	-.03	.01	-.05	-.00

Note. 95% CI = 95% confidence interval obtained using bootstrap method; *Boot. SE* = bootstrap estimate standard error; LL = lower limit; UL = upper limit.

IV. Discussion

This study investigated intelligence and its relationship with stress and optimism, which were discussed as environmental and personal variables that could affect intellectual development during adolescence. In particular, we focused on the role of optimism, defined as a generalized positive expectation, in this relationship. Based on this research focus, this is the first study to empirically examine the mediating role of optimism in the pathway from stress to intelligence among adolescents. The main results were as follows.

First, results from the correlation analysis and mediation analysis indicated that adolescent stress was not significantly associated with FSIQ, VCI, VSI, FRI, and WMI among the intelligence index scores. Although this result was not as we expected, it was consistent with prior studies that revealed no significant correlation between stress and cognitive abilities (Horvat & Tement, 2020; Lukasik et al., 2019; Oosterholt et al., 2014). The reason for this nonsignificant correlation between stress and intelligence could be explained by referring to Oosterholt et al.'s (2014) study, where they compared three groups of clinical burnout, non-clinical burnout, and healthy control. The result revealed that task performance was only significantly impaired in the

clinical burnout group, implying that cognitive performance may be reduced only when stress is experienced at a clinically significant level. Horvat and Tement's (2020) study, where emotional fatigue was correlated with self-reported cognitive difficulties but not with actual task performance among non-clinical population, also supported this assumption. Therefore, we interpreted our finding as supporting these prior studies, revealing that daily stress may be associated with perceived difficulties but does not have significant effect on actual cognitive performance among non-clinical adolescents.

On the other hand, PSI was the only intelligence index score to be negatively correlated with stress. PSI is a measure of processing speed, which refers to the ability to perform simple and repetitive tasks rapidly yet accurately (Caemmerer et al., 2018). The negative correlation demonstrated in our study is in line with previous studies showing that stress impeded abilities required to perform PSI subtests, such as processing speed, sustained attention, and cognitive flexibility (Eskildsen et al., 2015; May et al., 2015). This could be well explained by the arousal-biased competition theory (Mather & Sutherland, 2011), which is the most widely accepted perspective regarding how stress could affect cognitive processes. According to the theory, arousal from stress could bias perception and attention. That is, arousal in-

creases resource allocated for high-priority information processing at the expense of low-priority information processing. Information directly related to the current stressor is usually prioritized during stressful situations, so even when a task is assigned, one's attention would be biased towards it instead of the given task (Shields et al., 2016). In the same way, daily stress experiences would have hindered task-related information processing of highly stressed adolescents, resulting in lower PSI scores. This is also in line with Gagnon and Wagner's (2016) explanation about the trade-off between top-down and bottom-up processing in a stressful situation. The processing of task-relevant stimuli is volitionally promoted by the top-down attention network. However, since stress inhibits activation of this network, task-related processing is impeded in stressful situations. Combining the results until now, we could interpret that stress does not affect all cognitive processes in the same way despite its overall tendency of non-significant association with intelligence. General intelligence along with crystallized intelligence, visual processing ability, fluid reasoning ability, and short-term memory only declines under clinical-level stress, while processing speed could easily be impeded with daily stress.

Second, adolescent optimism predicted intelligence positively. The FSIQ and five primary index scores all showed significant correlation with optimism. This could be explained by previous theories suggesting that optimism helps continue strategy utilization, promotes performance and learning attempts through confidence, and induces positive emotions which broaden thought-action repertoires (Bjorklund, 2009; Miller, 2000; Fredrickson, 1998). In addition, our result is consistent with previous studies conducted on young children (Bjorklund et al., 1993; Kim & Kwak, 2011; Shin et al., 2007), which indicates that optimism has positive impact on intelligence of adolescents as well as young children.

This is understandable considering the characteristics of human adolescence. Through evolution, humans experience longer adolescence than other species and they learn various thoughts and behaviors required from the environment during this period (Thompson & Nelson, 2011). Since adolescence is a time of increased learning and plasticity as such, optimism could actively promote novel ways of thinking and acting during this period, leading to a positive growth in intelligence. Taken these explanations into account, we expect that our result could provide the basis for future discussions on the role of optimism in the intellectual domain.

Finally, optimism mediated the relationship between stress and intelligence among adolescents in general. The mediating effect of optimism was significant in FSIQ, VCI, VSI, FRI, and WMI among the intelligence index scores. On the other hand, mediating effect did not appear in the case of PSI, which indicated that stress had a direct adverse effect on processing speed rather than affecting it through optimism. The overall significance of the indirect effect demonstrated that high daily stress could adversely affect intelligence through lowered optimism among adolescents. Along with the overall nonsignificant direct effect, this result showed that stress in daily life cannot directly impede intellectual performance but is enough to hinder one's optimism. Although intelligence and optimism both appear relatively malleable in adolescence, a study on optimism reported low stability even down to .35, indicating a great responsiveness of optimism to contextual changes (Segerstrom, 2007). While optimism is known as a resource that modifies the adverse effect of stress (Nes & Segerstrom, 2006), it could also be diminished by stressful experiences in turn (Atienza et al., 2004; Tetzner & Becker, 2019), according to the social-cognitive perspective of personality. Following this view, we could assume that adolescents with low optimism are more

vulnerable to stress, and this could initiate a downward spiral that further reduces their level of optimism. This would result in adolescent intelligence exposed to various risk factors without sufficient buffer resource, leading to its impediment. Such explanation implies how important it is to maintain or improve optimism during adolescence, when optimism could easily be hindered by stress. Put it all together, we revealed the pathway from stress to intelligence among adolescents by demonstrating the mediating role of optimism in between.

Limitations of the current study are as follows. First, this study was conducted with a cross-sectional research design, so it is not enough to provide evidence for a causal relationship. Especially, although we aimed to study the role of optimism and thereby tested the pathways through which optimism mediates stress and intelligence, previous research suggests that optimism and stress could mutually influence each other (Boselie et al., 2014; Nes & Segerstrom, 2006; Tetzner & Becker, 2019). Hence, prospective longitudinal studies will be needed in the future to demonstrate causality. Second, in the current study, we aimed to measure variables in the most appropriate way among a large number of adolescents. With reference to previous studies (Rahdar & Galván, 2014; Wu et al. 2021), self-report method was used to measure stress that adolescents experience. However, since response bias could occur in a self-report questionnaire, subsequent studies should consider reducing bias by collecting additional data from multiple sources (e.g., parents, teachers, peers). Third, it is also possible that other variables not included in this study could explain part of the result (e.g., SES, family structure, grade, self-regulation capacity). Thus, additional variables should be considered in related future studies. For instance, Boselie et al. (2014) attributed the deteriorating effect of pain on executive function performance to the depletion of self-regulation capacity.

However, this adverse effect disappeared under optimistic condition, implying that optimism may have enhanced self-regulation. Considering this, future studies could additionally investigate the role of self-regulation in the relationship between adolescent stress, optimism, and intelligence. Fourth, the correlation coefficient between the variables is not so high. Therefore, the results should be interpreted with caution as they may be statistically significant because of the large sample size. Finally, we suggest that the variables could be studied using other methods in the future. For instance, it would be meaningful to identify the cognitive profile of adolescents by applying a person-centered approach (e.g., latent profile analysis) and to examine how stress or optimism could affect each cluster of individuals.

Despite some limitations, this study has significant implications for researchers, educators, and practitioners. First, the current study investigated the relationship between adolescent intelligence and variables that could affect its development. Through this investigation, we expanded the knowledge base on intelligence and provided direction for discussions on how to protect and enhance adolescent intelligence. Also, as this study focused on stress as one of the intelligence-related variables, we comprehensively examined how stress in adolescence could affect major cognitive abilities. Since prior results regarding the relationship between stress and intelligence were mixed, we empirically reconsidered it on a large sample of adolescents. Furthermore, we focused on adolescent optimism as another intelligence-related variable and expanded its role to the intellectual domain. Further studies could hence build upon our findings. Last, the current study is the first empirical attempt to investigate whether optimism mediates the relationship between stress and intelligence among adolescents. Through this attempt, we shed light on the path by which stress in adolescence is associated with

intelligence. Our result also implied that the intervention for enhancing optimism could prevent stress-induced cognitive impairment among severely stressed adolescents. Thus, we suggest that steps should be taken in hospitals and schools to implement optimism improvement programs for stressed adolescents.

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