

Future Self-Continuity and Adolescents' Depression: The Mediating Role of Pleasure Experience and the Moderating Role of School Connectedness

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Objective: Adolescent depression poses a significant mental health challenge. Drawing on cognitive theories of depression and the anhedonia susceptibility model, this study examined whether future self-continuity is associated with depressive symptoms through pleasure experience (anticipatory and consummatory pleasure), and whether these pathways are moderated by school connectedness.

Methods: Using a cross-sectional design, self-report data were collected from 835 adolescents (mean age = 16.40 years; 67.4% female) in China. Participants completed the Future Self-Continuity Questionnaire, Temporal Experience of Pleasure Scale, School Connectedness Scale, and Self-rating Depression Scale.

Results: (1) Future self-continuity positively predicted anticipatory pleasure ($\beta = 0.181, P < 0.001$) and consummatory pleasure ($\beta = 0.166, P < 0.001$). Both anticipatory pleasure ($\beta = -0.231, P < 0.001$) and consummatory pleasure ($\beta = -0.141, P < 0.001$) negatively predicted depression. (2) School connectedness moderated the paths from future self-continuity to anticipatory pleasure ($\beta = -0.056, P = 0.017$) and consummatory pleasure ($\beta = -0.098, P < 0.001$). (3) For depression prediction, the interaction between future self-continuity and school connectedness (Anticipatory model: $\beta = -0.093, P < 0.001$; Consummatory model: $\beta = -0.107, P < 0.001$) and the interactions between school connectedness and pleasures were significant (Anticipatory: $\beta = -0.084, P < 0.05$; Consummatory: $\beta = -0.063, P < 0.05$). (4) The indirect effect via anticipatory pleasure was significant across all levels of school connectedness, whereas the indirect effect via consummatory pleasure was non-significant at high levels of school connectedness.

Conclusion: These findings suggest that a coherent and positive sense of the future self is associated with lower levels of depressive symptoms in adolescents through greater pleasure capacity, particularly within supportive school environments. The results underscore the importance of integrating future-oriented self-concept interventions with school-based strategies to promote adolescent mental health.

Keywords: future self-continuity, anticipatory pleasure, consummatory pleasure, school connectedness, depression, adolescents

Introduction

Depression is a prevalent psychological disorder that significantly impacts adolescents, with early onset associated with a longer duration, greater severity, and higher recurrence rates.¹ Adolescence is a critical period for self-identity and personality development, and depressive symptoms during this time can adversely affect academic performance,

interpersonal relationships, and long-term mental health.² Understanding the psychological mechanisms that underlie adolescent depression is essential for developing effective interventions.

The cognitive theory of depression suggests that negative self-evaluation and cognition are pivotal factors influencing depression.³ According to Hershfield's theoretical model, future self-continuity reflects the degree to which individuals identify with their future selves and refers to the psychological connection between an individual's present self and their future self, reflecting the perceived continuity and coherence across temporal self-concepts.⁴ Future self-continuity is conceptually distinct from generalized optimism and temporal orientation: whereas optimism reflects positive expectations about future outcomes and temporal orientation refers to a general focus on the past, present, or future,^{5,6} future self-continuity specifically captures the perceived similarity, vividness, and positivity of one's future self relative to the present self.⁷ Individuals with higher future self-continuity perceive their future selves as more similar to their present selves, envision clearer and more vivid representations of their future selves, and hold more positive evaluations of them.⁷ As an indicator of temporal self-coherence, future self-continuity may constitute a significant factor in adolescent depression.⁸ Therefore, elucidating the relationship between future self-continuity and adolescent depression could provide novel insights into the underlying mechanisms of this condition.

A model of depression susceptibility centered on anhedonia highlights the role of impaired positive emotions in the onset of depression. Anhedonia, defined as a reduced capacity to experience pleasure, is a core feature of depression and is often accompanied by deficits in positive affect and approach motivation. Conceptually, anhedonia can be differentiated into present-state (consummatory) and anticipatory components, with the latter reflecting diminished pleasure derived from future-oriented expectations. The broaden-and-build theory suggests that positive emotions enhance future self-continuity, while negative emotions diminish it.⁹ Temporal Self-Regulation Theory (TSRT) further posits that future-oriented self-representations play a central role in behavior regulation by shaping how individuals anticipate, value, and pursue future rewards.¹⁰ From this perspective, a weakened sense of future self-continuity may be particularly detrimental to anticipatory pleasure capacity, which relies on the ability to mentally simulate rewarding future experiences and assign motivational value to them, rather than to general positive affect that is more strongly driven by immediate emotional states.¹¹ Accordingly, reduced anticipatory pleasure capacity may constitute a key pathway through which diminished future self-continuity is associated with depressive symptoms.

School connectedness reflects students' sense of belonging and identification with their school environment, encompassing cognitive, emotional, and behavioral engagement. Specifically, cognitive engagement involves active participation in learning, emotional engagement includes feelings of attachment and belonging, and behavioral engagement pertains to participation in school activities and adherence to norms. It primarily includes teacher support, peer support, and a sense of school belonging.¹² According to ecological systems theory, psychological development is a nested process centered on the individual and influenced by external environmental factors.¹³ Based on the depression susceptibility model, environmental factors can significantly influence personality and cognitive changes, which in turn may contribute to the development of anhedonia. Family and school are two closely connected environmental factors that exert a direct influence on an individual's self-development. As adolescents gradually reduce their dependence on the family, school becomes a critical context for their individualization and socialization. Thus, school connectedness emerges as a significant factor in adolescent development.¹⁴ It has been reported that individual levels of student connectedness were associated with lower levels of suicidal behavior and depression.¹⁵ As a key variable influencing adolescents' positive development and mental health,^{14,16} school connectedness may moderate the relationships among future self-continuity, pleasure experience, and adolescent depression.

In summary, this study examines the potential relationships among future self-continuity, pleasure experience, and adolescent depression, as well as the moderating role of school connectedness. We test the following hypotheses: H1: Future self-continuity will be negatively associated with adolescent depression, and this relationship will be mediated by pleasure experience. H2: School connectedness will moderate the relationship between future self-continuity and anticipatory pleasure. H3: School connectedness will moderate the indirect effect of future self-continuity on depression through anticipatory pleasure. The findings are intended to inform the development of targeted intervention programs aimed at preventing and mitigating adolescent depression.

Method

Participants and Procedure

This study was conducted via a convenience sampling administered self-report questionnaires to obtain data from adolescents residing in Shandong Province, China, selected based on accessibility and cooperation with the research team. Inclusion criteria included adolescents aged 15–19 years who were currently enrolled in school and able to read and complete the questionnaire independently. Exclusion criteria encompassed individuals with a known history of severe psychiatric disorders or those unable to provide informed consent. The sample consisted of 900 adolescents recruited through collaboration with school administrators who distributed invitations during class time. After excluding incomplete or invalid responses (eg, failing to select “strongly agree” for a prompt instructing them to do so), 835 valid questionnaires were retained, yielding an effective response rate of 92.8%. The achieved statistical power based on the current sample size was calculated using G*Power 3.1. With $N = 835$, $\alpha = 0.05$, and a moderate effect size ($f^2 = 0.15$), the achieved power was > 0.99 (approximately 1.00). This indicates that the present study was more than sufficiently powered to detect moderate effects in the tested regression equations.

The participants had a mean age of 16.40 years ($SD = 0.71$). The sample included 272 males (32.6%) and 563 females (67.4%). Geographically, 230 participants were from urban areas (27.5%), while 605 were from rural areas (72.5%). Urban/rural classification was based on participants’ self-reported current residential area, with “urban” referring to city or county-level urban districts, and “rural” referring to townships or villages, consistent with prior research on residential distinctions in adolescent mental health.¹⁷ Additionally, 66 participants (7.9%) were only children, and 769 (92.1%) were non-only children. This study was carried out following the Declaration of Helsinki and approved by the Ethics Committee of Qingdao University (Approval No.: QDU-HEC-2022216). Written consent was obtained from all participants and their legal guardians after they were informed about the study details.

To mitigate potential common method bias, several procedural remedies were implemented during the study design and data collection stages, following recommendations by Podsakoff et al^{18,19} All questionnaires were administered anonymously, and participants were explicitly informed that there were no right or wrong answers, thereby reducing evaluation apprehension. In addition, different Likert-type response formats were used across measures, and the constructs were presented in separate sections to minimize respondents’ tendency to infer hypothesized relationships among variables.

Measures

Future Self-Continuity Questionnaire

The Future Self-Continuity Questionnaire, developed by Sokol et al,²⁰ translated and revised by Zhang Feng et al,²¹ was used to assess future self-continuity. The questionnaire comprises 10 items across three dimensions: similarity, vividness, and positivity. Responses are rated on a 6-point scale, ranging from “completely different/not vivid/dislike” to “completely similar/vivid/like.” Higher scores indicate stronger future self-continuity. In this study, the Cronbach’s α coefficient for the scale was 0.908, indicating high internal consistency.

Temporal Experience of Pleasure Scale

The Temporal Experience of Pleasure Scale (TEPS) was employed to assess pleasure experience (pleasure capacity). This 18-item scale measures two dimensions: anticipatory pleasure (experiencing pleasure in anticipation of future events, 10 items) and consummatory pleasure (experiencing pleasure from ongoing activities, 8 items).²² Responses are rated on a 6-point scale, ranging from “strongly disagree” to “strongly agree.” Higher scores indicate greater pleasure capacity whereas lower scores reflect greater anhedonia. In this study, the Cronbach’s α coefficient for the scale was 0.932, indicating excellent internal consistency.

School Connectedness Scale

The School Connectedness Scale, developed by Yu, was employed to assess school connectedness.²³ This 10-item scale comprises three dimensions: peer support, teacher support, and sense of school belonging. Responses are rated on a 5-point Likert scale, ranging from “strongly disagree” to “strongly agree”. Higher scores indicate greater levels of

school connectedness. In this study, the Cronbach's α coefficient for the scale was 0.874, indicating good internal consistency.

Self-Rating Depression Scale

The Self-Rating Depression Scale (SDS), developed by Zung,²⁴ was employed to assess depressive symptoms. This scale consists of 20 items, rated on a 4-point scale ranging from "none or a little of the time" to "most or all of the time". Among these items, 10 are scored positively, and 10 are scored negatively. The total score is calculated by summing the item scores, multiplying by 1.25, and rounding to the nearest integer. Higher scores reflect greater severity of depressive symptoms. In this study, the Cronbach's α coefficient for the SDS was 0.846, indicating satisfactory internal consistency.

Statistical Analyses

Data analyses were conducted using SPSS 27.0. Initially, common method bias was assessed. Prior to the main analysis, assumptions of normality and multicollinearity were tested. Skewness and kurtosis values for all main variables fell within acceptable ranges (absolute skewness < 0.8, absolute kurtosis < 0.8), indicating that the data approximated a normal distribution. Multicollinearity diagnostics revealed that all VIF values were below 2 and tolerance values exceeded 0.60, suggesting no substantial multicollinearity concerns among predictors. Subsequently, descriptive statistics and correlation analyses were performed to examine the basic characteristics and relationships among the variables. The mediation and moderation effects were tested using the PROCESS macro.

Results

Common Method Bias Test

Harman's single-factor test was conducted to assess common method bias.²⁵ The first factor accounting for 24.9% of the variance, which is below the critical threshold of 40%. This suggests that common method bias was not a significant concern in this study.

Descriptive Statistics and Correlation Analysis

As shown in Table 1, future self-continuity was significantly and positively correlated with both anticipatory pleasure and consummatory pleasure, as well as with school connectedness and depression. Both anticipatory pleasure and consummatory pleasure were significantly positively associated with school connectedness and negatively associated with depression. School connectedness also showed a strong negative correlation with depression.

Moderated Mediation Analysis

Table 2 presents the detailed results of the moderated mediation model with anticipatory pleasure as the mediator. The model predicting anticipatory pleasure explained a significant portion of variance ($R^2 = 0.205$, $F(5, 829) = 42.862$, $P < 0.001$). Future self-continuity ($\beta = 0.181$, $P < 0.001$) and school connectedness ($\beta = 0.311$, $P < 0.001$) both positively predicted anticipatory pleasure, and their interaction was significant ($\beta = -0.056$, $P = 0.017$, $\Delta R^2 = 0.006$). Simple slope analyses indicated that future self-continuity positively predicted anticipatory pleasure at low ($\beta = 0.236$, $P < 0.001$), mean ($\beta = 0.181$, $P < 0.001$), and high levels of school connectedness ($\beta = 0.125$, $P = 0.003$) (Figure 1A). This pattern

Table 1 Descriptive Statistics and Correlation Analysis of Each Variable

Main Variables	M \pm SD	1	2	3	4	5
1 Future self-continuity	35.94 \pm 9.32	1				
2 Anticipatory Pleasure	39.72 \pm 10.12	0.330***	1			
3 Consummatory Pleasure	30.11 \pm 8.75	0.278***	0.828***	1		
4 School connectedness	35.39 \pm 7.26	0.444***	0.404***	0.315***	1	
5 Depression	49.95 \pm 11.64	-0.312***	-0.401***	-0.279***	-0.535***	1

Note: *** indicates $P < 0.001$.

Table 2 Moderated Mediation Analysis Predicting Depression via Anticipatory Pleasure

Outcome Variable	Predictor	β	SE	t	P
Anticipatory Pleasure	Future self-continuity	0.181	0.035	5.22	< 0.001
	School connectedness	0.311	0.035	8.9	< 0.001
	Future self-continuity \times School connectedness	-0.056	0.023	-2.39	0.017
	Gender	0.069	0.067	1.03	0.304
Depression	Age	-0.079	0.031	-2.52	0.012
	Future self-continuity	-0.057	0.031	-1.82	0.069
	Anticipatory pleasure	-0.231	0.031	-7.43	< 0.001
	School connectedness	-0.452	0.033	-13.90	< 0.001
	Future self-continuity \times School connectedness	-0.093	0.024	-3.95	< 0.001
	Anticipatory pleasure \times School connectedness	-0.084	0.025	-3.35	< 0.001
	Gender	-0.016	0.06	-0.27	0.784
	Age	0.062	0.028	2.22	0.027

Note: All variables are standardized. β , standardized coefficients; SE, standard error; t, t statistic; P, two-tailed significance level.

suggests that high school connectedness serves a compensatory role, buffering the impact of low future self-continuity on reduced anticipatory pleasure. For the outcome variable (depression), the model exhibited excellent fit ($R^2 = 0.371$, $F(7, 827) = 69.778$, $P < 0.001$). Anticipatory pleasure ($\beta = -0.231$, $P < 0.001$) and school connectedness ($\beta = -0.452$, $P < 0.001$) negatively predicted depression. The interactions between future self-continuity and school connectedness ($\beta = -0.093$, $P < 0.001$, $\Delta R^2 = 0.012$) and between anticipatory pleasure and school connectedness ($\beta = -0.084$, $P < 0.001$, $\Delta R^2 = 0.009$) were also significant. Simple slope tests for the future self-continuity \times school connectedness interaction on depression revealed that when school connectedness was low, future self-continuity did not significantly predict depression ($\beta = 0.036$, $P = 0.374$); when school connectedness was high, future self-continuity significantly and negatively predicted depression ($\beta = -0.150$, $P < 0.001$) (Figure 1B), indicating that high school connectedness strengthens the protective effect of future self-continuity against depression. For the anticipatory pleasure \times school connectedness interaction on depression, simple slopes showed that the negative predictive effect of anticipatory pleasure was stronger when school connectedness was high ($\beta = -0.314$, $p < 0.001$) than when school connectedness was low ($\beta = -0.147$, $P < 0.001$) (Figure 1C). Conditional standardized indirect effects showed that the indirect effect of future self-continuity on depression through anticipatory pleasure was significant across all levels of school connectedness: low school connectedness ($\beta = -0.035$, 95% CI = [-0.060, -0.015]), mean school connectedness ($\beta = -0.042$, 95% CI = [-0.065, -0.020]), and high school connectedness ($\beta = -0.039$, 95% CI = [-0.077, -0.003]). This indicates a robust mediation effect that persists across different levels of school connectedness.

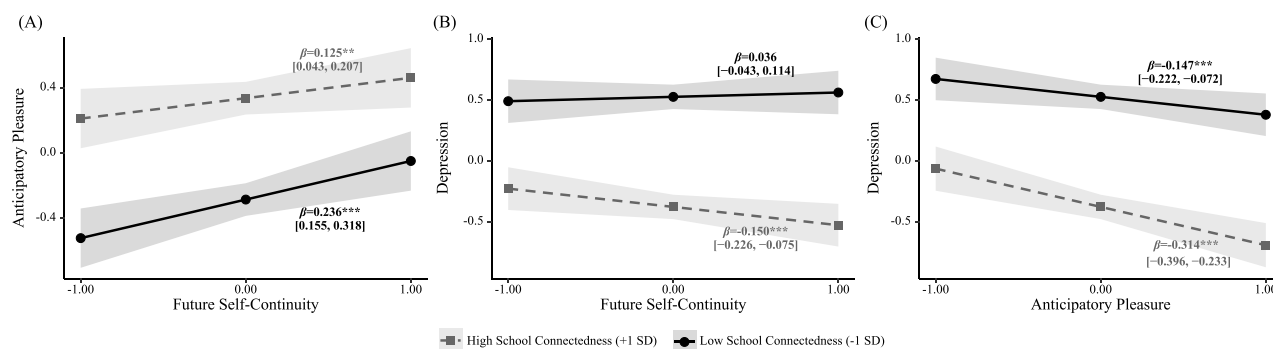


Figure 1 Moderating effects of school connectedness in the model with anticipatory pleasure as the mediator. Panel (A) shows the moderating effect of school connectedness on the relationship between future self-continuity and anticipatory pleasure. Panel (B) illustrates the moderating effect of school connectedness on the relationship between future self-continuity and depression. Panel (C) presents the moderating effect of school connectedness on the relationship between anticipatory pleasure and depression. All variables are standardized. High and low school connectedness are defined as ± 1 standard deviation (SD) from the mean. Shaded areas show 95% CIs for simple slopes. ** $P < 0.01$, *** $P < 0.001$.

Table 3 Moderated Mediation Analysis Predicting Depression via Consummatory Pleasure

Outcome Variable	Predictor	β	SE	t	P
Consummatory Pleasure	Future self-continuity	0.166	0.036	4.63	< 0.001
	School connectedness	0.22	0.036	6.08	< 0.001
	Future self-continuity \times School connectedness	-0.098	0.024	-4.03	< 0.001
Depression	Gender	-0.005	0.069	-0.08	0.939
	Age	-0.069	0.033	-2.12	0.034
	Future self-continuity	-0.076	0.032	-2.36	0.019
	Consummatory pleasure	-0.141	0.031	-4.58	< 0.001
	School connectedness	-0.494	0.033	-15.19	< 0.001
	Future self-continuity \times School connectedness	-0.107	0.023	-4.59	< 0.001
	Consummatory pleasure \times School connectedness	-0.063	0.026	-2.48	0.013
	Gender	-0.029	0.061	-0.47	0.641
	Age	0.072	0.029	2.53	0.012

Note: All variables are standardized. β , standardized coefficients; SE, standard error; t, t statistic; P, two-tailed significance level.

Table 3 presents the detailed results of the moderated mediation model with consummatory pleasure as the mediator. In contrast to the anticipatory pleasure model, this model explained less variance in the mediator ($R^2 = 0.145$, $F(5, 829) = 28.163$, $P < 0.001$). Future self-continuity ($\beta = 0.166$, $P < 0.001$) and school connectedness ($\beta = 0.220$, $P < 0.001$) positively predicted consummatory pleasure, with a significant interaction ($\beta = -0.098$, $P < 0.001$, $\Delta R^2 = 0.017$). Simple slope analyses revealed that future self-continuity significantly predicted consummatory pleasure at low ($\beta = 0.264$, $P < 0.001$) and mean levels of school connectedness ($\beta = 0.166$, $P < 0.001$), whereas this association was no longer significant at high levels of school connectedness ($\beta = 0.069$, $P = 0.113$). (Figure 2A). For depression, the model’s explanatory power was lower ($R^2 = 0.343$, $F(7, 827) = 61.726$, $P < 0.001$) than that of the anticipatory pleasure model. Future self-continuity ($\beta = -0.076$, $P = 0.019$), consummatory pleasure ($\beta = -0.141$, $P < 0.001$), and school connectedness ($\beta = -0.494$, $P < 0.001$) negatively predicted depression, with significant interactions between future self-continuity and school connectedness ($\beta = -0.107$, $P < 0.001$, $\Delta R^2 = 0.017$) and between consummatory pleasure and school connectedness ($\beta = -0.063$, $P = 0.013$, $\Delta R^2 = 0.005$). Simple slope tests for the future self-continuity \times school connectedness interaction on depression showed that when school connectedness was low, future self-continuity did not significantly predict depression ($\beta = 0.032$, $P = 0.440$); when school connectedness was high, future self-continuity significantly and negatively predicted depression ($\beta = -0.183$, $P < 0.001$) (see Figure 2B). For the consummatory pleasure \times school connectedness interaction on depression, simple slopes revealed that the negative predictive effect of consummatory pleasure was stronger when school connectedness was high ($\beta = -0.204$, $P < 0.001$) than when school

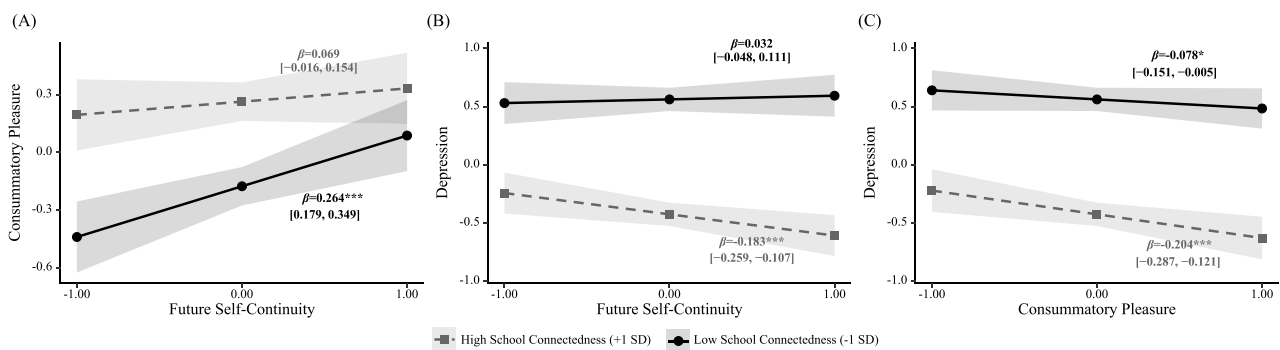


Figure 2 Moderating effects of school connectedness in the model with consummatory pleasure as the mediator. Panel (A) shows the moderating effect of school connectedness on the relationship between future self-continuity and consummatory pleasure. Panel (B) illustrates the moderating effect of school connectedness on the relationship between future self-continuity and depression. Panel (C) presents the moderating effect of school connectedness on the relationship between consummatory pleasure and depression. All variables are standardized. High and low school connectedness are defined as ± 1 standard deviation (SD) from the mean. Shaded areas show 95% CIs for simple slopes. * $P < 0.05$, *** $P < 0.001$.

connectedness was low ($\beta = -0.078$, $P = 0.037$) (see Figure 2C). However, the conditional standardized indirect effect of future self-continuity on depression through consummatory pleasure was only significant at low ($\beta = -0.021$, 95% CI = $[-0.045, -0.002]$) and mean ($\beta = -0.023$, 95% CI = $[-0.041, -0.010]$) school connectedness levels, but not at high school connectedness ($\beta = -0.014$, 95% CI = $[-0.037, 0.008]$). The non-significant indirect effect at high school connectedness level highlights that consummatory pleasure is a less stable mechanism than anticipatory pleasure in explaining the protective role of future self-continuity.

Discussion

The findings demonstrated that higher future self-continuity is associated with greater pleasure capacity (higher anticipatory/consummatory pleasure), which in turn mitigates depressive symptoms. Additionally, school connectedness moderates the relationship between future self-continuity and depression, as well as the mediated pathway through pleasure experience.

Consistent with prior work, higher future self-continuity was associated with fewer depressive symptoms.²⁰ Future self-continuity refers to the perceived connection, similarity, and sense of unity between one's present and future self.²⁶ According to the future self-continuity model, individuals with a more positive attitude toward their future selves are more likely to make decisions and engage in behaviors that are beneficial to their future selves.²⁷ When adolescents perceive their future self as psychologically connected to who they are now, they may be more inclined to engage in future-oriented, goal-directed behaviors and to interpret setbacks as temporary and manageable rather than as personally defining. Conversely, perceiving the future self as distant or disconnected may be accompanied by reduced motivation to invest in long-term goals and a greater sense of meaninglessness or helplessness, which could heighten vulnerability to depressive symptoms.

Pleasure experience, particularly anticipatory pleasure, served as a key statistical pathway linking future self-continuity to depressive symptoms. Notably, the findings revealed meaningful differences between anticipatory and consummatory pleasure in explaining the protective role of future self-continuity against adolescent depression. Future self-continuity showed a more robust and consistent association with anticipatory pleasure, remaining significant across all levels of school connectedness, whereas its association with consummatory pleasure was conditional and disappeared at high levels of school connectedness. Correspondingly, the indirect effect of future self-continuity on depression via anticipatory pleasure was stable across contexts, while the indirect effect via consummatory pleasure was context-dependent and non-significant in highly connected school environments. These distinctions suggest that future self-continuity primarily operates through future-oriented reward processes rather than immediate hedonic responses, pointing to anticipatory pleasure as a central mechanism linking self-representation to emotional well-being.^{28,29}

From a neuroscientific perspective, adolescence is a period marked by significant developmental changes in brain regions involved in both reward processing and future-oriented cognition.³⁰ The limbic system, which plays a central role in processing immediate rewards, is highly active during adolescence, contributing to heightened risk-taking and sensation-seeking behaviors.³¹ In contrast, the prefrontal cortex, responsible for self-regulation, decision-making, and future-oriented thinking, matures more gradually. This imbalance between the impulsive reward-seeking system and the developing cognitive control system may contribute to the difficulties adolescents face in balancing immediate gratification with long-term goals.³² Within this developmental context, weaker future self-continuity may be associated with less effective integration of future-oriented cognition and reward processing, which may relate to lower anticipatory pleasure and greater depressive symptoms.

Moreover, the moderation analysis demonstrated that school connectedness significantly moderated the entire mediation model, including the direct path from future self-continuity to depression and both segments of the indirect pathway through pleasure experience. Specifically, school connectedness buffered the association between low future self-continuity and reduced pleasure capacity, suggesting that supportive peer and teacher relationships and a positive school climate may provide alternative sources of meaning, reward, and hope when adolescents lack a clear or coherent future self-image.¹² In addition, school connectedness attenuated the negative association between reduced pleasure capacity and emotional well-being, such that supportive social relationships and a structured school environment offering positive feedback and reinforcement helped mitigate the emotional risks associated with elevated anhedonia.¹⁵ School

connectedness also moderated the direct link between future self-continuity and depression, indicating that an external sense of structure and guidance embedded in the school context may compensate for a weak internalized future self.³³ These findings are consistent with the interpersonal theory of depression, which emphasizes that disrupted relationships undermine individuals' sense of belonging and increase depression risk, as well as with self-determination theory, which posits relatedness as a fundamental psychological need for healthy development.³⁴ From this perspective, high levels of school connectedness may fulfill adolescents' relatedness needs, strengthen intrinsic motivation, and function as a key contextual protective factor that dynamically interacts with individual self-representations to influence depressive outcomes.³⁵

It also should be noted that the interaction between future self-continuity and school connectedness in predicting anticipatory pleasure exhibited a seemingly counterintuitive pattern, such that the positive association between future self-continuity and pleasure was stronger among adolescents with lower, rather than higher, levels of school connectedness (Figures 1A). According to the protective-protective model, the joint effects of two protective factors can be explained by two alternative hypotheses: the enhancing hypothesis and the antagonistic hypothesis.³⁶ The enhancing hypothesis proposes that one protective factor strengthens the beneficial effect of another, whereas the antagonistic hypothesis suggests that the protective effect of one factor is particularly pronounced when the other protective factor is relatively weak.³⁷ Consistent with the antagonistic interaction hypothesis, the present findings indicate that future self-continuity and school connectedness may function as mutually compensatory protective factors for anticipatory pleasure, such that future self-continuity plays a more salient role in sustaining pleasure capacity when school connectedness is low.³³

These results enrich our understanding of the key factors and mechanisms underlying adolescent depression, and highlight that future self-continuity, pleasure experience, and school connectedness are critical factors influencing adolescent depression, providing practical guidance for developing intervention strategies. For instance, interventions to foster future self-continuity can involve guiding adolescents through future self-imagery or writing exercises, helping them build an emotional connection with their future self to enhance long-term goal-directed behavior.^{4,38} Interventions to enhance school connectedness can include structured mentoring programs or support from mentors, increasing adolescents' sense of belonging and social support within the school community, thereby promoting mental health and positive academic outcomes.^{39,40}

Several limitations should be noted. First, the cross-sectional design precludes causal inferences; longitudinal or experimental studies are needed to establish directionality. Second, all measures were self-reported, which may introduce common-method bias; future research could incorporate behavioral tasks or multi-informant data. Third, the sample was drawn from a specific cultural and age group, limiting generalizability; replications in diverse populations are warranted.

Conclusion

This study found that future self-continuity was associated with lower levels of depressive symptoms in adolescents, both directly and indirectly through pleasure experience, particularly anticipatory pleasure, within the context of school connectedness. Importantly, school connectedness emerged as a significant moderating factor, suggesting that it may function as a compensatory contextual resource that buffers the association between low future self-continuity and depressive symptoms.

The findings should be interpreted with caution, as the sample was limited to adolescents from Shandong Province, China, which may restrict generalizability to other regions or cultural contexts. Future longitudinal and intervention studies are needed to test the temporal ordering and causal mechanisms implied by this model and to evaluate whether enhancing future self-continuity and school connectedness can prospectively reduce adolescent depressive symptoms.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding authors upon reasonable request.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing interests in this work.

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