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Early self-regulation, early self-regulatory change, and their longitudinal relations to adolescents' academic, health, and mental well-being outcomes

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Abstract

Objective: To evaluate the extent to which early self-regulation and early changes in self-regulation are associated with adolescents' academic, health, and mental well-being outcomes.

Methods: Data were collected from 1 of the cohorts in a large dual-cohort cross-sequential study of Australian children. This cohort consisted of a nationally representative data set of 4983 Australian children assessed at 4 to 5 years of age, who were followed longitudinally to 14 to 15 years of age. Using regression within a path analysis framework, we first sought to investigate associations of early self-regulation (at 4-5 years and 6-7 years of age) with a broad range of academic, health, and mental well-being outcomes in adolescence (at 14-15 years). We next investigated the extent to which an early change in self-regulation (from 4 to 7 years of age) predicted these adolescents' outcomes.

Results: Early self-regulation predicted the full range of adolescents' outcomes considered such that a 1-SD increase in self-regulation problems was associated with a 1.5- to 2.5-times greater risk of more-negative outcomes. An early positive change in self-regulation was associated with a reduced risk of these negative outcomes for 11 of the 13 outcomes considered.

Conclusion: These results suggest the potential of early self-regulation interventions, in particular, in influencing long-term academic, health, and well-being trajectories.

Disciplines
Education | Social and Behavioral Sciences

Early Self-Regulation, Early Self-Regulatory Change, and their Longitudinal Relations to Adolescents' Academic, Health, and Mental Wellbeing Outcomes

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Abstract

Objective: To evaluate the extent to which early self-regulation, and early change in self-regulation, are associated with adolescents' academic, health and mental wellbeing outcomes. *Method:* Data were drawn from one of the cohorts in a large dual-cohort cross-sequential study of Australian children. This cohort consisted of a nationally representative dataset of 4,983 Australian children assessed at 4-5 years of age, who were followed longitudinally to 14-15 years of age. Using regression within a path analysis framework, we first sought to investigate associations of *early* self-regulation (at 4-5 years and 6-7 years of age) with a broad range of academic, health, and mental wellbeing outcomes in adolescence (at 14-15 years). We next investigated the extent to which *early change* in self-regulation (from 4 to 7 years of age) predicted these adolescent outcomes. *Results:* Early self-regulation predicted the full range of adolescent outcomes considered, such that a 1 *SD* increase in self-regulation problems was associated with 1.5- to 2.5-times greater risk of more-negative outcomes. Early positive change in self-regulation was associated with reduced risk of these negative outcomes for 11 of the 13 outcomes considered. *Conclusion:* These results suggest the potential of early self-regulation interventions, in particular, for influencing long-term academic, health and wellbeing trajectories.

Keywords: self-regulation, early childhood, academic, substance use, mental health

INTRODUCTION

There is now extensive evidence that a young child's ability to exert control over their impulses and behaviors, attention and thinking, social interactions, as well as emotional and physiological reactions is related to a broad range of outcomes in later childhood and beyond. For children with low self-regulation in childhood, the likelihood of poorer academic outcomes[1] and poor health, substance abuse, financial difficulties, and criminal offending in adulthood is overwhelming.[2] The finding that any-cause improvements in childhood self-regulation are associated with more positive adult outcomes[2] further supports a likely causal role for self-regulation. Yet there is limited evidence of the particular importance of *early* self-regulation, and *early changes* in children's self-regulation, for later-life outcomes.

The emergence of individual differences in self-regulation in early childhood suggests a need to shift attention to younger children, as these (and related) skills lay a foundation for later development.[3] Research also suggests that early interventions, in particular, may produce more pronounced, stable and lasting changes,[4] and are more likely to produce greater return on investment.[5] Yet there is evidence that one-fifth of preschoolers do not improve in self-regulation over the preschool years–with implications for school readiness–and there are a concerning number of children who, at age 7, achieve levels of self-regulation common in 4-year olds.[6]

This suggests an imperative to increase knowledge about the implications of early levels of self-regulation for subsequent development. A particular period of developmental interest is adolescence, in which early self-regulation predicts the likelihood of engaging in harmful lifestyle behaviors as an adolescent (i.e., smoking, school dropout, unplanned pregnancy).[2] These lifestyle 'snares' further increase the risk of poorer adult outcomes, in addition to their immediate impacts.[2]

The developmental path from early self-regulation to later academic achievement and risk behavior likely involves a complex causal sequence, involving multiple transactional processes among individual and environmental factors. For instance, early self-regulatory problems are associated with problems in relating to peers,[7] internalizing and externalizing behavior problems,[8] and early anxiety,[9] all of which are possible precursors to adolescent mental health problems, risky behaviors, and school truancy. In contrast, children with better early self-regulatory abilities are more likely to develop positive peer relations[10] and stronger prosocial skills,[11] and experience less teacher-child conflict in the early school years.[12] These are all likely to increase academic engagement and success across time, and reduce the risk of poorer adolescent outcomes. Moreover, there are also likely direct effects of self-regulation on adolescent outcomes, as sufficiently high self-regulation facilitates individuals' ability to resist impulses (e.g., to commence and continue smoking), intrusive thoughts (e.g., related to self-harm), and distraction (e.g., from learning). High self-regulation supports an individual to sustain attention toward individual and contextual goals, while resisting interference from competing demands, as demonstrated by documented concurrent associations between self-regulation and performance/behavior into adulthood.[13]

Despite the importance of these developmental pathways from early self-regulation to later risk behaviors in adolescence, previous studies have generally focused only on early adolescence, before these risk behaviors become more prevalent, or have considered only a narrow range of adolescent outcomes.[2] As such, it remains unclear how self-regulation at different time points in early childhood may be associated with a broader range of later adolescent outcomes. The current study thus investigates the following questions:

1. What are the independent associations of self-regulation at each of 4-5 years and 6-7 years with a range of adolescent outcomes at 14-15 years, adjusting for important socio-demographic factors?

2. What are the associations between self-regulation at 6-7 years and outcomes at 14-15 years, controlling for self-regulation at 4-5 years? That is, to what extent does *change* in self-regulation across the transition to school period predict adolescent outcomes?

In line with previous assertions of the importance of early self-regulatory status, and potential benefits of early change in self-regulation, it was expected that both status and change would predict the range of adolescent outcomes considered, after controlling for important socio-demographic factors. The current study focuses on behavioral manifestations of cognitive (e.g., good attention span), behavioral (e.g., constantly fidgeting or squirming), social (e.g., shares readily with other children) and emotional domains of self-regulation (e.g., often has temper tantrums), through adult reports of children's observed behavior. While a complex interplay of factors are essential for understanding the reasons why attempts to self-regulate are successful or not (e.g., ability to control attention, adaptive vs. maladaptive goal setting, levels of persistence, selection and use of strategies, metacognition),[14] these are beyond the scope of the current study and remain an important area for further investigation.

METHODS

Participants

This study analysed data from the *Longitudinal Study of Australian Children* (LSAC), sponsored by the Australian Government through the Department of Social Services, which began in 2004. Full sampling and design details of LSAC are described elsewhere.[15] Briefly, LSAC employs a cross-sequential longitudinal design to follow two cohorts of approximately 5,000 children, aged 0-1 years and 4-5 years at recruitment in 2004. A two-stage clustered sampling design was used with 330 postcodes randomly selected and children randomly selected from these postcodes. Stratification was used to ensure the number of children in each state/territory, and within and outside each capital city, was proportionate to the population of children in these areas, except for remote and very remote communities. The

sampling frame was derived from the Medicare Australia database held by the Health Insurance Commission, which administers this universal health insurance scheme and in which more than 98% of all Australian children are enrolled by 12 months of age. Both LSAC cohorts are broadly representative of the Australian population. At each two-yearly data collection wave, parents and teachers complete questionnaires, computer assisted interviews are undertaken with parents and children, direct assessments with children are completed, and data are linked from a range of national databases. The focus for the current study was the Kindergarten (K) cohort, which comprised 4,983 children aged 4 to 5 years at Wave 1 in 2004, with data collected biennially thereafter. Self-regulation indices were available at each of two waves (when children were 4- to 5-years old and 6- to 7-years old), with outcome data collected when the children were 14- to 15-years old. Trained interviewers spent on average 106 minutes in the homes of each of the adolescents at the 14-15-year-old wave to collect parent interview data, adolescent self-complete computer assisted interview data, and to conduct direct assessments with the adolescents.

For the K cohort, a total of 51% of the children were boys and most spoke English as their main language at home (86%). A total of 3.8% of children identified as Aboriginal or Torres Strait Islander. Average weekly household income was $2,565.40 AUD. Maternal education levels when children were 4-5 years were: 22% had not completed high school; 16% had completed high school and no further study; 28% had certificate-level qualification; 7% had a diploma; 17% had a bachelors degree; and 11% had a postgraduate degree.

Variables

Descriptive statistics for all variables are found in Table 1.

Early Childhood Predictors. *Self-regulation problems* were indexed at 4-5 and 6-7 years of age by combining parent-, teacher-, and interviewer-report ratings of children's self-regulatory behaviors, paralleling the factor created by Moffitt et al.[2] (for correspondence of

items and respondents between the studies see Table 2; online). Constituent items index the extent to which children can control and sustain their attention (e.g., 'sees tasks through to the end'), as well as control their behavior (e.g., 'restless, overactive, cannot stay still for long') and emotions (e.g., 'often has temper tantrums'). Following the protocols of Moffitt et al.,[2] items were standardized and then averaged to create a single composite score, and were then restandardized. This 'self-regulation problems' factor, for which higher scores indicate more self-regulation problems, showed comparable inter-item correlations and internal consistency (alpha = 0.84 at 4-5 years, 0.86 at 6-7 years) as reported by Moffitt et al.[2]

Control variables included in the analyses were maternal education level (on a 6-point scale from incomplete high school to postgraduate degree), household income bracket, child gender, Aboriginal and Torres Strait Islander status (ATSI), language other than English (LOTE) background, a directly assessed measure of children's early receptive vocabulary (a proxy for verbal intelligence), and parent-reported frequency of parent-child book reading in the home during a typical week (a proxy for quality of the early home learning environment), all collected at 4-5 years.

Adolescent Outcomes. *Academic achievement* at 14-15 years was indexed by children's total scores on the Year 9 NAPLAN numeracy and writing subtests, part of a program of Australian standardized tests that are formally administered in schools and graded externally. The NAPLAN administering body reports children's results as Rasch modelled scores ranging from 0 to 1000 (for reading and numeracy respectively: α = .90, .83; average item discrimination = .42, .43).[16]

Mental health problems were measured in a private face-to-face interview with the parent/carer who knew the adolescent best, through a question that asked whether or not the adolescent had an ongoing condition in the area of depression or anxiety (1 = yes; 0 = no).

Overweight and obesity status was calculated using height and weight measurements taken during interview, which were converted to Body Mass Index (BMI) scores and used to calculate overweight and obese categories based on internationally recognized cut points (1 = overweight/obese, 0 = not overweight/obese).[17]

The remaining outcome measures were collected through audio computer-assisted self-interview, completed by each adolescent privately and confidentially within their home. This approach allowed for sensitive information to be provided by the adolescent with anonymity.

Self-harm ideation and behavior, and *suicidal ideation* were measured using a series of three dichotomous items, which asked adolescents if they had ever thought about hurting themselves, hurt themselves on purpose, and had ever considered attempting suicide (1 = yes, 0 = no for each item). Self-harm items were drawn from the Avon Longitudinal Study of Parents and Children,[18] which drew item wordings from the Childhood Interview for DSM-IV.[19] The suicidal ideation item was drawn from the National Survey of Mental Health & Wellbeing.[20] Similar items measuring self-harm through adolescent self-report have been found to be independently associated with symptoms of depression, anxiety, and antisocial behaviour, as measured through clinical interview in a large longitudinal study,[21] suggesting good predictive validity.

Substance use was measured using two items. First, had adolescents ever smoked part of a cigarette, with responses on a 5-point scale from 'no' to 'yes, I have smoked more than 100 cigarettes' (dichotomised as 1 = any level of cigarette smoking or 0 = no cigarette smoking, consistent with prior research[21]). Second, had adolescents ever had an alcoholic drink, with responses on a 4-point scale (1 = no; 2 = yes, just a few sips; 3 = yes, I have had fewer than 10 alcoholic drinks; 4 = yes, I have had 10 or more alcoholic drinks). Responses were then dichotomised with no drinking and 'just a few sips' coded as 0 and other responses coded as 1. Analyses were also repeated with a more stringent criteria for dichotomising (no drinking

= 0, 'just a few sips' or more = 1) and results presented below did not substantially differ. In a study using the same dataset as the current study, levels of adolescent drinking on this index were related to parents' levels of self-reported risky drinking, as expected,[22] suggesting the concurrent validity of the adolescent self-report item.

Crime was measured with a series of items that asked adolescents how often in the last 12 months they had engaged in certain behaviors, with responses on a 5-point scale from not at all to five or more times. Items were derived from the short form of the Self-Report of Delinquency scale.[23] Four items were related to *violent crimes* (e.g. got in to physical fights in public, carried a weapon) and nine items were related to *property offences* (e.g. stolen from a shop, drawn graffiti in public places. Items were summed and dichotomised to create a score of 1 = crime, 0 = no crime for each of *violent crimes* and *property offences*. Data on this measure for children aged 12-13 years have been associated with earlier risk factors including maternal alcohol use and harsh parenting, in line with expectations.[24]

School truancy was measured by a single item that asked adolescents whether they had ever been absent from school without parental permission (ranging from never to 10 times or more). Responses were dichotomised so that never was coded as 0 and one or more times of absence without parental permission was coded as 1.

Analytic Strategy

Regression models with multiple outcome variables were conducted in Mplus version 7.11. To address the first question, two models were run: one for self-regulation at 4-5 years and its association with adolescent outcomes (at 14-15 years); and one for self-regulation at 6-7 years and its association with adolescent outcomes. Path estimates represented linear regression coefficients for the two continuous outcome variables (i.e., reading and mathematics achievement), and logistic regression coefficients along with odds ratios are

presented for the 11 dichotomous outcome variables. Our identified covariates were included in both models as control variables.

To address the second research question we ran a third regression model incorporating self-regulation at 4-5 and 6-7 years as predictors of all adolescent outcomes, and controlling for the covariates. This approach to modelling means the estimated relationship between self-regulation problems at 6-7 years and the adolescent outcome represents residualized change in self-regulation problems from 4 to 7 years, because the effect of the earlier measure of self-regulatory problems has already been accounted for.

The amount of missing data ranged from no missing data for socio-demographic control variables, an average of 33% missing for adolescent outcome variables due primarily to study attrition, and 45% missing for the self-regulation composite at 4-5 years and 6-7 years due to item non-response on at least some of the constituent items of the composite score, including teacher-report and parent leave-behind survey items. Data were considered to be missing at random (MAR); that is, systematically related to other variables, but not likely related to the value of the self-regulation or outcome variables that would have been provided if the data were not missing.[25] For example, children with missing data on the self-regulation measure at 4-5 years had mothers with lower education levels and lower household income than those with complete data, but did not differ on parent-reported attentional and emotional regulation scales. Missing data were handled using full information maximum likelihood with a robust estimator and Monte Carlo integration, thereby retaining 98% of the sample in the statistical models. This approach yields unbiased estimates even when large amounts of missing data are present, because of the inclusion of variables representing the missing data mechanisms (in this case household income and maternal education) in the analytic model.[26] While this approach does not allow for reporting of typical fit indices where outcomes are categorical, such as those in the current study, comparison of model fits was not a goal of the current

research and models were not nested. We used the sampling weights provided for LSAC[15] to account for sampling error.

RESULTS

Descriptive statistics

Bivariate correlations and descriptive statistics for all variables are provided in Table 1. As expected, self-regulation problems at 4-5 years and 6-7 years were moderately correlated ($r = .67$), indicating a degree of longitudinal stability in this construct. Reading and numeracy achievement were also moderately correlated at 14-15 years ($r = .68$). Self-harm ideation and behavior, as well as suicidal ideation, were moderately correlated with each other. Most other correlations were small but significant.

Research Question 1: *What are the independent associations of self-regulation at each of 4-5 years and 6-7 years with a range of adolescent outcomes at 14-15 years, adjusting for important socio-demographic factors?*

Two separate models were run to determine the independent relations among self-regulation problems at each of 4-5 years and 6-7 years with the full complement of examined adolescent outcomes, controlling for identified covariates. Results are displayed in Table 3 (for unadjusted estimates see Table 4; online). Self-regulation problems at 4-5 years and at 6-7 years were significantly associated with each adolescent outcome. Specifically, a one-unit increase in self-regulation problems at either age was associated with an approximate one-fifth of a standard deviation reduction in reading and numeracy scores one decade later. Odds ratios for the dichotomous adolescent outcomes can be interpreted as risks. As such, a one-unit (equal to one standard deviation) increase in self-regulation problems in early childhood was subsequently associated, in adolescence, with: a more than two times increase in risk of self-harm ideation and behavior, suicidal ideation, and school truancy; almost two times increase in mental health problems, smoking, and violent and property crime; and more than

1.5 times risk of alcohol use. Self-regulation problems were also associated with a 1.2 to 1.4 times increase in the risk of being an overweight or obese adolescent.

Research Question 2: *What are the associations between self-regulation at 6-7 years and outcomes at 14-15 years, controlling for self-regulation at 4-5 years? That is, to what extent does change in self-regulation across the transition to school period predict adolescents' developmental progress?*

A third model was run to examine the extent to which change in early self-regulation problems was associated with each adolescent outcome, controlling for our covariates. In each model, self-regulation problems at 4-5 years and 6-7 years were included as predictors, along with the covariates. Standardized regression estimates and odds ratios for categorical outcomes are reported in Table 5 (for estimates for the covariates see Table 6; online).

For all non-academic outcomes, with the exception of overweight and obesity, the association with earlier self-regulation problems was no longer found when the more proximal measure of self-regulation problems at 6-7 years was included, indicating that *change* in self-regulation (reduction of problems) from 4-7 years was an important predictor of later adolescent outcomes. Self-regulation problems were not significantly associated with overweight or obese status in adolescence if both early time points were modelled together.

For reading and numeracy achievement, self-regulatory problems at 4-5 years remained significant even when the more proximal measure of self-regulation problems at 6-7 years, also a significant factor, was included. This indicates that levels of self-regulation problems at *both* times, as well as any early *change* in self-regulation that occurs, are each important predictors of these adolescent outcomes.

Holding earlier self-regulation problems and all covariates constant, odds ratios for self-regulation problems at 6-7 years in this model were higher than in the previous independent model for this predictor, suggesting that increases in problems across 4 to 7 years heighten

risk of poorer outcomes. By corollary, reduction in problems across this time is a significant predictor of reduced risk of poorer outcomes. In this model, a one standard deviation higher self-regulation problems score at age 6-7 was associated with a more than three times risk of self-harm ideation and behavior, and more than two times risk in suicidal ideation, smoking, property crime, and school truancy. The final model explained 40% of variance in self-harm behavior, 30% of variance in academic outcomes, and almost 20% of the variance in violent crime and smoking.

DISCUSSION

This study supports and extends suggestions of the importance of *early* self-regulatory status, and the potential benefits of *early change* in self-regulation,[2,4] using a large, nationally representative sample of Australian children. Specifically, early self-regulatory problems were significantly associated with the full range of adolescent outcomes considered, up to a decade later, within areas of academic achievement, health, and mental wellbeing. This adds further weight to the existing body of research showing that self-regulatory capacity predicts outcomes into adolescence and beyond.[2,3] This study also extends upon previous studies by documenting the potential for early change in self-regulation (from 4 to 7 years) to reduce the risk of poor achievement and engagement in risk behaviors that begin in adolescence, which may have ramifications for lifelong health and wellbeing.[2]

Examining the importance of *early* self-regulation specifically, our results indicated that self-regulation at 4-5 years of age predicted the entire complement of academic, health, and wellbeing outcomes that were considered. The current study also demonstrated importance of *early self-regulatory change* from 4 to 7 years, which was a significant predictor of 11 of 13 adolescent outcomes we examined, affirming the widespread research and practice focus on targeting self-regulatory skills in young children.[27] Adolescent overweight status and obesity were two outcomes where small independent associations between early childhood measures

of self-regulation were found, but these attenuated and became non-significant in the final model, upon inclusion of self-regulation at both time points. This suggests there are a number of other early developmental pathways (e.g., availability and socialisation of unhealthy diet, low levels of physical activity) through which obesity develops that are not represented in this modelling.

The current study was limited by the data available in LSAC. Specifically, research on early skill development cautions that longitudinal observational data can indicate a greater strength and persistence of associations than those typically found in experimental studies. Although the observational nature of this study precludes any definitive conclusions of the strength, persistence and areas of influence of early self-regulatory improvements – and most studies investigating the efficacy of self-regulation interventions tend not to investigate long-term outcomes – there are at least some intervention approaches that suggest long-term implications. For instance, the causal role of self-regulation is speculated from the outcomes of historical attempts to increase IQ via targeted preschool programs. While these programs were unsuccessful in their stated aims of improving IQ, they nevertheless yielded improved rates of school completion and reduced levels of teen pregnancy, delinquency, and work absenteeism (a result ascribed, at least in part, to improvements in self-regulation).[28] While other factors undoubtedly also contribute to and moderate ongoing effects of early change, and fadeout is likely in impoverished circumstances (e.g., poor educational quality), available evidence suggests it is plausible that improvements in early self-regulation may lead to stable and lasting improvements.

What are the conditions that might facilitate growth in self-regulatory capacity in young children? A broad range of observational and intervention research has indicated favourable conditions for self-regulatory development that engage children in activities that challenge and extend their capacity for cognitive and behavioral control (e.g., shared book reading[29])

and minimize factors that undermine a child's ability to develop and exert self-regulatory control (e.g., unresolved early childhood sleep problems[30]). This is an important area for further investigation, given that the solid body of evidence for the importance of early self-regulation has not yet helped to generate overly successful or consistent methods for enacting this change. Although we identified early and any-cause self-regulatory growth as associated with improvements in 11 of our 13 adolescent outcomes, the conditions that could optimally improve self-regulation remain unknown.

The current study makes important contributions to our understanding of the importance of *early* self-regulation, and viability of *early change* in self-regulation for influencing a wide range of later-life outcomes. Specifically, the finding that early self-regulation predicted the entire range of adolescent outcomes we considered (with a 1 *SD* reduction in self-regulation being associated with a 1.5- to 2.5-times increased risk of more-negative outcomes) suggests the likely direct and indirect influences of early self-regulation more than a decade later. That this strength of prediction is found in adolescence is additionally important given indications that falling into negative lifestyle 'snares' in adolescence increases the risks of negative adult outcomes. Our finding that early growth in self-regulation predicted a reduction in negative adolescent outcomes (for 11 of the 13 outcomes considered) supports the early malleability of self-regulation and potential efficacy of early intervention approaches. Our results thus bridge the existing evidence to demonstrate the specific importance of early self-regulation and self-regulatory change for outcomes into adolescence. Taken together, our results support Moffitt et al.'s[2] assertion that preventative early self-regulation intervention should be paired with protective strategies in adolescence.

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Table 1. Correlations and descriptive statistics for variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Self-regulation problems (4-5 years)	-																					
2. Self-regulation problems (6-7 years)	.67	-																				
3. Reading achievement (14-15 years)	-.31	-.29	-																			
4. Numeracy achievement (14-15 years)	-.27	-.24	.68	-																		
5. Mental health problems (14-15 years)	-.10	.10	-.02	-.10	-																	
6. Overweight (14-15 years)	-.07	.08	-.08	-.12	.07	-																
7. Obese (14-15 years)	-.09	.08	-.09	-.12	.07	.45	-															
8. Self-harm ideation	.03	.06	.03	-.06	.25	.06	.05	-														
9. Self-harm behaviour	.05	.07	-.01	-.09	.27	.05	.05	.67	-													
10. Suicidal ideation	.08	.09	-.01	-.06	.28	.04	.05	.53	.50	-												
11. Smoking	.10	.10	-.13	-.15	.12	.00	.02	.20	.21	.20	-											
12. Alcohol use	.06	.08	-.08	-.10	.08	.01	.02	.23	.21	.21	.42	-										
13. Violent crime	.17	.17	-.13	-.13	.07	.02	.04	.12	.14	.16	.22	.22	-									
14. Property crime	.12	.13	-.09	-.10	.07	-.00	-.01	.19	.16	.19	.32	.31	.35	-								
15. School truancy	.12	.12	-.11	-.14	.09	-.01	.00	.15	.19	.19	.28	.22	.22	.24	-							
16. Maternal education level	-.20	-.12	.33	.31	-.05	-.12	-.12	-.06	-.07	-.04	-.06	-.05	-.06	-.02	-.02	-						
17. Household income bracket	-.18	-.15	.27	.23	-.05	-.09	-.08	-.04	-.06	-.06	-.07	-.05	-.07	-.02	-.08	.34	-					
18. Female	.24	-.293	.13	-.08	.09	.06	-.00	.21	.17	.10	.04	.01	-.19	-.06	.00	-.01	.01	-				
19. ATSI	.10	.073	-.14	-.14	-.00	.06	.05	-.01	-.02	-.02	.05	.02	.04	.06	.04	-.12	-.14	.01	-			
20. LOTE	.01	-.019	.07	.15	-.05	.01	.01	-.04	-.04	-.03	-.06	-.07	-.04	-.04	-.03	.05	-.09	-.00	-.04	-		
21. Vocabulary	-.26	-.174	.34	.23	-.05	-.03	-.06	-.00	.01	-.01	-.02	.03	-.06	-.02	-.02	.20	.21	.07	-.07	-.23	-	
22. Home learning	-.16	-.147	.25	.20	-.02	-.08	-.09	.01	-.03	-.01	-.05	-.04	-.03	.00	-.03	.27	.22	-.00	-.10	-.10	.24	-
Range	-1.81 – 4.38	-1.69 – 4.42	195.6 – 890.6	355.7 - 920												1 – 6	0 – 15				28.2 – 84.78	0 – 3
Mean / Frequency	0	0	599.97	605.32	9.6%	26.4%	6.6%	16.1%	9.1%	8.4%	10.3%	14.3%	13%	13.3%	5.6%	3.14	10.4	49.1%	3.8%	14.2%	64.18	2.2
SD	1	1	68.41	74.03												1.65	2.77				6.19	.88

Note. All correlations above .04 are significant at $p < .01$

Table 2. Self-Regulation Item Correspondences between Moffitt et al. (2011) and Current Study

Factor	Moffitt et al. (2011) items	Corresponding LSAC items
Impulsive Aggression	Flies off handle [P,T] Fights [P,T] Requires attention [O]	Often has temper tantrums/hot tempers [P,T] Often fights with other children or bullies them [P,T] Often argumentative with adults [P,T]
Hyperactivity	Runs and jumps about [P,T] Cannot settle [P,T], restless [O] "On the go", "driven by a motor" [P,T] Difficulty sitting still [P,T] Has short attention span [P,T]	Restless, overactive, cannot stay still for long [P,T] Constantly fidgeting or squirming [P,T] If this child is upset, it is hard to comfort him/her [P,T]
Lack of Persistence & Inattention	Fails to finish tasks [P,T], trouble sticking to a task [S] Difficulty sticking to activity [P,T], brief attention to task [O] Lacks persistence in reaching goals [O] Easily distracted [P,T], difficulty paying attention [S]	The child likes to complete one task or activity before going on to the next (reversed) [P,T] Sees takes through to the end, good attention span (reversed) [P,T] The child stays with an activity (e.g., puzzle, construction, kit, reading) for a long time (reversed) [P,T] Easily distracted, concentration wanders [P,T,O]
Impulsivity	Acts before thinking [P,T], impulsive [O] Has difficulty awaiting turn [P,T] Sits excessively between activities [P,T] Difficulty waiting turn [S] Talking while others are still talking [S] Low frustration tolerance [O]	Can stop and think things out before acting (reversed) [P,T] Shares readily with other children (reversed) [P,T] Degree of negative mood (withdrawn, uncooperative, sulky, seeming upset, angry) to interview [O]

Factor names parallel those adopted by Moffitt et al. (2011). Notation following items indicates the source of the data. [P] parent rating. [T] teacher rating. [O] observer rating. [S] self-rating.

Table 3. Standardized estimates and odds ratios for independent regression models for the relations between early self-regulation (SR) problems at each of 4-5 years and 6-7 years (modelled separately) and adolescent outcomes, adjusting for covariates.

Outcome 14-15 years	SR problems 4-5 years standardized β	Odds Ratio	95% CI	SR problems 6-7 years standardized β	Odds Ratio	95% CI
Reading	-.20*	-	-.24, -.15	-.19*	-	-.234, -.149
Numeracy	-.23*	-	-.28, -.19	-.21	-	-.250, -.165
Mental health	.29*	1.73*	1.51, 1.94	.28*	1.70*	1.48, 1.91
Overweight	.12*	1.24*	1.11, 1.36	.12*	1.24*	1.12, 1.36
Obese	.21*	1.46*	1.21, 1.71	.19*	1.41*	1.19, 1.62
Self-harm ideation	.34*	1.94*	1.70, 2.17	.38*	2.19*	1.93, 2.45
Self-harm behavior	.40*	2.33*	1.98, 2.67	.44*	2.60*	2.21, 2.98
Suicidal ideation	.40*	2.16*	1.85, 2.46	.41*	2.25*	1.93, 2.56
Smoking	.35*	1.91*	1.66, 2.15	.34*	1.88*	1.64, 2.10
Alcohol use	.28*	1.67*	1.48, 1.84	.27*	1.63*	1.45, 1.80
Violent crime	.33*	1.88*	1.65, 2.10	.30*	1.77*	1.56, 1.97

Property crime	.33*	1.81*	1.60, 2.00	.32*	1.80*	1.59, 2.00
School truancy	.40*	2.14*	1.80, 2.47	.40*	2.18*	1.84, 2.51

Note. SR = self-regulation, * $p < .01$

Table 4. Standardized estimates and odds ratios for independent, unadjusted, regression models for the relations between early self-regulation (SR) problems at two time points and adolescent outcomes.

Outcome 14-15 years	SR problems 4-5 years standardized β	Odds Ratio	95% CI	SR problems 6-7 years standardized β	Odds Ratio	95% CI
Reading	-.33*	-	-.37, -.29	-.30*	-	-.35, -.26
Numeracy	-.32*	-	-.36, -.28	-.27*	-	-.32, -.23
Mental health	.28*	1.65*	1.45, 1.87	.25*	1.58*	1.39, 1.80
Overweight	.14*	1.28*	1.16, 1.42	.13*	1.27*	1.15, 1.39
Obese	.26*	1.60*	1.36, 1.89	.22*	1.49*	1.30, 1.72
Self-harm ideation	.24*	1.55*	1.36, 1.76	.29*	1.68*	1.49, 1.90
Self-harm behavior	.33*	1.82*	1.56, 2.12	.35*	1.93*	1.67, 2.23
Suicidal ideation	.32*	1.80*	1.55, 2.09	.34*	1.88*	1.63, 2.17
Smoking	.33*	1.81*	1.59, 2.07	.33*	1.82*	1.61, 2.07
Alcohol use	.25*	1.58*	1.41, 1.77	.25*	1.58*	1.41, 1.77
Violent crime	.36*	1.96*	1.75, 2.21	.35*	1.92*	1.72, 1.16
Property crime	.31*	1.75*	1.56, 1.97	.31*	1.77*	1.58, 1.99
School truancy	.36*	1.93*	1.66, 2.25	.39*	2.10*	1.80, 2.45

Note. SR = self-regulation, * $p < .01$

Table 5. Standardized estimates, odds ratios and variance explained for each of the adolescent outcome variables in the final model for the association between self-regulation (SR) problems at 6-7 years and adolescent outcomes, controlling for SR problems at 4-5 years and adjusted for covariates.

Adolescent outcome	SR problems 4-5 years standardized β	Odds Ratio	95% CI	SR problems 6-7 years standardized β	Odds Ratio	95% CI	% variance explained
Reading	-.11*	-	-.19, -.04	-.13*	-	-.19, -.07	31
Numeracy	-.12*	-	-.20, -.03	-.12*	-	-.22, -.08	30
Mental health problems	-.07	1.82	.58, 1.33	.32*	1.82*	1.40, 2.35	16
Overweight	.06	1.11	.90, 1.36	.09	1.17	.99, 1.38	5
Obese	.18	1.40	.99, 1.97	.08	1.15	.89, 1.50	13
Self-harm ideation	-.33	.49	.27, .89	.54*	3.12*	2.23, 4.34	33
Self-harm behavior	-.36	.44	.20, .97	.61*	3.86*	2.51, 5.93	40
Suicidal ideation	-.30	.54	.28, 1.06	.55*	2.98*	2.09, 4.24	26
Smoking	-.16	.74	.44, 1.23	.42*	2.21*	1.64, 2.99	18
Alcohol use	-.07	.72	.47, 1.10	.36*	1.93*	1.51, 2.47	13

	SR						
Violent crime	-.09	.85	.54, 1.33	.35*	1.95*	1.49, 2.55	19
Property crime	-.12	.80	.52, 1.23	.39*	2.04*	1.56, 2.66	12
School truancy	-.07	.87	.50, 1.52	.44*	2.34*	1.68, 3.28	14

Note. SR = self-regulation, * $p < .01$.

Table 6. Standardized estimates for the covariates in the final model for relations between self-regulation problems at 6-7 years and later adolescent outcomes, controlling for self-regulation problems at 4-5 years and the covariates listed in this table.

Adolescent outcome	Gender (female)	ATSI	LOTE	Income	Maternal education	Vocabulary	Home learning environment
Reading	.06*	-.09*	.13*	.08*	.17*	.26*	.10*
Numeracy	-.13*	-.10*	.21*	.12*	.16*	.17*	.07*
Mental health problems	.22*	-.02	-.13	-.04	-.05	-.06	.03
Overweight	.09*	.07	.04	-.07*	-.09*	.03	-.04
Obese	.04	.06	.02	-.06	-.15*	.05	-.11*
Self-harm ideation	.38*	-.03	-.07	-.04	-.07	.01	.07
Self-harm behavior	.41*	-.05	-.07	-.05	-.08	.06	.00
Suicidal ideation	.25*	-.09	-.06	-.09	-.03	.04	.03
Smoking	.15*	.04	-.13*	-.09	-.04	.01	-.03
Alcohol use	.07	.01	-.16*	-.06	-.04	.09	-.06
Violent crime	-.24*	.05	-.08	-.07	-.03	-.06	.02
Property crime	-.04	.09*	-.05	-.01	-.02	.00	.04
School truancy	.12*	.05	-.07	-.16*	.04	.02	-.02

Note. SR = self-regulation, * $p < .01$.