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Self-regulation in childhood as a predictor of future outcomes: A meta-analytic review

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Abstract

This meta-analysis explores whether self-regulation in childhood relates to concurrent and subsequent levels of achievement, interpersonal behaviors, mental health, and healthy living. A comprehensive literature search identified 150 studies that met inclusion criteria (745 effect sizes; total n = 215,212). Data were analyzed using inverse-variance weighted random effects meta-analysis. Mean effect sizes from 55 meta-analyses provided evidence that self-regulation relates to 25 discrete outcomes. Results showed that self-regulation in preschool (~age 4) was positively associated with social competency, school engagement, and academic performance, and negatively associated with internalizing problems, peer victimization, and externalizing problems, in early school years (~age 8). Self-regulation in early school years was positively related to academic achievement (math and literacy), and negatively related to externalizing problems (aggressive and criminal behavior), depressive symptoms, obesity, cigarette smoking and illicit drug use, in later school years (~age 13). Results also showed that self-regulation in early school years was negatively related to unemployment, aggressive and criminal behavior, depression and anxiety, obesity, cigarette smoking, alcohol and substance abuse, and symptoms of physical illness in adulthood (~age 38). Random effects metaregression identified self-regulation measurement as the most important moderator of pooled mean effects, with task-based assessments and teacher-report assessments often showing stronger associations than parent-report assessments. Overall, findings from this meta-analysis provide evidence that self-regulation in childhood can predict achievement, interpersonal behaviors, mental health, and healthy living in later life.

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Keywords: academic achievement; body mass; measurement; mental health; self-control

Public Significance Statement: This study found that children's ability to self-regulate (exercise control over their dominant impulses) can predict outcomes in later childhood, adolescence, and adulthood. These outcomes included academic achievement, aggressive behavior, depression, obesity, cigarette smoking, unemployment, alcohol and substance abuse.

Self-regulation in childhood as a predictor of future outcomes: A meta-analytic review

Introduction

Safeguarding and maximizing children's developmental outcomes should be a prime concern for all societies (World Health Organization, United Nations Children's Fund, World Bank Group, 2018). Globally, under-five mortality decreased by 58% between 1990 and 2017 (UNICEF, WHO, World Bank Group and United Nations, 2018). Nevertheless, many children who survive do not thrive, with more than 250 million children in low and middle-income countries at risk of not attaining their full developmental potential (Lu, Black, & Richter, 2016). It is generally accepted that physical and mental health, educational and occupational attainment, subjective well-being, and the capacity for mutually rewarding social relationships, all have their roots in early childhood (Daelmans et al., 2015). Early life cognitive skills are thought to have a major role in shaping life outcomes (Smithers et al., 2018) and educational programs that help to develop such skills have been found to benefit children in their learning and development (Pandey et al., 2018; Smithers et al., 2018). In particular, a child's ability to self-regulate – that is, exercise control over their thoughts, feelings, and behaviors – is positioned as a foundational ability with potential to affect population trajectories in health, wealth and criminality (Blair & Raver, 2015; Heatherton & Wagner, 2011; Pandey et al., 2018).

This meta-analysis sought to determine whether self-regulation in childhood relates to a variety of outcomes in later childhood and adulthood. We conducted a series of meta-analyses of empirical research testing associations between self-regulation in childhood and concurrent and subsequent levels of achievement, interpersonal behaviors, mental health and healthy living. We considered whether associations were moderated by individual difference factors such as age and sex, as well as methodological decisions such as the measurement of self-regulation and the timespan between measurement of self-regulation and theoretical

outcomes. The results of this meta-analysis have implications for theoretical advancement in child development and can provide an empirical basis for subsequent research on processes connecting self-regulation to important outcomes in later life. Moreover, the findings might be used to improve prognostic capabilities that could be valuable to childcare professionals working with children at risk of not reaching their full developmental potential.

Self-regulation Conceptualization

Definitions of self-regulation have diverged somewhat since its initial conception. Historical roots of the scientific study of self-regulation can be traced to Bernard's (1865) research into the mechanisms through which an organism can regulate their internal state in response to internal and external stressors. In this original conceptualization, self-regulation refers to the ability to control one's physiological responses to stressors. For example, a child better able to regulate their behavioral response to fear-inducing stressors would be said to possess high self-regulation. The construct of ego-resiliency (Block & Martin, 1955; Block & Kremen, 1996), which refers to children's capacity to regulate or modulate impulse, governed much of the early research on child development in the mid to late 20th century. Since its original conceptualization, researchers have adopted different approaches to conceptualizing and operationalizing self-regulation, and a cluster network map analysis of the self-regulation literature documented 447 different uses of the term *self-regulation* (Burman, Green, & Shanker, 2015).

In recent years, a recasting of self-regulation as *self-control* extended self-regulation to the broader control of attention, thinking, behavior, interpersonal interactions, and emotion. Some researchers draw distinctions between self-regulation and self-control, with self-regulation referring to almost any self-selected and goal-directed behavior, and self-control referring to overcoming salient but maladaptive impulses (Hofmann, Schmeichel, & Baddeley, 2012). Research in child samples has most often focused on the latter and the two

terms are often used interchangeably (e.g., de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; also see Werner & Milyavskaya, 2019). A control-focused conception of self-regulation is the one that most commonly permeates educational curricula, as well as parents' and educators' acute concerns (Blair & Raver, 2015; Heaviside & Farris, 1993). Moreover, this conception of self-regulation is the one most commonly adopted by those who spend the most time with children. In the current research we adopt a broad control-based definition of self-regulation in which self-regulation refers to *the ability to inhibit dominant impulses to modify thought, feeling and behavior* (Baumeister, Vohs, & Tice, 2007; de Ridder et al., 2012).

Framework for Self-regulation

Control theory (Carver & Scheier, 1981, 1982, 1998) is a prominent theoretical framework that seeks to understand self-regulation from the perspective of self-control. This theory considers self-regulation through a discrepancy-reducing negative feedback loop, in which an individual compares present with desired conditions to identify discrepancies and required behavior changes. Maintaining this feedback loop (in other words, achieving set goals) requires a process of *test-operate-test-exit*. In this process, the individual 'tests' (evaluates) their current state, 'operates' (acts) if a discrepancy is perceived, and again performs a test to determine if the discrepancy remains (and the loop continues) or has been resolved (and the loop can be 'exited'). The strength model of self-control (Baumeister & Heatherton, 1996; Muraven & Baumeister, 2000) expanded on this framework, postulating three factors necessary for successful self-regulation. The first is having a clear standard or goal, without which, action toward that goal will never be initiated. Second, motivation is required to persist in goal-directed behavior, especially when impulses or distractions are contrary and compelling. The third is sufficient capacity to resist these impulses and distractions – enabled by executive functions (Hofmann, Schmeichel, & Baddeley, 2012) –

which research has shown can be undermined by factors such as stress, tiredness, loneliness, hunger, illness, and sadness (Muraven & Baumeister, 2000).

The strength model provides a useful explanatory framework for self-regulation affecting a broad array of outcomes over a long period of time. In this model, self-regulation is considered a limited resource that subserves ongoing control of thought, feeling, and behavior. Self-regulatory failure stems from deciding not to pursue a particular goal, motivational difficulties in persisting toward that goal, and/or a pervasive or momentary lack of capacity to overcome distractions that can undermine successful goal completion (Muraven & Baumeister, 2000). The prediction that self-regulation is a limited resource that can be used up through depleting mental tasks is a contemporary topic of discussion with research producing conflicting results (cf. Baumeister, Tice, & Vohs, 2018; Hagger et al., 2016). Nevertheless, the ability to override maladaptive impulses is predicted to have an important role in trajectories and outcomes related to health (e.g., diet, exercise), wealth (e.g., gambling, socioeconomic status), antisocial behavior (e.g., criminality, poor social skills), intellectual pursuits (e.g., academic success, job promotion), and risky behaviors (e.g., contraception use, dangerous activities). Despite the plausible connection between childhood self-regulation and important life outcomes, it is still unclear which associations are robust and of a meaningful magnitude.

Previous Meta-analyses

Previous meta-analyses have attempted to synthesize research findings on childhood self-regulation (and related concepts) as a correlate of important life outcomes. For instance, a meta-analysis of 75 studies tested the association between *inhibitory control* and academic performance in children aged 3 to 6 years (Allan, Hume, Allan, Farrington, & Lonigan, 2014). Self-regulation and inhibitory control are related but distinct abilities (Hofmann et al., 2012). Executive functions – referring to cognitive control capacities (of which inhibition is

one, along with working memory and cognitive flexibility) – have been proposed to underpin the capacity component of self-regulation (Hofmann et al., 2012). This positions executive functions as critical for, but not synonymous with, self-regulation, that is further influenced by goals and motivation (Baumeister & Heatherton, 1996). The meta-analysis (Allan et al., 2014) found that inhibitory control had a positive association with academic performance, k = 85, r = .27 (95% CI: .24, .29). This effect was moderated by measurement approach, such that task-based assessments and teacher-report assessments showed larger effect sizes than parent-report assessments. Inhibitory control also appeared more important for math performance, k = 32, r = .34 (95% CI: .29, .39), than for literacy performance, k = 80, r = .25 (95% CI: .22, .28).

In another comprehensive meta-analysis of 504 observational studies, associations were explored between self-control skills (of which self-regulation is one, alongside skills such as attention, cognitive flexibility, perseverance, emotional relativity, working memory, and conscientiousness) and important life outcomes in children under 12 years of age (Smithers et al., 2018). The meta-analysis found that self-control related skills are associated with academic achievement, k = 15, g = .22 (95% CI: .14, .31), math performance, k = 31, g = .17 (95% CI: .12, .21), literacy performance, k = 30, g = .16 (95% CI: .12, .20), vocabulary, k = 9, g = .16 (95% CI: .05, .27), internalizing problems, k = 17, g = .15 (95% CI: .09, .21), externalizing problems, k = 28, g = .21 (95% CI: .15, .28), social competence, k = 14, g = .13 (95% CI: .07, .18), and intelligence test scores, k = 2, g = .20 (95% CI: .11, .30), but not body mass index (BMI), k = 5, g = .06 (95% CI: –.03, .16). The associations showed evidence of small sample effects (publication bias) to varying degrees (Smithers et al., 2018).

Existing meta-analyses of outcomes associated with self-regulation have tended to have a narrower focus. A recent meta-analysis explored emotion-related aspects of self-regulation as a correlate of externalizing problems (problems related to disruptive and

aggressive behavior) and internalizing problems (emotional or psychological states related to depression, withdrawal, anxiety, loneliness, or suicidal thoughts) in children and adolescents aged 5 to 19 years (Compas et al., 2017). It was found that higher emotion regulation was associated with a lower incidence of internalizing problems, $k = 15$, $r = –.23$ (95% CI: –.34, –.11), and externalizing problems, $k = 18$, $r = –.27$ (95% CI: –.37, –.17), with some evidence of small sample bias in the results. Moderator analyses showed that effects were somewhat larger in child samples (age 5 to 10 years) for both internalizing problems, $k = 8$, $r = –.30$ (95% CI: –.44, –.15), and externalizing problems, $k = 11$, $r = –.32$ (95% CI: –.42, –.21). In another meta-analysis, self-regulation was explored as a correlate of forms of victimization (e.g., online bullying, sexual harassment, etc.) in child and adult samples (Pratt, Turanovic, Fox, & Wright, 2014). The meta-analysis showed that low self-regulation was associated with a greater likelihood of victimization, $k = 311$, $r = .15$ (95% CI: .10, .20), with no significant moderation of this effect across child and adult samples.

Only one previous meta-analysis has explored self-regulation as it relates to a broad array of life outcomes (de Ridder et al., 2012). This meta-analysis synthesized findings from 102 studies of self-control (self-regulation) in adolescent and adult samples. The study found that higher levels of self-control related to better outcomes in school and work, $k = 5$, $r = .36$ (SD = .05), $p < .001$, eating behavior and body weight, $k = 14$, $r = .17$ (SD = .03), $p < .001$, interpersonal functioning (e.g., commitment to relationships, loyalty), $k = 17$, $r = .25$ (SD = .02), $p < .001$, and well-being and adjustment (e.g., self-esteem, happiness), $k = 16$, $r = .33$ (SD = .02), $p < .001$. The study also found that low self-control was related to a greater likelihood of involvement in addictive behaviors (e.g., smoking, alcohol use), $k = 13$, $r = .25$ (SD = .02), $p < .001$, and deviant behaviors (e.g., cheating, stealing), $k = 22$, $r = .15$ (SD = .01), $p < .001$. While this provides the clearest insight into the pattern and degree of association that might be expected for self-regulation in childhood, critical differences

between adult and child populations (e.g., life experience) prevent direct extrapolation of these findings to younger samples.

Self-regulation Assessment

Reconciliation of the evidence on outcomes associated with childhood self-regulation is complicated by researchers' different approaches to assessing self-regulation. Assessments that are considered to capture self-regulation include tasks that involve children touching their knees when told to touch their head (Ponitz, McClelland, Matthews, & Morrison, 2009), measuring the length of delay in eating a marshmallow in order to receive a second marshmallow (Mishel, Shoda, & Rodriguez, 1989), ratings of the extent to which a child has difficulty waiting between impulse-inducing tasks (Smith-Donald, Raver, Hayes, & Richardson, 2007), and parents' or teachers' ratings of children's ability to persist with difficult tasks (Howard & Melhuish, 2017). A meta-analysis of the convergent validity of self-regulation measures indicated only moderate convergence and substantial heterogeneity between measures, with correlations between self-control measures typically below $r = .20$ (Duckworth & Kern, 2011; also see Malanchini, Engelhardt, Grotzinger, Harden, & Tucker-Drob, 2018).

At present it remains difficult to advocate for any particular approach. Task-based assessments have greater objectivity but are often devoid of emotional investment that is typical of children's everyday self-regulation (e.g., to not lash out when another child is playing with a toy they want). It is unclear to what extent these tasks are able to capture a child's capacity to self-regulate in emotional contexts. Parent- and teacher-report assessments tend to have greater ecological validity than task-based assessments, but they are also more susceptible to self-report biases (e.g., social desirability). Moreover, adult-report approaches might fail to capture developmental change in self-regulation, due to adults referencing children to their age-equivalent peers, rendering adult-report ratings as relative ranks that are

more stable over time (Howard, Vella, & Cliff, 2018). Nevertheless, each approach to measurement has been adopted in cross-sectional and prospective research testing correlates of self-regulation. Given the strong possibility for assessment type to moderate the strength of associations (Allan et al., 2014; Duckworth & Kern, 2011), we test the various approaches to assessment as a potential moderator of pooled mean effects.

Individual Differences

Previous meta-analyses have often explored child age as a moderator of associations between self-regulation and life outcomes. However, substantial differences in the length of prospective research suggest that associations might be better explored in separate analyses. Some research has focused on self-regulation in the preschool years due to suggestions that early self-regulatory improvements might generate more pronounced and lasting benefits to children (Wass, Scerif, & Johnson, 2012), while other research has focused on self-regulation in later childhood given that measures of self-regulation are typically more reliable at this age (McClelland & Cameron, 2012). Moreover, researchers have tended to address three separate research questions in prospective studies. First, researchers have tested whether self-regulation in preschool can predict social skills and academic readiness in early school years. Second, researchers have tested whether self-regulation in early school years can predict mental and physical health and academic achievement in later school years (adolescence). And third, researchers have tested whether self-regulation in childhood can predict health, occupational outcomes, and criminal behavior in adulthood.

In this meta-analysis we explore age as a potential moderator of associations in cross-sectional research, and test the three major categories of prospective research in separate analyses. We also explore whether associations are moderated by child sex. Girls tend to outperform boys in self-regulation tasks and also score higher on teacher-report assessments of self-regulation (Matthews, Ponitz, & Morrison, 2009). However, whether self-regulation

has a stronger connection to life outcomes for boys than for girls remains unknown. In adult samples, there is some evidence that the association between self-control and victimization is stronger in male samples (Pratt et al., 2014). In adolescent and adult samples, the association between self-regulation and desired behaviors did not differ between male (k = 13, r = .25) and female (k = 29, r = .18) samples (de Ridder et al., 2012), but the association between self-regulation and undesired behaviors was stronger in male (k = 12, r = –.26) than female (k = 26, r = –.14) samples (de Ridder et al., 2012). The current meta-analysis further explores whether self-regulation has a stronger connection to life outcomes among boys than among girls.

The Current Meta-analysis

The aim of this meta-analysis was to determine whether self-regulation in childhood relates to concurrent and subsequent levels of achievement, interpersonal behaviors, mental health and healthy living. Moreover, we aimed to build on previous meta-analyses by testing associations between self-regulation in preschool and outcomes in early school years, associations between self-regulation in early school years and outcomes in later school years, and associations between self-regulation in childhood and outcomes in adulthood. We also test for moderation by timeframe within these categories given that longer timespans provide more opportunity for self-regulation to change and for other environmental factors to affect outcomes. We also sought to test whether the magnitude of associations differs between boys and girls, and between different approaches to self-regulation assessment. The results of this meta-analysis might have implications for theoretical advancement in child development and can provide a foundation for subsequent research on processes connecting self-regulation to outcomes in later life. Considering the importance of academic achievement, interpersonal relationships, and mental and physical health for well-being and quality of life (Diener, Suh, Lucas, & Smith, 1999), findings from this meta-analysis might also have implications for

professional practice that could be valuable to childcare professionals working with children at risk of not reaching their full developmental potential.

Method

The meta-analysis was prepared in accordance with the meta-analysis reporting standards (American Psychological Association, 2010) and the PRISMA statement for the reporting of systematic reviews and meta-analyses (Moher, Liberati, Tetzlaff, & Altman, 2009).

Eligibility Criteria

Observational studies assessing correlates of childhood self-regulation were eligible for inclusion. The age range for eligibility was an assessment of childhood self-regulation between age 3.00 and 12.99 years, as determined by the mean age of the sample. In cases where a mean age was not available we used the midpoint of the age range. Prospective studies needed to include childhood self-regulation as the baseline measure. The measure of self-regulation needed to be consistent with self-regulation defined as *the ability to inhibit dominant impulses to modify thought, feeling and behavior* (Baumeister et al., 2007; de Ridder et al., 2012). This resulted in some measures not explicitly characterized as self-regulation being included (e.g., some temperament subscales where items are near-identical to items in self-regulation measures) and some measures characterized as assessing self-regulation being excluded (e.g., where subscales are capturing executive function). Measures that combined an assessment of self-regulation with other components of childhood behavior or executive function were not eligible for inclusion. Observational measures, task-based measures, self-report measures, and parent- and teacher-report measures of self-regulation were all eligible for inclusion.

Search Strategy

A systematic search of six electronic databases was conducted in June 2018 and included all publication dates up to the search date. The databases searched were: Web of Science, Scopus, EBSCO, PsycINFO, PsycARTICLES, and ERIC. The search terms were developed by three researchers and were based on terms used in previous self-regulation narrative and meta-analytic reviews (e.g., Allan et al., 2014; De Ridder et al., 2012). The search terms used were: self-regulat* [OR self-control] AND child* [OR preschool OR pre-school OR early years] AND psychological [OR wellbeing OR well-being OR academic OR school OR dropout OR health OR illness OR drug* OR substance OR abuse OR alcohol OR smoking OR suicide OR self-harm OR mental health OR anxiety OR depression]. There were no restrictions in terms of the type of publication or language. An example of the full search strategy is provided in Supplementary File S1.

Study Selection

A single researcher screened the titles, keywords and abstracts of each study for eligibility (see Supplementary File S2 for details of search engine hits). If a study appeared to meet eligibility criteria, or if the relevance of the study was uncertain, then full texts were obtained. Full texts of all identified studies were then independently assessed for inclusion by two researchers. Figure 1 summarizes the screening procedure. A total of 2605 records were identified through electronic databases. After title, keyword and abstract screening, the full texts of 242 studies were obtained. Two researchers then independently assessed the full texts of identified studies for inclusion. Discrepancies were resolved through discussion between the two researchers. The main reasons for exclusion were an incongruent measure of self-regulation and a sample outside of the specified age range for childhood (see Supplementary File S3 for details on exclusion). A manual search of introduction sections and reference lists of the remaining 121 studies (using a snowball search strategy), an electronic search (using Google Scholar search engine) for articles that had cited these 121 studies, and a general

search in Google Scholar for articles published in 2018 (with 'self-regulation' as the search term) identified a further 61 studies for full-text search with 31 of these studies eligible for inclusion. During data extraction (see below) two further studies with duplicate data to a study already included were also excluded from the final sample. In total, 150 articles were included in the meta-analysis.

Data Extraction and Study Quality

Data extraction was performed by three researchers, who completed different aspects of data extraction, meaning all data were extracted by a single researcher. The information extracted from each study included study design (prospective or cross-sectional), total sample size, nation where the study was conducted, sex of participants (as a percentage), the age of participants at baseline and follow-up (mean and standard deviation, or age range if mean age was unavailable), the measure of self-regulation used (coded as task-based, observational, self-report, teacher-report or parent-report), the measured outcomes, effect size estimates, and other information used to assess study quality. In cases where effect sizes estimates were not reported, the corresponding author was contacted via email and the missing effect size was requested. Study quality was assessed using the AXIS tool (Downes, Brennan, Williams, & Dean, 2016). This scale is designed for non-experimental research and includes 20 items that measure aspects of study quality including justification of sample size, representativeness of the sample, a description of non-responders, use of validated measures, description of statistical methods, discussion of non-response bias, and reporting of funding and conflicts of interest. Each study was assigned a score from 0 to 20 with higher scores reflecting higher study quality (see Supplementary File S4 for computation table).

Meta-Analytic Strategy

Calculation of the pooled mean effect size was conducted using inverse-variance weighted random effects meta-analysis. The inverse-variance method assigns each included

effect size a weighting that is equal to the inverse of its variance allowing more weight to be given to more precise studies (Borenstein, Hedges, Higgins, & Rothstein, 2009). The zero-order correlation coefficient (*r*) was adopted as the effect size metric of interest. This was because most studies provided information on non-adjusted effects with *r* being the most common statistic reported across studies. Effect sizes were taken directly from the published study (see Supplementary File S5) or were converted to *r* prior to analyses using standard formulae (Borenstein et al., 2009). In instances where a study reported standardized regression coefficients but not correlation coefficients, *r* was imputed using the formula $r = 98\beta + .05\lambda$, where λ is an indicator variable that equals 1 when β is non-negative and 0 when β is negative (Peterson & Brown, 2005).

Effect size data reported in studies fell broadly within four categories that were used for data analyses. Studies reported (1) cross-sectional associations (across all childhood ages), or longitudinal associations that tested (2) whether self-regulation in preschool years predicted outcomes in early school years, (3) whether self-regulation in early school years predicted outcomes in later school years (childhood or adolescence), or (4) whether self-regulation in childhood predicted outcomes in adulthood. Studies often provided information on both cross-sectional and cross-time associations (see Supplementary File S5), and we extracted all usable effect sizes. In cases where a study reported results without a usable effect size, the authors of the study were contacted and the missing effect size was requested. In total, 12 authors were contacted and four authors provided us with the missing effect size. The remaining eight studies were retained in the meta-analysis but were used in sensitivity analyses only. In instances where a study reported a non-significant association, but did not report an effect size, the data were first explored with the study excluded and then with an effect size of zero imputed to check on the robustness of results (Pigott, 1994). In instances where a significant positive or negative association was reported, but with no effect size

presented, data were first explored with the study excluded and sensitivity analyses were also computed with the pooled mean effect imputed for the study (Pigott, 1994).

Included studies often provided multiple usable effects for the same association. In instances where multiple eligible measures of self-regulation were included in a single study (for example, a task-based assessment and a parent-report measure) we extracted all effects and adopted a computed average for use in main analyses (Duckworth & Kern, 2011). In instances where multiple assessments of an outcome were included in a single study (e.g., a study assessed multiple components of mathematics ability) we again extracted all effect sizes and computed an average coefficient resulting in a single effect size per sample across outcome variables. This avoids violating assumptions of independence in meta-analysis (Borenstein et al., 2009). Egger's regression asymmetry test (Egger, Davey Smith, Schneider, & Minder, 1997) was used to identify small sample effects. If there is no small sample bias then estimates should vary most in small sample studies (due to random error) and least in large sample studies (Egger et al., 1997). Asymmetry in the predicted funnel shape of the plot is an indicator of publication bias and the tendency for journals to favor the publication of statistically significant findings in underpowered studies.

We report the I^2 statistic as an estimate of the total variation across studies due to heterogeneity rather than sampling error (Higgins, Thompson, Deeks, & Altman, 2003). Values of 25%, 50% and 75% are considered to represent low, medium and high levels of heterogeneity (Higgins et al., 2003). An I^2 value above 50%, together with a statistically significant Q statistic (which provides a test of the hypothesis that variation in effect sizes across studies is greater than that expected by chance alone), prompted a search for potential moderators of the effect (see Gonzalez-Mulé & Aguinis, 2018). To test the impact of moderating variables, we employed a protocol for random effects meta-regression (Borenstein et al., 2009) in which the correlation between self-regulation and, for example,

academic achievement is set as the criterion variable and the moderating variables are included as predictors (a mixed effects model), with studies being weighted by their inverse variance weights.

We tested child age (or length of time between baseline measure and follow-up in longitudinal models), child sex, study quality (computed score on the AXIS tool), and self-regulation measure as potential moderators. Two regression models were run for each meta-analysis in which *k* was greater than 10 (Borenstein et al., 2009). We first tested the effects of age, sex (percentage of boys in the sample), and study quality (all entered as integer variables). There were some instances in which information on sex was unavailable and missing values were handled using mean-value imputation (in preference to listwise deletion) given that moderators were tested in a multiple regression design. Regression models were tested using maximum likelihood estimation and the three moderator terms were entered concurrently (forced entry multiple meta-regression). Correlation matrices of regression coefficients were also explored for potential high covariance between moderators.

Self-regulation measure was dummy-coded (as parent-report, teacher-report, self-report, observation, or task-based assessment) and entered as a categorical variable in a separate regression model. This was because studies often included multiple assessments of self-regulation (e.g., parent-report and task-based assessments). We first tested effects of self-regulation measure with the study as the unit of analysis. This involved some studies with multiple assessments of self-regulation being listwise deleted. We then ran a second regression model in which studies with multiple self-regulation assessments were modeled as independent data sets. This involved a single study sample being included more than once. However, findings for this follow-up regression analysis should be interpreted with some cation given that the assumption of independence is violated. All analyses were computed using *Comprehensive Meta-Analysis 3.0* statistical software (Borenstein, Hedges, Higgins, &

Rothstein, 2014). Based on contemporary guidelines for effect size interpretation in psychological science, an effect size *r* of .10 was considered *small* at the level of single events (but potentially more consequential in the long run), an effect-size *r* of .20 was considered *medium* and of some explanatory and practical use even in the short run, and an effect-size *r* of .30 was considered *large* and potentially powerful in both the short and long run (Funder & Ozer, 2019).

Results

The characteristics of included studies are presented in Table 1. The 150 studies included 745 usable effect sizes (effect size raw data is available in Supplementary File S5). There were 43 cross-sectional studies (Model 1) and 107 longitudinal studies providing information for Model 2 (preschool to early school years; $n = 55$), Model 3 (early school years to later school years; $n = 40$), and Model 4 (childhood to adulthood; $n = 15$). For Model 1 (cross-sectional associations) the grand-mean age was 8.4 (± 3.2) years; for Model 2 the grand-mean age was 4.5 (± 0.8) years at baseline and 8.0 (± 3.0) years at follow-up; for Model 3 the grand-mean age was 9.6 (± 2.1) years at baseline and 13.0 (± 2.8) years at follow-up; and for Model 4 the grand-mean age was 7.0 (± 2.6) years at baseline and 37.9 (± 8.9) years at follow-up. The studies sampled a total of 215,212 children, including 89,463 girls (41.6%) and 91,911 boys (42.7%), with 33,838 sexes unknown (15.7%). The samples were from North America ($n = 98$), Europe ($n = 29$), Australasia ($n = 14$), Asia ($n = 8$), and multicontinental ($n = 1$). The mean score for study quality was 16.3 (± 1.7; range = 10–20). Overall, 67 different measures of self-regulation had been used across studies (for details see Supplementary File S6). This included nine task-based assessments, nine observational measures, and 49 written report (questionnaire) assessments used in parent-report, self-report, or teacher-report formats.

We extracted data for 25 outcomes that had been correlated with self-regulation in childhood. These outcomes were grouped into four broad categories related to achievement, interpersonal behaviors, mental health, and healthy living. The outcomes included: academic performance (subcomponents: mathematics, literacy, vocabulary), school/class engagement, intelligence test scores, completion of university degree, unemployment, social competence (social skills), peer victimization (bullied or treated badly by peers), externalizing problems (subcomponents: aggressive behavior, criminal behavior), sexual activity, internalizing problems (subcomponents: depressive symptoms, anxiety symptoms, suicidal thoughts), physical activity, body mass (overweight), alcohol abuse, illicit drug use, cigarette smoking, sleep quality, and symptoms of physical illness. Findings from 55 separate meta-analyses are reported in Table 2. Forest plots, and funnel plots for publication bias estimates, are available in Supplementary File S7 and significant moderator terms are depicted in Supplementary File S8.

Academic Performance

For cross-sectional studies (mean age = 6.5 ± 2.3 years), a positive association was observed between self-regulation and academic performance, $k = 32$, $r = .37$ (95% CI: .32, .41). For Model 2, the mean age at baseline was 4.3 (± 0.7) years with an average length follow-up of 2.7 (± 2.1) years. There was a positive association between self-regulation in preschool years and academic performance in early school years, $k = 29$, $r = .28$ (95% CI: .22, .33). Egger's test showed evidence of small sample effects in Model 2, $t(24) = 6.35$, $p < .001$. For Model 3, the mean age at baseline was 8.6 (± 2.0) years with an average follow-up of 3.3 (± 2.1) years. There was a positive association between self-regulation in early school years and academic achievement in later school years, $k = 17$, $r = .28$ (95% CI: .18, .38), with no evidence of small sample effects. A sensitivity analysis involving the imputation of three missing effect sizes in Model 2 produced unchanged results.

There was substantial heterogeneity across all models prompting a search for potential moderators. For cross-sectional studies, there were no significant effects for age, sex, or study quality, $k = 32$, $\chi^2(3) = 2.71$, $p = .438$, $R^2 = .07$. However, there was a significant effect for measure, $k = 23$, $\chi^2(3) = 9.03$, $p = .029$, $R^2 = .31$. Observation of dummy-coded measures showed that the positive correlation between self-regulation and academic performance was stronger for task-based assessments, $b = .27$ (95% CI: .03, .51), $p = .026$, and teacher-report assessments, $b = .38$ (95% CI: .12, .64), $p = .004$, than for parent-report assessments. For Model 2, a significant regression model again emerged for measure, $k = 23$, $\chi^2(2) = 8.22$, $p = .016$, $R^2 = .29$, showing that the positive association between self-regulation in preschool and academic performance in early school years was stronger for task-based assessments than for parent-report assessments, $b = .19$ (95% CI: .05, .33), $p = .007$. For Model 3, the regression models were non-significant. Follow-up regression models (for self-regulation measure) with subgroup modelled as the unit of analysis produced unchanged results for Model 2, but effects for Model 1 were no longer significant (see Supplementary File S8).

Mathematics. Performance in mathematics had a positive correlation with self-regulation in cross-sectional studies, $k = 22$, $r = .42$ (95% CI: .35, .48). Egger's test showed no evidence of small sample bias. The regression model for age, sex, and study quality was non-significant, $\chi^2(3) = 7.18$, $p = .067$, $R^2 = .27$, but a significant coefficient did emerge for child age, $b = –.04$ (95% CI: –.07, –.01), indicating that the positive association between self-regulation and math performance was stronger among younger children. There was no meaningful covariance between age and other predictors in the regression model (r's < .30). The regression model for self-regulation measure was non-significant. For Model 2, self-regulation in preschool was related to math performance in early school years, $k = 20$, $r = .31$ (95% CI: .23, .38), with no significant moderation by timespan, sex, or study quality, $\chi^2(3) = 3.64$, $p = .303$, $R^2 = .23$, but a significant moderation by measure, $k = 15$, $\chi^2(3) = 24.92$, $p <$

.001, R^2 = .70, that showed the correlation between self-regulation in preschool and math performance in early school years was stronger for task-based assessments than for parent-report assessments. A follow-up regression model with subgroup modelled as the unit of analysis produced the same finding.

Literacy. Literacy skills (reading and writing) also had a positive correlation with self-regulation in cross-sectional studies, k = 20, r = .34 (95% CI: .28, .39). There was no evidence of small sample bias, and no significant moderation by age, sex, or study quality, $\chi^2(3) = 3.81$, p = .283, R^2 = .24, or self-regulation measure, k = 14, $\chi^2(3) = 1.99$, p = .370, R^2 = .19. For Model 2, self-regulation in preschool was related to literacy performance in early school years, k = 20, r = .24 (95% CI: .16, .32), albeit with evidence of small sample bias, $t(18) = 4.53$, $p < .001$. There was no significant moderation by measure for effects modelled at the level of the study, k = 14, $\chi^2(3) = 2.46$, p = .292, R^2 = .21, or the subgroup, k = 26, $\chi^2(3) = 1.65$, p = .649, R^2 = .09. There were an insufficient number of effects to test for moderators of the positive association observed in Model 3, k = 8, r = .20 (95% CI: .07, .32).

Vocabulary. An assessment of vocabulary had often been included in young sample studies. In cross-sectional studies, children with better self-regulation tended to have better vocabulary skills, k = 11, r = .34 (95% CI: .25, .43). There was no evidence of small sample bias. There was a significant regression model, $\chi^2(3) = 8.60$, p = .035, R^2 = .49, showing a significant moderation by child age, b = .13 (95% CI: .01, .25). The positive coefficient indicates that the positive association between self-regulation and vocabulary skills was stronger among older children in the sample (age range 4 – 7). There was also a significant regression model for measure, k = 8, $\chi^2(3) = 32.27$, $p < .001$, R^2 = .90, with teacher-report assessments showing stronger associations with vocabulary skills than parent-report, b = –.67 (95% CI: –.91, –.42), $p < .001$, and task-based assessments, b = –.45 (95% CI: –.70, –.21), $p < .001$. However, this effect did not emerge in moderation analysis modelled at the subgroup

level, $k = 14$, $\chi^2(3) = 4.13$, $p = .248$, $R^2 = .28$. For Model 2, self-regulation in preschool was associated with better vocabulary skills in early school years, $k = 8$, $r = .24$ (95% CI: .13, .34), albeit with some evidence of small sample bias, $t(6) = 3.27$, $p = .017$.

Intelligence

Intelligence test scores have often been explored as a marker of academic competence and showed a positive association with self-regulation in cross-sectional studies (mean age = 8.3 ± 2.6 years), $k = 12$, $r = .29$ (95% CI: .23, .35). There was no evidence of small sample effects and no moderation by sample age, sex, or study quality. However, there was a significant moderation by measure, $k = 9$, $\chi^2(3) = 46.73$, $p < .001$, $R^2 = 1.00$, with regression coefficients showing that the positive correlation between self-regulation and intelligence was smaller for parent-report assessments than for task-based assessments, $b = .27$ (95% CI: .14, .41), $p < .001$, and teacher-report assessments, $b = .31$ (95% CI: .21, .40), $p < .001$. A follow-up regression model with subgroup specified as the unit of analysis produced identical results, albeit with a lower amount of variance explained, $k = 15$, $\chi^2(3) = 13.19$, $p = .004$, $R^2 = .57$.

School Engagement

Higher levels of self-regulation were associated with greater school/class engagement in cross-sectional studies (mean age = 6.7 ± 3.4 years), $k = 3$, $r = .30$ (95% CI: .18, .41). A sensitivity analysis involving imputation of one missing effect produced unchanged results. For Model 2, the mean age at baseline was 5.0 (± 0.7) years with an average length follow-up of 2.3 (± 1.4) years. There was a positive association between self-regulation in preschool and school/class engagement in early school years, $k = 6$, $r = .27$ (95% CI: .18, .36), with no evidence of small sample bias.

University Completion and Unemployment

Higher levels of self-regulation in childhood (mean age = 6.5 years) were associated with a greater likelihood of having completed a higher education qualification in adulthood (mean age = 25.5 years), $k = 2$, $r = .22$ (95% CI: .16, .28). For unemployment, the mean age for self-regulation measurement was 7.8 (± 2.8) years, and the mean age for measurement of unemployment/financial troubles was 38.0 (± 8.1) years. There was a negative association between self-regulation in childhood and unemployment in adulthood, $k = 5$, $r = –.15$ (95% CI: –.20, –.10). Egger's test showed no evidence of small sample effects and all studies used adult-report measures of self-regulation.

Social Competence

For cross-sectional associations (mean age = 7.0 ± 3.6 years), there was a positive association between self-regulation and social competencies (social skills), $k = 10$, $r = .26$ (95% CI: .17, .34). Egger's test showed some evidence of small sample bias, $t(8) = 5.77$, $p < .001$. There was no moderation by age, sex, or study quality, $\chi^2(3) = 3.27$, $p = .352$, $R^2 = .21$, and no moderation by self-regulation measure, $\chi^2(3) = 5.29$, $p = .152$, $R^2 = .49$. For Model 2, self-regulation in preschool (mean age = 4.6 ± 1.0 years) had a positive association with social competence in early school years (mean age = 6.8 ± 1.3 years), $k = 5$, $r = .22$ (95% CI: .10, .33). A small number of studies also provide evidence that self-regulation in childhood relates to social competence in later childhood and adulthood (see Table 2).

Peer Victimization

For cross-sectional studies (mean age = 7.5 ± 3.9 years), a negative correlation showed that children were less likely to be victimized by their peers (target of aggressive behavior or social exclusion) if they had higher levels of self-regulation, $k = 8$, $r = –.33$ (95% CI: –.46, –.19). There was no evidence of small sample effects. There was a significant regression model for integer terms, $\chi^2(3) = 16.15$, $p = .001$, $R^2 = .72$, with a significant coefficient for study quality, $b = –.07$ (95% CI: –.12, –.02), $p = .003$. The negative regression

coefficient indicates that the magnitude of the negative association became smaller as the study quality rating became higher. In other words, higher quality studies showed a smaller negative association between self-regulation and peer victimization. Higher self-regulation in preschool (mean age = 4.2 ± 0.2 years) was also associated with lower peer victimization in early school years (mean age = 6.0 ± 0.4 years), $k = 4$, $r = –.21$ (95% CI: –.35, –.05), and higher self-regulation in early school years (mean age = 8.7 ± 0.8 years) was associated with a lower occurrence of peer victimization (peer rejection or peer pressure) in later school years (mean age = 12.3 ± 3.6 years), $k = 3$, $r = –.22$ (95% CI: –.37, –.06).

Externalizing Problems

For cross-sectional studies (mean age = 7.7 ± 3.0 years), a negative association was observed between self-regulation and externalizing problems, $k = 40$, $r = –.34$ (95% CI: –.38, –.31). A sensitivity analysis involving imputation of one missing effect size produced unchanged results and there was no evidence of small sample bias. For Model 2, there was a negative association between self-regulation in preschool (mean age = 3.9 ± 0.7 years) and externalizing problems in early school years (mean age = 7.5 ± 1.9 years), $k = 10$, $r = –.30$ (95% CI: –.42, –.18). Egger's test showed no evidence of small sample bias and sensitivity analysis involving imputation of two missing effects produced unchanged results. A negative association also emerged between self-regulation in early school years (mean age = 8.5 ± 2.2 years) and externalizing problems in later school years (mean age = 11.3 ± 2.3 years), $k = 15$, $r = –.28$ (95% CI: –.37, –.18). There was no evidence of small sample bias and imputation of one missing effect produced unchanged results. The final model showed that self-regulation in childhood (mean age = 6.6 ± 2.7 years) also had a negative association with externalizing problems in adulthood (mean age = 35.0 ± 6.5 years), $k = 5$, $r = –.17$ (95% CI: –.20, –.13).

Regression analysis showed that cross-sectional associations were not moderated by age, sex, or study quality, $\chi^2(3) = 6.74$, $p = .081$, $R^2 = .18$. However, there was a significant

moderation by measure, $k = 31$, $\chi^2(4) = 23.97$, $p < .001$, $R^2 = .49$, such that the negative correlation between self-regulation and externalizing problems was stronger for task-based assessments than for parent-report, $b = –.28$ (95% CI: –.45, –.10), $p = .002$, teacher-report, $b = –.48$ (95% CI: –.67, –.29), $p < .001$, observational, $b = –.30$ (95% CI: –.52, –.07), $p = .009$, and self-report, $b = –.27$ (95% CI: –.45, –.08), $p = .004$, measures. A follow-up regression model with subgroup as the unit of analysis produced similar results, $k = 41$, $\chi^2(4) = 17.56$, $p = .002$, $R^2 = .32$. For Model 2, there was no significant regression model for integer terms, $\chi^2(3) = 5.59$, $p = .133$, $R^2 = .37$. However, a significant regression coefficient did emerge for timespan, $b = –.08$ (95% CI: –.15, –.01), $p = .018$. The negative coefficient indicates that the negative correlation between self-regulation in preschool and externalizing problems in early school years was stronger for shorter duration studies. Observation of the correlation matrix showed that the regression coefficient for timespan was confounded with participant sex ($r = .60$). For Model 3, there were no significant regression models.

Aggressive behavior. For cross-sectional studies (mean age = 8.1 ± 3.0 years), a negative association was observed between self-regulation and aggressive behavior, $k = 14$, $r = –.27$ (95% CI: –.38, –.15), with no evidence of small sample bias. Moderator analyses showed no significant moderation by age, sex, or study quality, $\chi^2(3) = 2.74$, $p = .433$, $R^2 = .18$, but a significant moderation by measure, $k = 14$, $\chi^2(3) = 171.57$, $p < .001$, $R^2 = 1.00$, such that the negative correlation between self-regulation and aggression was stronger for task-based assessments than for parent-report, $b = –.21$ (95% CI: –.37, –.07), $p = .005$, and teacher-report, $b = –.49$ (95% CI: –.63, –.35), $p < .001$, assessments. There was no significant association between self-regulation in early school years and aggression in later school years, $k = 4$, $r = –.12$ (95% CI: –.24, .01).

Criminal behavior. Self-regulation in childhood (mean age = 9.4 ± 4.1 years) was associated with criminal behavior in later school years (mean age = 14.4 ± 0.1 years), $k = 2$, r

= –.19 (95% CI: –.28, –.10). Self-regulation in childhood (mean age = 7.2 ± 2.8 years) was also associated with criminal behavior in adulthood (mean age = 36.5 ± 6.4 years), $k = 4$, r = –.15 (95% CI: –.18, –.12).

Internalizing Problems

For cross-sectional studies (mean age = 8.2 ± 2.6 years), a negative association was observed between self-regulation and internalizing problems, $k = 22$, r = –.29 (95% CI: –.35, –.24). There was no evidence of small sample bias and findings were unchanged following imputation of two missing effects. There was also a negative association between self-regulation in preschool years (mean age = 4.1 ± 0.5 years) and internalizing problems in early school years (mean age = 9.2 ± 2.8 years), $k = 8$, r = –.15 (95% CI: –.19, –.11), and a negative association between self-regulation in early school years (mean age = 8.6 ± 2.0 years) and internalizing problems in later school years (mean age = 11.6 ± 2.2 years), $k = 12$, r = –.18 (95% CI: –.25, –.12), with no evidence of small sample bias. Model 4 showed that self-regulation in childhood (mean age = 7.3 ± 2.3 years) related to internalizing problems approximately 30 years later (mean age = 35.1 ± 6.6 years), $k = 8$, r = –.09 (95% CI: –.16, –.03), with no evidence of small sample bias.

Cross-sectional associations were not moderated by age, sex or study quality, $\chi^2(3) = 4.17$, $p = .244$, $R^2 = .17$, or measure, $k = 16$, $\chi^2(3) = 7.59$, $p = .055$, $R^2 = .36$. However, there was a significant coefficient for one measure comparison, showing the negative association between self-regulation and internalizing problems was stronger for parent-report than for teacher-report assessments, b = –.25 (95% CI: –.43, –.07), $p = .006$. This finding did not however emerge in a follow-up regression model with subgroup set as the unit of analysis ($k = 29$). For Model 3, there was no significant moderation by integer variables, $\chi^2(3) = 1.24$, $p = .744$, $R^2 = .22$, and assessments were too varied to reliably explore as moderators. We also computed a regression analysis for Model 4 despite only eight effects in the model. There

was a significant overall effect, $\chi^2(3) = 28.60$, $p < .001$, $R^2 = 1.00$, with significant coefficients for study quality, $b = –.07$ (95% CI: –.11, –.02), $p = .001$, and length of follow-up time, $b = .08$ (95% CI: .03, .12), $p = .001$. These effects were such that the negative association between childhood self-regulation and adult internalizing problems was stronger among studies coded as lower quality and in those with a longer timeframe between baseline and follow-up. There was little covariance between these predictors ($r = .21$).

Depressive symptoms. For cross-sectional studies (mean age = 8.7 ± 2.4 years), a negative association was observed between self-regulation and symptoms of depression, $k = 6$, $r = –.37$ (95% CI: –.52, –.21), with no evidence of small sample bias. Prospective studies also showed that self-regulation in preschool, $k = 2$, $r = –.25$ (95% CI: –.39, –.10), and early school years, $k = 5$, $r = –.21$ (95% CI: –.30, –.12), related to depressive symptoms in later school years. There was also evidence that higher self-regulation in childhood (mean age = 7.4 ± 2.6 years) was associated with a decreased likelihood of depression in adulthood (mean age = 36.5 ± 7.2 years), $k = 6$, $r = –.11$ (95% CI: –.21, –.01).

Anxiety and suicidal thoughts. For cross-sectional studies (mean age = 7.2 ± 3.8 years), a negative association was observed between self-regulation and symptoms of anxiety, $k = 5$, $r = –.29$ (95% CI: –.46, –.11). There was also evidence that higher self-regulation in childhood (mean age = 9.0 ± 1.0 years) was associated with a decreased likelihood of anxiety in adulthood (mean age = 30.2 ± 5.8 years), $k = 3$, $r = –.09$ (95% CI: –.13, –.05). Two further studies provided evidence that higher self-regulation in childhood (mean age = 9.5 ± 0.6 years) related to a decreased likelihood of suicidal thoughts in adulthood (mean age = 27.3 ± 3.9 years), $r = –.14$ (95% CI: –.25, –.02).

Body Mass and Physical Activity

For cross-sectional associations (mean age = 6.2 ± 3.4 years), a negative correlation showed that children were less likely to be overweight if they had higher levels of self-

regulation, $k = 4$, $r = –.09$ (95% CI: –.15, –.03). There was no association between self-regulation in preschool (mean age = 4.0 ± 0.7 years) and body mass in later school years (mean age = 13.1 ± 1.9 years), $k = 4$, $r = –.06$ (95% CI: –.17, .06), but there was a negative association between self-regulation in early school years (mean age = 7.9 ± 1.9 years) and body mass in later school years (mean age = 13.7 ± 2.1 years), $k = 5$, $r = –.11$ (95% CI: –.17, –.04). There was also evidence that higher self-regulation in childhood (mean age = 5.5) relates to a lower body mass index in adulthood (mean age = 40.5), $k = 2$, $r = –.17$ (95% CI: –.25, –.09). There was no evidence of small sample effects and there were an insufficient number of effects to explore moderators. Three studies explored self-regulation as it relates to physical activity but could not be combined in meta-analysis (see Table 2).

Alcohol

Self-regulation in childhood (mean age = 9.0 ± 2.6 years) was unrelated to alcohol use in adolescence (mean age = 16.0 ± 2.6 years), $k = 2$, $r = –.14$ (95% CI: –.30, .02). However, a sensitivity analysis involving the imputation of one missing (negative) effect narrowed the confidence intervals indicating that higher self-regulation in childhood relates to lower alcohol use in adolescence, $k = 3$, $r = –.13$ (95% CI: –.21, –.04). There was also a significant negative correlation showing that higher self-regulation in childhood (mean age = 8.5 ± 0.4 years) was related to a decreased likelihood of alcohol abuse in adulthood (mean age = 38.0 ± 6.9 years), $k = 3$, $r = –.11$ (95% CI: –.18, –.03).

Substance Use

For cross-sectional studies, higher self-regulation in later childhood (mean age = 11.7 ± 1.2 years) was associated with a decreased likelihood of substance use, $k = 6$, $r = –.25$ (95% CI: –.28, –.21). Sensitivity analysis involving imputation of one missing effect produced unchanged results. Self-regulation in later childhood (mean age = 11.5 ± 1.4 years) also related to substance use in adolescence (mean age = 14.7 ± 1.9 years), $k = 8$, $r = –.14$ (95%

CI: –.20, –.08). A sensitivity analysis involving imputation of one missing effect produced unchanged results and Egger's test showed no evidence of small sample bias. Despite only eight effect sizes available, a regression model was run for integer variables and showed no significant effects, $\chi^2(3) = 5.40$, $p = .145$, $R^2 = .47$. There was also evidence that higher self-regulation in childhood (mean age = 7.5 ± 3.8 years) related to a lower incidence of substance abuse in adulthood (mean age = 28.8 ± 3.9 years), $k = 3$, $r = –.11$ (95% CI: –.19, –.03).

Cigarette Smoking

Higher self-regulation in childhood (mean age = 8.4 ± 2.1 years) related to a lower incidence of cigarette smoking in adolescence (mean age = 16.3 ± 2.4 years), $k = 2$, $r = –.09$ (95% CI: –.11, –.07). Imputation of one missing (negative) effect produced identical results. There was also evidence that higher self-regulation in childhood (mean age = 8.8 ± 1.3 years) related to a lower incidence of cigarette smoking in adulthood (mean age = 42.3 ± 10.2 years), $k = 4$, $r = –.17$ (95% CI: –.20, –.13). There was no evidence of small sample effects and an insufficient number of effects to explore moderators.

Sleep and Physical Health

A small number of studies showed that higher self-regulation was associated with better sleep quality in childhood (Table 2). Self-regulation was also associated with markers of physical illness. In particular, self-regulation in early childhood (mean age = 5.0 ± 2.3 years) had a negative correlation with physical illness in adulthood (mean age = 38.6 ± 4.8 years), $k = 4$, $r = –.05$ (95% CI: –.07, –.04).

Discussion

This meta-analysis sought to determine whether self-regulation in childhood relates to concurrent and subsequent levels of achievement, interpersonal behaviors, mental health and healthy living. Important findings were that higher self-regulation in preschool was related to better social skills, class/school engagement, and performance in mathematics, literacy and

vocabulary, as well as lower instances of peer victimization, internalizing problems and externalizing problems in early school years. Higher self-regulation in early school years was related to better performance in mathematics and literacy, and a lower incidence of aggressive behavior, depressive symptoms, obesity, cigarette smoking and illicit drug use in later school years. Higher self-regulation in childhood was also related to a greater likelihood of unemployment, criminal behavior, symptoms of depression and anxiety, obesity, cigarette smoking, alcohol and substance abuse, and symptoms of physical illness in adulthood. The magnitude of these associations differed relative to self-regulation measure, with task-based assessments and (to a lesser extent) teacher-report assessments often showing stronger associations than parent-report assessments.

Main Findings

Achievement. The finding that higher levels of self-regulation were associated with higher levels of concurrent and subsequent academic achievement – for mathematics, literacy and vocabulary – is similar to previous meta-analyses exploring inhibitory control (Allan et al., 2014) and self-control related skills (Smithers et al., 2018). Effect sizes were somewhat larger for cross-sectional associations than for longitudinal associations. Cross-sectional associations were moderated by child age, such that self-regulation had a stronger association with mathematics performance among younger children. There was also an age moderation effect for vocabulary performance with a stronger association observed for older children, albeit with a somewhat restricted age range in the analysis (age 4–7 years). Self-regulation appeared to have a stronger association with mathematics performance than with literacy or vocabulary performance, and this is consistent with findings from a previous meta-analysis of inhibitory control (Allan et al., 2014), but not those of a meta-analysis of self-control related skills (Smithers et al., 2018) that showed comparable effect sizes across academic outcomes. This finding might be anticipated given that mathematical problem-solving requires cognitive

control skills (Bull & Lee, 2014; Zhou, Chen, & Main, 2012) and prefrontal regions of the brain (Allan et al., 2014; Blair & Raver, 2015) that are considered critical for self-regulation. The smaller effect sizes for vocabulary and literacy might also relate to greater educational efforts directed toward language at home and in preschool (Siraj et al., 2016) that could limit the effect of individual difference factors (i.e., self-regulation) in the development of these abilities.

Similar to previous meta-analytic findings on inhibitory control (Allan et al., 2014) we also found that task-based assessments (such as those that involve children touching their knees when told to touch their head) tended to produce larger effect sizes than parent-report assessments. However, contrary to findings on inhibitory control (Allan et al., 2014) we did not find that task-based assessments produced larger effect sizes than teacher-report assessments. Therefore, a key finding from this meta-analysis is that teacher-report assessments produced comparable effect sizes to task-based assessments, at least in relation to academic achievement, with both teacher-report and task-based assessments producing larger effect sizes than parent-report assessments. This finding might reflect teachers having a broader reference point than parents in relation to situating a child within a normal developmental continuum, and their understanding of the attributes required for success in school. The same finding emerged for intelligence test scores (often considered a marker of academic achievement) with larger effect sizes observed for task-based and teacher-report assessments than for parent-report assessments. The finding that self-regulation relates to intelligence test scores in cross-sectional studies is consistent with previous meta-analytic findings on self-control related skills (Smithers et al., 2018).

The finding that higher self-regulation in childhood was associated with a greater likelihood of achieving a higher education qualification in later life is similar to a previous meta-analysis in adult samples that showed effort regulation (persistence and effort when

faced with challenging academic situations) is associated with achievement in higher education (Richardson, Abraham, & Bond, 2012). We also found that higher self-regulation in childhood was associated with a decreased likelihood of long-term unemployment in adulthood, and this finding extends those of a previous meta-analysis in adults showing that higher self-control is associated with better work-related outcomes (de Ridder et al., 2012). These findings might be anticipated given that school performance is a reliable indicator of adult unemployment (Caspi, Wright, Moffitt, & Silva, 1998). The effect sizes for adult outcomes were somewhat smaller than those for short-term academic achievement, but were small-medium in magnitude (Funder & Ozer, 2019) suggesting a practically meaningful effect. This is a notable finding given the near 30-year timeframe between measurement of self-regulation and subsequent adult unemployment.

Interpersonal behavior. The finding that higher levels of self-regulation were associated with higher concurrent and subsequent levels of social competence is consistent with previous meta-analytic findings that showed self-control related skills correlate with social skills in child samples (Smithers et al., 2018), and that self-regulation relates to better interpersonal functioning skills in adolescent and adult samples (de Ridder et al., 2012). Poor social skills have been found to increase risk of peer victimization in children (Fox & Boulton, 2006) and we also found that higher self-regulation was associated with a decreased risk of peer victimization (e.g., being called names or teased by other children) in cross-sectional and prospective studies. This is consistent with a previous meta-analysis that found higher levels of self-regulation relate to a greater likelihood of general victimization (e.g., online bullying, sexual harassment) in child and adult samples (Pratt et al., 2014). The effect sizes were medium in magnitude. However, it should be noted that studies coded as being of higher quality showed smaller effect sizes in cross-sectional studies.

Self-regulation is thought to improve social interactions by curtailing undesirable or aggressive behaviors that can result in peer rejection (Montroy, Bowles, Skibbe, & Foster, 2014; Vohs & Ciarocco, 2004). Externalizing problems (e.g., aggression, disruption, non-cooperative behaviors) have been the most frequently investigated correlates of self-regulation in childhood. The finding that higher levels of self-regulation were associated with fewer externalizing problems when measured concurrently is consistent with previous meta-analyses that found externalizing problems are associated with self-control related skills (Smithers et al., 2018) and emotion-related aspects of self-regulation (Compas et al., 2017) in child samples. The effect size was comparable to Compas et al. (2017), but also varied relative to the method of self-regulation assessment. In this instance, task-based measures of self-regulation showed a larger effect than teacher-report, parent-report, observational, and self-report measures.

An important new finding was that higher child self-regulation was related to lower externalizing problems across all three categories of prospective studies. In particular, higher self-regulation in preschool was associated with fewer externalizing problems in early school years, with smaller effect sizes found for longer duration studies. However, it should be noted that this timeframe moderation effect was confounded with participant sex – longer duration studies tended to have a greater number of girls in the sample – and we cannot discount the possibility that child sex (rather than study duration) is the variable moderating the pooled mean effect. Higher self-regulation in early school years was also associated with fewer externalizing problems in adolescence and adulthood. Interestingly, the self-regulation measure moderation observed in cross-sectional studies did not emerge in prospective studies. This finding might reflect the less varied approach to measurement in prospective studies with most prospective studies adopting adult-report assessments. A key finding is that self-regulation at age 7 could predict aggressive behavior 30 years later, and this builds on

previous meta-analytic findings that found self-control in adolescent and adult samples is associated with deviant behaviors such as stealing and cheating (de Ridder et al., 2012). However, it should be noted that the effect size was small in magnitude, but might be practically meaningful given the large timeframe between baseline and follow-up (Funder & Ozer, 2019).

Mental health. The finding that higher levels of self-regulation were associated with fewer internalizing problems (psychological states related to depression, withdrawal, anxiety, loneliness, or suicidal thoughts) in cross-sectional studies is consistent with a previous meta-analysis that found emotion-related aspects of self-regulation relate to internalizing problems in child samples, with a comparable effect size (Compas, 2017). Higher self-regulation was also associated with fewer internalizing problems in prospective studies. Self-regulation in preschool related to internalizing problems in early school years, and self-regulation in early school years related to internalizing problems in both adolescence and adulthood. Effects in prospective studies were small, and for internalizing problems in adulthood the pooled mean effect was moderated by the duration and quality of the research. This effect was such that smaller effects emerged in studies of longer duration and those coded as being of higher quality. These moderation effects might be anticipated given that over longer timespans there is greater opportunity for other factors to affect internalizing problems, and lower quality studies with larger effects are more likely to be published than lower quality studies with smaller and non-significant effects.

We also explored symptoms of depression, anxiety, and suicidal thoughts in separate analyses. Higher self-regulation was associated with lower reported depression and anxiety symptoms in cross-sectional studies. Higher self-regulation in early school years was also associated with a decreased likelihood of depressive symptoms in adolescence, and a decreased likelihood of depression, anxiety, and suicidal thoughts in adulthood. That self-

regulation at age 7 years can predict mental health issues 30 years later is an important new finding and consistent with theoretical models that predict the ability to tolerate and regulate emotions has a prominent role in suicidality (Law, Khazem, & Anestis, 2015). Moreover, the ability to tolerate negative emotions and the coping methods used in response to negative emotions are predicted to increase (or decrease) vulnerability toward suicidality more so than the experience of emotion itself (Law et al., 2015). Findings from the prospective research showed a small pooled mean effect (and confidence intervals neared zero), suggesting that findings require further study.

Healthy living. The finding that higher self-regulation was associated with a lower BMI in cross-sectional research differs somewhat from previous research that found self-control related skills in general were unrelated to BMI in child samples (Smithers et al., 2018). However, effect sizes were comparable (i.e., small) and we also found that self-regulation in preschool was unrelated to BMI in early school years, albeit with substantial unexplained heterogeneity in the data. Nevertheless, we did find that higher self-regulation in early school years was associated with a lower BMI in adolescence and adulthood. This finding builds on previous meta-analytic research that found self-control relates to body mass in adolescent and adult samples (de Ridder et al., 2012), and might reflect the finding that eating behavior and physical activity are partly determined by visceral and impulsive processes (de Ridder et al., 2012; Lavagnino, Arnone, Cao, Soares, & Selvaraj, 2016). Few studies explored self-regulation as it relates to physical activity and sleep parameters, but those available seem to suggest that self-regulation might be important for active living and sleep.

Higher self-regulation in early school years was associated with a decreased likelihood of illicit drug use and cigarette smoking in adolescence, and a decreased likelihood of substance abuse, alcohol abuse, and cigarette smoking in adulthood. These findings align

with a previous meta-analysis that found lower self-control in adolescence and adulthood relates to a greater involvement in addictive behaviors (de Ridder et al., 2012). Importantly, we also found that higher self-regulation in early school years was related to more reported symptoms of physical illness (e.g., cardiovascular disease) nearly 30 years later, albeit with a trivial-small effect size. Given the importance of healthy living for non-communicable disease (Ding et al., 2016; Lee et al., 2012), self-regulation might relate to symptoms of physical illness through the mediating process of healthy or unhealthy living.

Overall, findings are in general agreement with previous meta-analytic research in adolescent and adult samples showing that self-control is important for overall desired and undesired behavior (de Ridder et al., 2012). The findings are also consistent with results from a meta-analysis of self-control related skills (including attention, cognitive flexibility, working memory, emotional reactivity, alongside self-regulation) and life outcomes in children, that found intellectual functions are associated with academic achievement, social skills, internalizing problems and externalizing problems (with small effect sizes) but not BMI (Smithers et al., 2018). Effect sizes in the current study appear somewhat larger for academic achievement, but are similar in magnitude to Smithers et al. for psychosocial outcomes and BMI. The larger effect sizes observed for academic achievement might indicate that self-regulation is one of the more important cognitive skills for achievement outcomes, but could also reflect important methodological differences between meta-analyses.

Limitations

Strengths of this research include the systematic approach to study identification, the broad range of life outcomes tested, the testing of multiple moderator effects, and testing cross-sectional and age-specific longitudinal designs in separate analyses. However, there are a number of important limitations that readers must consider in order to place the findings

firmly in context. First, many populations of children were not well represented in the overall sample with the majority of research being conducted in nations with a high native European population (North America, Europe, and Australasia). No research was identified for populations in Africa or South America, and few samples were available for Asia. In other words, people from 'Western, educated, industrialized, rich and democratic' (WEIRD) societies (Henrich, Heine, & Norenzayan, 2010) are over-represented in the sample and cultural and wealth differences could factor into the magnitude of associations between self-regulation and outcomes in later life. Therefore, findings from this meta-analysis should be considered a reflection of sampled participants that might not necessarily transfer across world regions.

Another limitation is that most samples included in the meta-analysis had an even distribution of boys and girls meaning that potential sex moderation effects were difficult to detect. Academic achievement, interpersonal skills, mental health issues, and healthy living are all known to differ in magnitude between boys and girls (Bauman et al., 2012; Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015; Voyer & Voyer, 2014). Failure to detect sex moderation effects in the current meta-analysis could mean that there are no effects to be found, but could also indicate that the samples were too uniform in terms of sex-ratio to reliably explore sex as a moderator. In many instances, the sample size was small meaning the meta-regression models likely had insufficient power to detect even a large effect (see Gonzalez-Mulé & Aguinis, 2018). It is also possible that sex moderations are non-linear in nature. In one study it was found that while boys' and girls' self-regulatory abilities were similar on average, the bottom 10% of boys scored considerably worse than the bottom 10% of girls (Matthews, Ponitz, & Morrison, 2009). This greater variation among boys might indicate that abilities develop at different rates between sexes that might require consideration in further prospective research of self-regulation and life outcomes.

A third limitation is that some estimates showed substantial small sample bias in the results. In particular, funnel plots for academic achievement outcomes were considerably skewed (see, for example, Model 2 estimates in Supplementary File S7) indicating a tendency for journal editors to favor the publication of statistically significant results in underpowered studies, and this contributes to biased estimates in meta-analysis (McShane, Böckenholt, & Hansen, 2016). It is also important to note that for studies where $k < 10$ publication bias estimates tend to be unreliable (Borenstein et al., 2009). Study quality was assessed using the AXIS tool and tested as a moderator, but failed to predict the strength of associations. It should be noted that there was little variation in scores for this assessment measure with most studies scoring highly meaning the small differences between studies could reflect differences in study quality but could also reflect journal editors placing restrictions on word counts meaning authors are compelled to remove important information from high quality studies. Perhaps the best method to remove publication bias from the scientific record is for researchers to adopt registered reports as the preferred method of publication (Chambers, 2013; Nosek & Lakens, 2014) and future meta-analyses to establish registered reports as a criterion for inclusion in the meta-analysis.

A fourth potential limitation is that all included studies will differ somewhat in their overall design with some studies adopting more rigorous methods than others. In particular, outcomes can be assessed in multiple ways with some measures being more susceptible to response distortion (e.g., social desirability bias). For example, body mass index and physical activity levels can be assessed using self-report but can also be assessed using objective measures such as researcher calculated height and weight (for BMI) and pedometers or accelerometers for physical activity levels (see e.g., Reilly et al., 2008). Objective measures are considered the better assessment method in most instances and most outcomes can be assessed using objective measures (see Moffitt et al., 2011, for a good example of objective

measures of life outcomes in self-regulation research). To date, most studies have used subjective (self-report) measures of interpersonal and health outcomes in self-regulation research and we encourage future research to adopt objective assessments for outcomes in studies of childhood self-regulation.

A fifth limitation is that heterogeneity estimates often remained high even after controlling for potential moderators and measurement in particular. Measurement was grouped into five categories (parent-report, teacher-report, self-report, observational and task-based) and explained a substantial proportion of the total variation in academic achievement outcomes across studies due to heterogeneity. However, the explained variance was in the region of 30 percent (somewhat higher for intelligence test scores) and measurement coding was unable to explain variation across studies for other outcomes. This finding might be due to differences in reliability and validity between specific assessments within these groups – the current meta-analysis identified 67 assessments of self-regulation that were grouped into categories and not all have been subjected to critical validation – but could also reflect assessments tapping into different components of self-regulation (e.g., processes that enable self-controlled behavior and those processes that disrupt it). The potential dimensionality of self-regulation is captured in the dual systems model (Steinberg, 2010) that distinguishes between volitional and impulsive processes, and whether assessment measures are capturing constructs that are meaningfully distinct is an important question for research integration and theoretical development. It is interesting to note that while correlations between self-regulation measures tend to be low (Duckworth & Kern, 2011; Enkavi et al., 2019) they tend to predict outcomes to a similar extent. As more knowledge on the strengths and weaknesses of various teacher-report and task-based assessments accumulates, future meta-analyses might narrow their focus to include only those measures that satisfy a minimum threshold of validity and reliability in order to establish self-regulation as a coherent entity.

A sixth potential limitation is that the findings of this meta-analysis are for crude (non-adjusted) correlation coefficients. The potential downside of using zero-order correlations is that the effects do not account for potential spurious correlations. Because the influence of other potential confounds have not been removed (e.g., socioeconomic status), the correlations reported are likely to be inflated (although see, Allen, Walter, & Swann, 2019). It is common and appropriate to explore crude and multivariable controlled effects in separate meta-analyses (e.g., Pratt et al., 2014). However, for the current research there were few instances in which studies reported effects that controlled for important confounds, and those that did often differed substantially in the variables held constant (see Supplementary File S9). We included non-adjusted estimates where available but in some instances it was necessary to include an adjusted coefficient where the zero-order correlation was not reported (see Supplementary File S9). Nevertheless, the effects reported in this meta-analysis should be considered representative of the zero-order correlation coefficient. We encourage researchers to provide both crude estimates and those adjusted for important confounds in subsequent work. If some consistency can emerge in control variables held constant across studies then subsequent meta-analyses will be able to test the importance of self-regulation for life outcomes independent of these potential confounds.

Despite the potential inflated correlation coefficients from uncontrolled confounds, it is also likely that correlation coefficients were deflated as a result of measurement error. For example, if two perfectly measured constructs are expected to correlate at $r = .25$, but the actual measurement of each correlates with its pure construct at .63 (reliability estimate), then the observed correlation between the two measures will be reduced to $r = .10$ (Cohen, 1988). The degree to which parent-report, teacher-report, task-based, and observational assessments reflect the real-world self-regulatory abilities of children is unknown and each approach provides only an approximation of a child's ability. Parent/teacher report and observational

assessments might have higher ecological validity than task-based assessments but they are also susceptible to a variety of observational biases (e.g., social desirability, researcher bias). That teacher-report and task-based assessments produced similar effect sizes for academic outcomes (that differed somewhat from parent-report assessments) might suggest that parent-report assessments are a less reliable source of information on child self-regulation. This has implications for future research and methods of assessment in professional practice.

Tied into the point above, a final limitation is that the current meta-analysis focused on prospective associations where baseline levels of the dependent variable are uncontrolled. The decision of whether to control for baseline levels of a dependent variable depends largely on the research question being asked. Both analytical approaches can be useful and address slightly different research questions with different potential applications. For example, our meta-analysis provides evidence that a measure of self-regulation in childhood can predict (to some extent) levels of aggression in adulthood. However, this does not address whether self-regulation is related to change in aggression over time. To a theorist interested in identifying cause and effect our findings are of little value. However, to a practitioner who wants to know whether sampling children for self-regulation skills in preschool can help identify likelihood of problem behavior in early school years (for example), our findings should be very useful. Analyses without baseline measures provide the more practical information for population-level interventions, whereas analyses that control for baseline scores provide the more practical information for individual clinicians interested in changing child behavior. For some outcomes (e.g., unemployment or final educational attainment) it will not be possible to obtain baseline levels, but we recommend researchers explore both uncontrolled and change score approaches where possible.

Implications

The results of this meta-analysis have implications for theoretical advancement and subsequent research in child development. The finding that teacher-report and task-based assessments of self-regulation tended to produce larger effect sizes than parent-report assessments (for academic outcomes), and that task-based assessments tended to produce larger effect sizes than adult-report assessments (for interpersonal outcomes) has implications for measuring child self-regulation in research and professional practice. It is unknown whether task-based measures are inflating the true effect size or whether adult-report measures are deflating the true effect size. That parent-report measures consistently produced smaller effect sizes might reflect parents (of lower ability children) being more susceptible to inflate the capabilities of their child, resulting in heightened measurement error. As teachers are less susceptible to such bias, our recommendation is that researchers and practitioners adopt task-based measures or teacher-report measures (or preferably both) where possible to obtain a more reliable estimate of child self-regulation.

The findings of this meta-analysis might also be valuable for theoretical advancement and could contribute to development of a framework that helps to explain how self-regulatory abilities in early childhood help to shape life trajectories. Control-based models explain how factors such as stress, tiredness, hunger, and emotions undermine abilities (or decisions) to resist impulses and distractions (Muraven & Baumeister, 2000) and there might be scope to develop more long-term predictions about how self-regulation feeds back into psychological states shaping patterns of development and consequential life outcomes. The findings of this meta-analysis indicate that self-regulation in childhood is important for unemployment, criminal behavior, depression and anxiety symptoms, obesity, cigarette smoking, alcohol and substance abuse, and symptoms of physical illness in adulthood, and many of these outcomes are interrelated. Identifying the various processes connecting these outcomes (perhaps

through longitudinal data exploration) would seem a useful approach to theoretical advancement in childhood self-regulation.

In addition to theoretical value, the findings of this meta-analysis should be of interest to child development practitioners interested in helping 'at risk' children reach their full developmental potential. More research is required before practical applications of the research can be made in confidence, but they might have implications in terms of early identification of children at risk of less desirable life trajectories and who might benefit most from inclusion in self-regulation based interventions. To illustrate, when implementing an intervention to promote child and adolescent growth (e.g., interpersonal skills) a useful target population might be those children who score poorly on self-regulation tasks placing them at greater risk of poor social competency. Indeed, children who score lowest in self-regulation assessments tend to be those who benefit most – or even exclusively – from self-regulation intervention (Tominey & McClelland, 2011). An understanding of self-regulation might also be valuable to older children in developmental programs in terms of creating awareness of their own self-regulatory abilities and how they can affect life trajectories.

In many instances the effect sizes detected in this meta-analysis were small-medium in magnitude. This means that rather substantial changes in self-regulatory capacity might be required to see meaningful (real-world) changes in life outcomes. Nevertheless, small effects can have meaningful practical consequences at the population level. For example, a large intervention (perhaps delivered through social media) that provides information on self-regulation to parents and teachers might have meaningful value at the societal level even if effects at the individual level are rather small. A better understanding of self-regulation and its correlates might go some way towards decreasing risk of undesirable life outcomes. From a practical perspective, the effect sizes indicate that self-regulation might not be the sole target in interventions targeting child development, but rather, self-regulation might form part

of a larger multimodal intervention that targets multiple skills for growth. Indeed, training a specific executive function skill in isolation has been found to have limited practical value (Kassai, Futo, Demetrovics, & Takacs, 2019). More research is required to narrow the application possibilities of epidemiological research on self-regulation and develop evidence-based interventions.

Future Research

The findings of this meta-analysis highlight a number of possible avenues future research might take in order to advance theoretical understanding of self-regulation and life outcomes. First, the evidence base for some life outcomes (e.g., academic achievement, externalizing problems) was considerably more plentiful than others (e.g., physical activity, sexual activity) despite the importance of such outcomes for health and disease. More research is needed into outcomes such as sleep quality, suicidal thoughts, self-harm, family dysfunction (e.g., parent separation), eating disorders, and racial discrimination. Moreover, considering the importance of impulse control for sexual activity in adolescence (Steinberg, 2007) more research is needed into how self-regulatory capacity relates to sexual health outcomes such as early sexual debut (before age 16) and sexual risk taking (e.g., condom use). Adolescence is a time of heightened vulnerability for risky behavior (Steinberg, 2007) and further prospective research into outcomes at this important developmental stage would be particularly welcome.

Another important avenue for further research inquiry is prospective studies exploring outcomes from early childhood to adulthood. The current meta-analysis identified 15 studies (10% of sample) that had explored outcomes over long time spans (about 30 years on average) and more research is needed to help narrow the CIs for self-regulation in childhood as it relates to life outcomes such as employment, healthy living, mental health, and criminal behavior. Moreover, because experimental studies for 30-year outcomes are not feasible, this

research should include rigorous control of potential confounding factors to better understand the independent contribution of self-regulation in life trajectories. The current meta-analysis cannot provide information on cause and effect, but experimental studies provide compelling evidence that developing child self-regulation can lead to improved short-term outcomes for academic achievement, substance abuse, and conduct problems (Pandey et al., 2018). A variety of research designs can help to shed light on the causal pathways connecting self-regulation and outcomes and researchers might consider exploring feedback loops that also consider how changes in life circumstances might feed back into changes in self-regulation (Howard et al., 2018).

Tied into the point above, there is a need to explore the processes connecting self-regulation to life outcomes. For example, higher self-regulation is thought to improve academic achievement through aiding concentration, problem solving, engagement, and positive social interaction (Blair, 2002; Blair & Raver, 2015). Prospective studies that test the degree to which these processes contribute to the association between self-regulation and academic achievement would be particularly valuable to those working in academic settings. A final direction for future research is for greater conceptual clarity and uniformity in measurement of self-regulation in childhood. Studies adopting a control-based definition of self-regulation have adopted 67 different measures, with the most common being the 'head-toes-knees-shoulders' task (Ponitz et al., 2009), subscales of the child behavior questionnaire (Putnam & Rothbart, 2006) and early adolescence temperament questionnaire (Putnam, Ellis, & Rothbart, 2001). Tests of validity and reliability of new and established measures is an important direction for further research.

Conclusion

Improving life trajectories requires an understanding of the factors that shape child and adolescent behavior. This meta-analysis provides evidence that childhood self-regulation

relates to concurrent and subsequent levels of achievement, interpersonal behaviors, mental health, and healthy living. In particular, higher self-regulation in preschool was related to better social skills, higher performance in mathematics, literacy and vocabulary, as well as fewer instances of peer victimization, internalizing problems and externalizing problems in early school years. Higher self-regulation in early school years was related to a lower incidence of aggressive behavior, depressive symptoms, obesity, cigarette smoking, and illicit drug use in later school years (adolescence), and a decreased likelihood of unemployment, criminal behavior, depression and anxiety, obesity, cigarette smoking, alcohol and substance abuse, and symptoms of physical illness in adulthood. These findings should be of interest to child care professionals interested in developing education programs that aim to foster better life trajectories. Early childhood is a period of great vulnerability but also one of great opportunity and we encourage continued research into self-regulatory processes and how developing these skills might help children attain their full developmental potential.

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Table 1

Characteristics of included studies

Study	*N*	Study design	Nation	Child sex (% boys)	Mean age (± SD)		Measure of self-regulation	Outcomes tested	Study quality
					Baseline	Follow-up			
Althoff et al. (2010)	2076	Longitudinal	Netherlands	Both (49%)	9.9 (3.7)	24.5 (3.8)	Parent-report: CBCL-DP	Anxiety disorder; drug abuse; depression; suicidality	19
Anzman & Birch (2009)	197	Longitudinal	United States	Girls	5	15	Parent-report: CBQ-IC	BMI; overweight	18
Appleton et al. (2011)	400	Longitudinal	United States	Both (42%)	7	42.2	Observation: AO	C-reactive protein; cigarette smoking; depression; BMI	17
Appleton et al. (2013)	377	Longitudinal	United States	Both (42%)	7	42.2	Observation: AO	Cardiovascular disease	16
Aro et al. (2012)	199	Longitudinal	Finland	Both (53%)	5	8	Parent-report: BASC	Social competence; adaptability	15
Ayduk et al. (2006)	S1: 98 S2: 59	Cross-sectional	United States	Boys	S1: 11.4 (0.7) S2: 10.2 (1.6)	-	Task-based: DG	Aggression	18
Backer-Grøndahl et al. (2018)	1155	Longitudinal	Norway	Both (52%)	4.0	7.5	Task-based: DG	Externalizing behaviors; internalizing behaviors; academic achievement	20
Barnes et al. (2017)	86	Cross-sectional	United States	Both (53%)	10.5 (0.8)	-	Parent-report: BRIEF	Physical health problems; respiratory symptoms	17
Bater & Jordan (2017)	146	Cross-sectional	United States	Both (45%)	3.6 (0.6)	-	Parent-report: CBQ	Externalizing behaviors	14
Becker et al. (2014a)	51	Cross-sectional	United States	Both (57%)	3-5 (4.8)	-	Task-based: HTKS	Physical activity (active play); academic achievement (math, literacy)	14
Becker et al. (2014b)	127	Cross-sectional	United States	Both (54%)	5.7 (0.7)	-	Task-based: HTKS	Academic achievement (math,	13

								literacy, vocabulary)	
Berthelsen et al. (2017)	4819	Longitudinal	Australia	Both (51%)	4.8 (0.2)	14-15	Parent-report: STSC	Executive function; school engagement (approach to learning)	20
Birgisdottir & Thorsdottir (2015)	111	Longitudinal	Iceland	Both (51%)	4.6 (0.3)	6-7	Task based: HTKS Teacher report: CBRS	Academic achievement (literacy)	15
Blair et al. (2015)	1292	Longitudinal	United States	Both (85%)	4-5	7-8	Task-based: DG Parent-report: CBQ Teacher-report: CBQ	Academic achievement (math)	16
Blair & Razza (2007)	170	Longitudinal	United States	Both (53%)	5.1	6.2	Parent-report: CBQ Teacher-report: CBQ	Academic achievement (math, literacy)	17
Bohlmann et al. (2015)	250	Longitudinal	United States	Both (49%)	4.2 (0.5)	5-6	Observation: PSRA	Expressive vocabulary (academic achievement)	17
Breslau et al. (2010)	590	Longitudinal	United States	Both (47%)	6-11	11-17	Teacher report: TRF	Academic achievement (math, literacy)	19
Brody & Ge (2001)	120	Longitudinal	United States	Both (52%)	12.0 (0.7)	14.0 (0.7)	Teacher report: CSCS	Depression; hostility (aggression); self-esteem; alcohol use	19
Bub et al. (2016)	1023	Longitudinal	United States	Both (52%)	4.5	15	Task-based: DG Parent-report: CBQ	BMI; general health; sleep problems	19
Buckner et al. (2009)	155	Cross-sectional	United States	Both (47%)	12.0	-	Observational: CCQ, HQ	Depression; anxiety; behavior problems; social competence; academic achievement	14
Causadias et al. (2012)	136	Longitudinal	United States	Both (55%)	4-5	32	Teacher-report: CCQ	Externalizing behaviors; internalizing behaviors; global adjustment (social functioning)	17

Chapple et al. (2005)	756	Longitudinal	United States	Both (53%)	11-13	15.9 (0.8)	Parent-report: BPI	Substance use (various)	16
Checa et al. (2008)	69	Cross-sectional	Spain	Both (49%)	12.7 (0.7)	-	Parent-report: EATQ-R Self-report: EATQ-R	Social competence; peer victimization; academic achievement	13
Cho (2017)	2844	Cross-sectional	South Korea	-	11	-	Self-report: SCS	Peer victimization	17
Chui & Chan (2013)	365	Cross-sectional	China	Boys	12.9 (1.9)	-	Self-report: SCS	Bullying behaviors (behavior problems); victim of bullying	18
Connor et al. (2016)	852	Longitudinal	United States	-	6.7	8.5	Task-based: HTKS Teacher-report: CRS	Academic achievement (academic knowledge)	16
Crockett et al. (2006)	518	Longitudinal	United States	Both (49%)	8-9	16-17	Parent-report: BPI	Risk proneness; risky sexual behavior; substance use; peer pressure	18
Daly et al. (2015)	S1: 6675 S2: 10,107	Longitudinal	UK	Both (50%)	S1: 10 S2: 7-11	S1: 42 S2: 50	S1: Teacher-rated: CDB S2: Teacher-rated: BSAG	Unemployment; intelligence	16
Daly et al. (2016)	S1: 8526 S2: 12,605	Longitudinal	UK	Both (49%) Both (51%)	S1: 10 S2: 7-11	S1: 42 S2: 55	S1: Teacher-rated: CDB S2: Teacher-rated: BSAG	Cigarette smoking; cognitive ability; psychological distress (internalizing problems)	16
Dawes et al. (1997)	380	Longitudinal	United States	Boys	11.3 (0.1)	12-14	Combined child and adult-reports: K-SADS-E	Academic performance; problem behaviors; family dysfunction	16
Day & Connor (2017)	282	Cross-sectional	United States	Both (43%)	8.5 (0.4)	-	Task-based: RRRP	Academic achievement (math and literacy)	15
de Winter et al. (2016)	2230	Longitudinal	Netherlands	Both	11.1 (0.6)	16.3 (0.7)	Parent-report: EATQ-R	Healthy living	15
Deblois & Kubzansky (2016)	1709	Longitudinal	United States	Both (50%)	10.6 (1.7)	12-19	Parent-report: BPI, PBS	Cigarette smoking	17

Denham et al. (2012)	322	Longitudinal	United States	Both (50%)	4.2 (0.6)	4.6 (0.6)	Observational: PSRA	School engagement (adjustment); academic achievement	18
Dich et al. (2015)	239	Longitudinal	United States	Both (49%)	9.2 (1.1)	17.5 (1.1)	Task-based: DG	Stress	20
Duckworth et al. (2015)	S2: 509	Longitudinal	United States	S2: Both (48%)	S2: 11.7 (1.3)	S2: ~12.7 (1.3)	S2: teacher and parent report: ISC	Academic achievement	16
	S3: 519			S3: Both (50%)	S3: 12.5 (1.2)	S3: ~13.5 (1.2)	S3: teacher report: ISC		
Duckworth et al. (2010)	105	Longitudinal	United States	Both (48%)	10.6 (0.4)	13-14	Multi-source: Composite	BMI; happiness; intelligence	17
Duckworth et al. (2012)	S1: 1364	S1: Longitudinal	United States	S1: Both (52%)	S1: 9-10	S1: 14-15	S1: Multiple adult reports: SSRS	Academic achievement; intelligence	17
	S2: 549	S2: Longitudinal		S2: Both (48%)	S2: 11.7 (1.3)	S2: ~12.7 (1.3)	S2: Multiple adult reports: ISC		
Dyson et al. (2015)	151	Cross-sectional	United States	-	12.2	-	Self-report: EATQ-R	Internalizing problems (anxiety/depression)	13
Edossa et al. (2018)	13,287	Longitudinal	UK	Both (51%)	3	11	Parent-report: CSBQ, Composite	Academic achievement	15
Eisenberg et al. (2004)	214	Longitudinal	United States	Both (55%)	6.2 (0.9)	7.7 (0.8)	Parent-report: CBQ Task-based: ET	Externalizing problems; internalizing problems	19
Eisenberg et al. (2005)	186	Longitudinal	United States	Both (51%)	7.5 (1.2)	13.4 (1.2)	Parent and teacher report: CBQ	Externalizing problems	19
Evans & Rosenbaum (2008)	S1: 97	Longitudinal	United States	Both (51%)	9	13.4	Task-based: DG	Academic achievement; Cognitive development	15
	S2: 774			Both (52%)	4	10-11			
Farrell & Danish (1993)	1256	Longitudinal	United States	Both (40%)	12-13	13-14	Self-report: ERS	Substance use	15
Fergusson et al. (2013)	1265	Longitudinal	New Zealand	Both (50%)	6-12	30	Multiple adult-reports:	Criminal offending; alcohol abuse;	16

							Composite score	cigarette smoking; illicit drug use; education attainment; unemployment; sexual behavior; anxiety; suicidal ideation	
Finigan-Carret et al. (2015)	452	Cross sectional	United States	Both (50%)	12 (1.1)	-	Self-report: SCRS	Aggressive behavior	16
Flouri et al. (2014)	16,916	Longitudinal	UK	Both (51%)	3	7	Parent report: CSBQ	Academic achievement (verbal ability), externalizing behavior; internalizing behavior	16
Francis & Susman (2009)	1061	Longitudinal	United States	Both (52%)	3	12	Task-based: DG Parent-report: CBCL, CBQ	BMI; externalizing behavior	17
Galindo & Fuller (2010)	3640	Longitudinal	United States	Both (51%)	5.4 (0.4)	5-6	Teacher-report: SSRS	Academic achievement (math)	17
Garner & Waajid (2012)	74	Cross-sectional	United States	Both (54%)	4.1 (0.7)	-	Techer report: CBC	Behavior problems; cognitive ability; social competence; happiness	16
Gawrilow et al. (2014)	S2: 80	Cross-sectional	Germany	S2: Both (60%)	S2: 6.5 (0.5)	-	S2: Task-based: DG	Academic achievement (math)	17
Gestsdottir et al. (2014)	260	Longitudinal	France, Germany, Iceland	Both (57%)	5-6	6-8	Task-based: HTKS Teacher-report: Q-EM/CBRS	Academic achievement (math, literacy)	17
Gibbons et al. (2012)	889	Longitudinal	United States	Both (46%)	10.5	18	Self-report: SCRS	Racial discrimination, Substance use	16
Gunduz et al. (2015)	217	Cross-sectional	Turkey	Both (50%)	4.5 (0.8)	-	Parent-report: CBQ	Social competence; depressive symptoms	16

Hallquist et al. (2015)	2450	Longitudinal	United States	Girls	5-8	14-17	Multiple adult-reports: SSRS	Borderline personality; negative emotions (internalizing problems)	19
Hanish et al. (2004)	154	Cross-sectional	United States	Both (54%)	4.3 (0.8)	-	Teacher-report: CBQ	Peer victimization; anger; anxiety; aggression; withdrawal	16
Hernández et al. (2018)	301	Longitudinal	United States	Both (48%)	5.5 (0.4)	7-8	Task-based: HTKS	Academic achievement	18
Holtmann et al. (2011)	325	Longitudinal	Germany	Both (47%)	8	19	Parent-report: CBCL	Anxiety disorder; conduct disorder; alcohol abuse; cannabis abuse; eating disorder; nicotine; suicide ideation/attempt	15
Hope & Chapple (2005)	709	Longitudinal	United States	Both (48%)	11-13	15-17	Parent report-BPI	Sexual activity	14
Howard & Williams (2018)	4385	Longitudinal	Australia	Both (51%)	4-5	14-15	Multi-source: Composite	Academic achievement (reading, math); internalizing problems; overweight/obese; self-harm; suicidal ideation; cigarette smoking; alcohol use; criminal behavior	16
Howard et al. (2018)	4385	Longitudinal	United States	Both (51%)	4-5	6-7	Multi-source: Composite	Physical activity (sports participation)	15
Howse et al. (2003a)	122	Cross-sectional	United States	Both (47%)	4.7 (0.2)	-	Task-based: GERO Parent-report: ERC Teacher-report: COMPSCALE	Academic achievement (math, literacy); intelligence test (IQ)	18
Howse et al. (2003b)	S1: 43 S2: 42	Cross-sectional	United States	S1: Both (70%) S2: Both	S1: 6.1 (0.3) S2: 8.1 (0.3)	-	Task-based: SRTC Teacher-report: COMPSCALE	Academic achievement (literacy)	18

				(48%)					
Hubert et al. (2015)	135	Longitudinal	France	Both (52%)	5.7 (0.3)	6.8 (0.3)	Task-based: HTKS	Academic achievement (literacy, math); intelligence test (IQ)	16
Hubert et al. (2017)	131	Longitudinal	France	Both (51%)	5.7 (0.3)	6-7	Task-based: HTKS	Social skills; intelligence test (IQ)	17
Ivrendi (2016)	74	Longitudinal	Turkey	Both (54%)	5.9 (0.5)	10-12	Task-based: HTKS	Academic achievement (literacy, math)	14
Kathawala & Bhamani (2015)	210	Cross-sectional	Pakistan	Both	6-8	-	Teacher-report: ESSRS	Academic achievement	10
Kim & Cicchetti (2010)	421	Longitudinal	United States	Both (64%)	8.1 (1.8)	7-13	Teacher-report: ERC	Peer acceptance/rejection; internalizing problems; externalizing problems	17
Kim & Deater-Deckard (2011)	1079	Longitudinal	United States	Both (52%)	4	11	Multiple Adult-report: Composite	Anger; internalizing problems; externalizing problems	17
Kim et al. (2001)	102	Longitudinal	United States	-	11.2 (1.4)	13.0 (1.5)	Parent-report: CSCS Teacher-report: CSCS	Academic achievement (literacy, math)	15
Kim et al. (2013)	87	Longitudinal	United States	Both (53%)	3	8	Task-based: DG	Behavior problems; academic achievement (literacy, math)	16
Kim-Spoon et al. (2012)	54	Longitudinal	United States	Both (58%)	4.9 (0.4)	6.6 (0.4)	Parent-report: BRIEF	Internalizing behaviors; Externalizing behaviors	19
Kokko et al. (2000)	311	Longitudinal	Finland	Both (53%)	7-8	36	Teacher-report: Composite	Unemployment; depression; anxiety; academic success	16
Korucu et al. (1988/2017)	212	Cross-sectional	Turkey	Both (50%)	4.5 (0.9)	-	Parent report: CBQ	Social competence; aggression	15
Krueger et al. (1996)	428	Longitudinal	United States	Boys (100%)	12.7 (0.8)	-	Task-based: DG	Internalizing behaviors;	16

								externalizing behaviors	
Kuhn & Laird (2013)	180	Cross-sectional	United States	Both (51%)	12.0 (0.8)	-	Self-report: LSCS	Behavior problems	17
Kurdek & Sinclair (2000)	293	Longitudinal	United States	Both (38%)	7.0-10.9		Teacher-report: CSCS	Academic achievement (math, literacy)	14
Kwon et al. (2016)	417	Cross-sectional	United States	Both (48%)	10.0 (0.9)	-	Teacher-report: RS	Academic achievement (literacy, math)	18
Lengua (2002)	89	Cross-sectional	United States	Both (55%)	9.9 (0.9)	-	Observation: Perfection, Tiazzle, SS, DG Multiple adult-reports: EATQ, CBQ	Social competence (adjustment problems)	16
Lengua (2003)	79	Longitudinal	United States	Both (55%)	9.9 (0.9)	~10.9 (0.9)	Observation: Perfection, Tiazzle, SS, DG Multiple adult-reports: EATQ, CBQ	Social competence; internalizing problems; externalizing problems; anxiety	16
Lengua & Long (2002)	101	Cross-sectional	United States	Both (55%)	9.9	-	Multiple adult-reports: EATQ, CBQ	Avoidant coping; active coping	16
Lengua et al. (2015)	306	Longitudinal	United States	Both (50%)	3.1 (0.1)	5	Task-based: HTKS, DG	Academic readiness; social competence; adjustment problems	17
Liau et al. (2015)	2712	Cross-sectional	Singapore	Both (72%)	10.9 (2.0)	-	Self-report: PSI	Addictive behavior (pathological gaming)	17
Lindblom et al. (2017)	452	Cross-sectional	Finland	Both	7-8	-	Parent-report: EQ	Anxiety; depression, peer exclusion (peer acceptance)	16
Lipsey et al. (2017)	S1: 435 S2: 356	Longitudinal	United States	Both (52%) Both (53%)	4.6 4.4	~5.1 ~4.9	Task-based: HTKS	Academic achievement	18

Liu et al. (2016)	1066	Longitudinal	China	Both (50%)	9.6 (0.3)	10-11	Peer-report: RCP	Peer preference (liked by others); loneliness	19
Lonigan et al. (2017a)	1082	Cross-sectional	United States	Both (55%)	4.6 (0.3)	-	Task based-HTKS Teacher report- CTRS	Academic achievement (literacy)	16
Lonigan et al. (2017b)	815	Longitudinal	United States	Both (56%)	4.6 (0.3)	-	Task-based: HTKS	Externalizing behaviors (behavior problems); school readiness (language ability)	17
Lotze et al. (2010)	50	Cross-sectional	United States	Both (38%)	9.8 (1.5)	-	Self-report- EATQ-R	Internalizing behaviors; externalizing behaviors	14
Magi et al. (2016)	775	Longitudinal	Estonia	Both (52%)	7.5 (0.5)	10-11	Teacher-report: BSRS	Academic achievement (literacy, math)	17
Martin et al. (2007)	138	Cross-sectional	United States	Both (44%)	5.4 (1.3)	-	Multiple adult-reports: SCRS	Academic achievement (science and math)	15
Matthews et al. (2009)	268	Longitudinal	United States	Both (48%)	5.5 (0.3)	5-7	Task-based: HTKS	Academic achievement (math, literacy, general knowledge, vocabulary)	15
McClelland et al. (2013)	430	Longitudinal	United States	Both (56%)	4	21	Parent-report: CCTI	Academic achievement (math, literacy, college completion)	13
McClelland et al. (2007)	310	Longitudinal	United States	Both (49%)	3-5	4-6	Task-based: HTKS	Academic achievement (math, literacy, vocabulary)	15
McClelland & Wanless (2012)	134	Longitudinal	United States	Both (47%)	3-5	4-6	Task-based: HTKS	Academic achievement (math, literacy, vocabulary)	16
McLear et al. (2016)	97	Longitudinal	United States	Both (53%)	4-6	4.5-6.5	Observation: PSRA	Academic achievement	16
Moffitt et al. (2011)	1036	Longitudinal	New Zealand	Both (52%)	3	32	Multi-source: Composite	Physical health; depression;	16

								substance dependence; income; financial struggles; criminality	
Montroy et al. (2014)	118	Longitudinal	United States	Both (66%)	4.1 (0.5)	4.6 (0.5)	Task-based: HTKS	Academic achievement (math, literacy); social competence; problem behaviors	17
Muris et al. (2007)	208	Cross-sectional	Netherlands	Both (55%)	10.9 (0.7)	-	Self-report: EATQ-R	Internalizing behaviors; externalizing behaviors	14
Muris et al. (2008)	207	Cross-sectional	Netherlands	Both (44%)	10.3 (1.0)	-	Self-report: ECS, ACS	Anxiety; depression; aggression	14
Neuenschwander et al. (2012)	459	Longitudinal	Switzerland	Both (51%)	7.4 (0.6)	8.1 (0.6)	Parent-report: CBQ	Academic achievement (literacy, math), intelligence	17
Normandeau & Guay (1998)	291	Longitudinal	Canada	Both (46%)	5-6	-	Teacher-report: CSCS	Intelligence; prosocial behavior; aggressive behavior; academic achievement (math)	16
Oldehinkel et al. (2004)	2230	Cross-sectional	Netherlands	Both (49%)	11.1 (0.6)	-	Parent-report: EATQ-R	Internalizing problems; externalizing problems	20
Olson & Lifgren (1988)	56	Longitudinal	United States	Both (60%)	4-5	5-6	Task-based: KRISP	Peer acceptance/rejection	14
Olson et al. (1999)	89	Longitudinal	United States	Both (56%)	6	8	Task-based: WALS, DG	Aggression	15
Otten et al. (2010)	428	Longitudinal	Netherlands	Both (50%)	12	13.4 (0.5)	Self-report: SCS	Cannabis use; depressive symptoms	17
Pearce et al. (2016)	S1: 11,168 S2: 3028	Longitudinal	S1: UK S2: Australia	Both	5 6-7	7 8-9	Multiple adult-report: Composite	Academic achievement (math, literacy)	15
Petitclerc et al. (2015)	497	Cross-sectional	United States	Both (49%)	4.8	-	Observation: DB-DOS	Behavior problems	16
Piche et al. (2012)	966	Longitudinal	Canada	Both	6.2	10.2	Teacher-report: SBQ	BMI; physical activity (sports participation); aggression	13
Piche et al. (2015)	935	Longitudinal	Canada	Both (49%)	6.2	10.1	Multiple adult-reports:	Classroom engagement;	19

							SBQ	extracurricular activity	
Pitzer et al. (2011)	341	Longitudinal	Germany	Both (48%)	4	11	Multi-source: Composite	Depression	17
Ponitz et al. (2009)	343	Longitudinal	United States	Both (48%)	5.5 (0.3)	6.0 (0.3)	Task-based: HTKS	Classroom functioning; Academic achievement (math, literacy, general knowledge)	18
Portilla et al. (2014)	338	Longitudinal	United States	Both (52%)	5.3 (0.3)	~6.8 (0.3)	Multiple adult-report: HBQ	Academic achievement (math, literacy, general knowledge); school engagement	16
Prior et al. (2001)	282	Longitudinal	Australia	Both (60%)	3-4	11-12	Parent-report: STSC	Behavior problems	17
Pulkkinen et al. (2011)	285	Longitudinal	Finland	Both (53%)	8.3 (0.3)	42	Multiple adult-reports: Composite	Psychological well-being; self-esteem; depression; aggression; alcohol abuse; criminal behavior; social relations	17
Rasmussen et al. (2019)	837	Longitudinal	New Zealand	Both (51%)	3	38	Multi-source: Composite	Chronic inflammation	17
Rimm-Kaufman (2009)	172	Longitudinal	United States	Both (54%)	4-6	5-7	Observation: PSRA	Classroom engagement (school work habits)	19
Rudolph et al. (2013)	419	Longitudinal	United States	Both (47%)	8.9 (0.4)	~9.9 (0.4)	Parent-report: TMCQ	Aggressive behavior; depressive symptoms	19
Russell et al. (2016)	1264	Longitudinal	United States	Both (52%)	4	6-7	Parent-report: CBQ	Peer relationships; aggressive (oppositional) behavior; social competence (skills)	16
Sawyer et al. (2015a)	3410	Longitudinal	Australia	Both (52%)	4-5	6-7	Parent-report: Composite	Academic achievement (math, literacy)	17
Sawyer et al. (2015b)	510	Longitudinal	Australia	Both (49%)	4.7 (0.3)	6	Parent-report: DECA	Internalizing problems;	19

								externalizing problems	
Schatz et al. (2008)	169	Longitudinal	United States	Both (54%)	3	5	Observation: OCERS	Behavioral problems; academic achievement (math, literacy)	18
Schlam et al. (2013)	164	Longitudinal	New Zealand	Both (43%)	4	39.0 (2.0)	Task-based: DG	BMI	16
Schmitt et al. (2014)	247	Cross-sectional	United States	Both (50%)	5.1 (0.4)	-	Task-based: HTKS Observation: OCES Teacher-report: CBRS	Academic achievement (math, literacy)	15
Seeyave et al. (2009)	818	Longitudinal	United States	Both (47%)	4	11	Task-based: DG	BMI; Overweight risk	18
Sektnan et al. (2010)	1298	Longitudinal	United States	Both	4-5	6-7	Parent-report: CBQ	Academic achievement (math, literacy, vocabulary)	16
Sher-Censor et al. (2016)	187	Longitudinal	United States	Both (50%)	4.1 (0.2)	6.1 (0.2)	Teacher-report: CBQ	Externalizing problems; peer acceptance; intelligence test (IQ)	19
Stenseng et al. (2015)	762	Longitudinal	Norway	Both (50%)	4	6	Parent-report: CBQ	Peer victimization (social exclusion)	15
Tsukayama et al. (2010)	844	Longitudinal	United States	Both (50%)	9	15.6 (0.2)	Multiple adult-reports: SSRS	Overweight (BMI computed)	15
Turanovic & Pratt (2013)	1463	Longitudinal	United States	Both (48%)	12.3 (0.6)	~14.3 (0.6)	Self-report: LSCS	Substance abuse; violent offending	15
Vaughn et al. (2009)	17,212	Longitudinal	United States	Both (51%)	5-6	10-11	Combined parent and teacher-report: SSRS	Externalizing behaviors; social competence	15
Vazsonyi & Huang (2010)	1155	Longitudinal	United States	Both (51%)	4-5	10-11	Parent-report: SSRS	Behavioral problems	18
Veenstra et al. (2010)	2230	Longitudinal	Netherlands	Both (49%)	11.1 (0.5)	13.6 (0.5)	Parent-report: EATQ-R	Behavior problems (truancy)	17
von Suchodoletz et al.	412	Cross-sectional	Germany,	Both (51%)	5.4	-	Task-based: HTKS	Academic achievement (math,	15

(2013)			Iceland				Teacher-report: CBRS	literacy, vocabulary)	
von Suchodoletz et al. (2015)	150	Cross-sectional	Kosovo	Both (49%)	4.5 (0.1)	-	Task-based: HTKS, DG Observation: PSRA Teacher-report: CBRS	Academic achievement (math, vocabulary)	13
Walker & Berthelsen (2017)	2315	Longitudinal	Australia	Both (51%)	6.8 (0.2)	-	Teacher-report: SSRS	Academic achievement (math, literacy)	16
Weed et al. (2011)	113	Longitudinal	United States	Both (54%)	8.0 (0.2)	14.2 (0.5)	Teacher-report: T-CRS	Academic achievement (math, literacy)	18
White et al. (1994)	430	Longitudinal	United States	Boys	10.2	12-13	Task-based: DG Teacher-report: CBCL	Behavioral problems; intelligence test (IQ)	16
Williams et al. (2017)	4109	Longitudinal	Australia	Both (51%)	4.8 (0.2)	8.9 (0.3)	Parent-report: ATS-SF	Sleep problems	17
Williams et al. (2016a)	2880	Longitudinal	Australia	Both (52%)	4.8 (0.2)	6.3 (0.5)	Parent-report: ATS-SF	Classroom engagement	18
Williams et al. (2016b)	5107	Longitudinal	Australia	Both (51%)	4.8	8.9	Parent-report: Composite Teacher-report: Composite	Academic achievement (math); intelligence test	16
Willoughby et al. (2011)	926	Cross-sectional	United States	Both (50%)	4.6 (0.4)	-	Observation: PSRA	Academic achievement (math, literacy); aggression	14
Wills et al. (2007a)	332	Cross-sectional	United States	Both (48%)	9.3 (0.6)	-	Self-report: WS	Internalizing behaviors; externalizing behaviors	15
Wills et al. (2001)	1810	Longitudinal	United States	Both (49%)	11.5 (0.6)	12.5 (0.7)	Self-report: DOTS-R, WS	Substance use	15
Wills et al. (2000)	889	Cross-sectional	United States	Both (46%)	10.5 (0.7)	-	Self-report: DOTS-R, WS	Substance use; school engagement	15
Wills et al. (2010)	290	Cross-sectional	United States	Both (45%)	10.2 (0.5)	-	Self-report: WA	Substance use	16
Wills et al. (2007b)	670	Cross-sectional	United States	Both (47%)	11.2 (0.4)	-	Self-report: WS	Substance use; sexual behavior; classroom engagement (academic competence)	14

Wills et al. (2016)	3561	Cross-sectional	United States	Both (48%)	12.5 (0.9)	-	Self-report: WS	Internalizing behaviors; externalizing behaviors	16
Wills & Stoolmiller (2002)	1526	Longitudinal	United States	Both (50%)	11-12	14-15	Self-report: DOTS-R, EASI, WA Teacher-report: DOTS-R, EASI, WA	Substance use	14
Woodward et al. (2017)	223	Longitudinal	New Zealand	Both (51%)	4	9	Parent-report: ERC Observation: WLO	Academic achievement (maths, literacy); anxiety; behavior problems	19
Zalot et al. (2007)	277	Cross-sectional	United States	Both (50%)	8.3 (7.3)	-	Parent-report: CSCS	Behavior problems	14

Note. BMI: Body mass index. See Supplementary File for reference list of measures used. Self-regulation acronyms, with eligible subscales (where only specific subscales were considered) and measure citation in brackets, as follows: ABCL: Adult Behavior Checklist; ACS: Attention Control Scale; AO: Appleton Observation; ATS-SF: Australian Temperament Scales, Short Form; BASC: Behavior Assessment System for Children (attention problems, hyperactivity, aggression); BPI: Behavior Problems Index; BRIEF: Behavior Rating Inventory of Executive Functioning (behavioral regulation, inhibit, shift, emotional control); BSAG: Bristol Social Adjustment Guide; BSRS: Behavioral Strategy Rating Scale; CBCL: Child Behavior Checklist (attention control, impulsivity, self-regulation, dysregulation); CBQ: Child Behavior Questionnaire (impulsivity, inhibitory control, attention focusing, approach, anger/frustration); CBRS: Child Behavior Rating Scale; CCQ: California Child Q-Sort (ego-under-control); CCTI: Colorado Child Temperament Inventory (attention span-persistence); CDB: Child Development Behaviors; COMPSCALE: Instrumental Competence Scale for Children (TR-self-regulation); CRS: Conners Rating Scale (attention, hyperactivity); CSBQ: Child Social Behavior Questionnaire (self-regulation, emotion dysregulation); CSCS: Children's Self-Control Scale; CTRS: Connors Teacher Rating Scale (inattention, hyperactivity, impulsivity, oppositional behavior); DB-DOS: Disruptive Behavior Diagnostic Observation Schedule; DECA: Devereaux Early Childhood Assessment (self-control); DG: Delay of Gratification; DOTS-R: Revised Dimensions of Temperament Survey; EASI: Emotionality, Activity, and Sociability Inventory (negative emotionality); EATQ-R: Early Adolescence Temperament Questionnaire Revised (activation control, attention control, inhibitory control, anger/frustration, effortful control); ECS: Effortful Control Scale; EIS: Eysenck Impulsiveness Scale; EQ: Emotion Questionnaire; ERC: Emotion Regulation Checklist; ERS: Emotion Restraint Scale; ESSRS: Early School Self-Regulation Scale; ET: Eisenberg Task; GERO: Goldsmith Emotion Regulation Observation; HBQ: MacArthur Health and Behavior Questionnaire (inattention, impulsivity); HQ: Haan Q-Sort; HTKS: Head-Toes-Knees-Shoulders; ISC: Impulsivity Scale for Children; KRISP: Kansas Reflection – Impulsivity Scale for Preschoolers; K-SADS: Kiddie Schedule for Affective Disorders and Schizophrenia (lifetime symptoms, disruptive behavior); LRAR: Leiter-R Assessor Report; LSCS: Low Self-Control Scale; OCERS: Observational Cognitive and Emotional Regulation Scale; OCES: Observed Child Engagement Scale (behavioral self-regulation); PAPA: Preschool Age Psychiatric Assessment (ADHD symptoms); PBS: Positive Behavior Scale; PSI: Personal Strengths Inventory; PSRA: Preschool Self-Regulation Assessment; Q-EM: Questionnaire pour l'École Maternelle (behavioral self-regulation); RCP: Revised Class Play; RRRP: Remembering Rules and Regulation Picture Task; RS: Rydell Scale; SBQ: Social Behavior Questionnaire (impulsivity); SCRS: Self-Control Rating Schedule; SCS: Self-Control Scale; SRTC: Self-Regulation Test for Children; SS: Simon Says; SSRS: Social Skills Rating System (approaches to learning, impulsivity, self-control, externalizing); STSC: Short Temperament Scale for Children (inflexibility, persistence); TABC: Temperament Assessment Battery for Children (distractibility, persistence); T-CRS: Teacher-Child Rating Scale (acting out, frustration tolerance, task orientation); TMCQ: Temperament in Middle Childhood Questionnaire (inhibitory control); TRF: Teacher Report Form (attention); WA: Wills Adult-Report; WALS: Walk a Line More Slowly; WLO: Woodward Observation; WMO: White Observation; WS: Wills Self-Report.

Table 2

Random-effects mean associations for self-regulation in childhood as it relates to components of achievement, relationships, mental health and healthy living

	Cross-sectional associations				Preschool → early childhood				Early childhood → later childhood				Childhood → adulthood			
	k	*n*	*r* (95% CI)	I^2	*k*	*n*	*r* (95% CI)	I^2	*k*	*n*	*r* (95% CI)	I^2	*k*	*n*	*r* (95% CI)	I^2
Achievement																
Academic performance	32	27,393	.37 (.32, .41)	96	29	59,298	.28 (.22, .33)	99	17	32,399	.28 (.18, .38)	99	-	-	-	-
Mathematics	22	7076	.42 (.35, .48)	91	20	26,128	.31 (.23, .38)	98	9	14,628	.20 (.10, .28)	98	-	-	-	-
Literacy	20	7472	.34 (.28, .39)	84	20	21,132	.24 (.16, .32)	97	8	9521	.20 (.07, .32)	98	-	-	-	-
Vocabulary	11	20,260	.34 (.25, .43)	96	8	19,274	.24 (.13, .34)	93	-	-	-	-	-	-	-	-
School/class engagement	3	1549	.30 (.18, .41)	83	6	9466	.27 (.18, .36)	94	-	-	-	-	-	-	-	-
Intelligence test	12	22,898	.29 (.23, .35)	93	1	5107	.14 (.12, .16)	0	1	5107	.15 (.13, .17)	0	-	-	-	-
University completion	-	-	-	-	-	-	-	-	-	-	-	-	2	1575	.22 (.16, .28)	0
Unemployment	-	-	-	-	-	-	-	-	-	-	-	-	5	9159	–.15 (–.20, –.10)	82
Interpersonal Behaviors																
Social competence	10	8301	.26 (.17, .34)	81	5	1900	.22 (.10, .33)	76	1	79	.27 (.06, .47)	0	2	343	.16 (.05, .26)	0
Peer victimization	8	3111	–.33 (–.46, –.19)	94	4	2269	–.21 (–.35, –.05)	90	3	2005	–.22 (–.37, –.06)	92	-	-	-	-
Externalizing problems	40	44,562	–.34 (–.38, –.31)	93	10	22,141	–.30 (–.42, –.18)	97	15	10,420	–.28 (–.37, –.18)	96	5	2780	–.17 (–.20, –.13)	26
Aggressive behavior	14	4238	–.27 (–.38, –.15)	93	1	1264	–.15 (–.20, –.10)	0	4	628	–.12 (–.24, .01)	43	2	343	–.23 (–.33, –.13)	0
Criminal behavior	1	155	–.57 (–.67, –.45)	0	-	-	-	-	2	5848	–.19 (–.28, –.10)	0	4	2644	–.15 (–.18, –.12)	0
Sexual activity	-	-	-	-	-	-	-	-	1	709	–.13 (–.20, –.06)	0	1	1265	–.08 (–.12, –.03)	0
Mental Health																
Internalizing problems	22	47,184	–.29 (–.35, –.24)	97	8	23,810	–.15 (–.19, –.11)	71	12	10,539	–.18 (–.25, –.12)	91	8	5567	–.09 (–.16, –.03)	79
Depressive symptoms	6	1450	–.37 (–.52, –.21)	91	2	341	–.25 (–.39, –.10)	0	5	1094	–.21 (–.30, –.12)	56	6	4166	–.11 (–.21, –.01)	82

Anxiety symptoms	5	1057	–.29 (–.46, –.11)	92	1	129	–.48 (–.65, –.27)	0	-	-	-	-	3	3652	–.09 (–.13, –.05)	0
Suicidal thoughts	-	-	-	-	-	-	-	-	1	4385	–.09 (–.12, –.06)	0	2	3341	–.14 (–.25, –.02)	0
Healthy Living																
Body mass	4	1956	–.09 (–.15, –.03)	40	4	6859	–.06 (–.17, .06)	95	5	6497	–.11 (–.17, –.04)	71	2	564	–.17 (–.25, –.09)	0
Physical activity	1	51	.46 (.21, .65)	0	1	3959	.19 (.15, .23)	0	1	966	.09 (.03, .15)	0	-	-	-	-
Alcohol intake	-	-	-	-	-	-	-	-	2	4505	–.14 (–.30, .02)	0	3	1608	–.11 (–.18, –.03)	36
Substance use	6	5771	–.25 (–.28, –.21)	9	-	-	-	-	8	7120	–.14 (–.20, –.08)	84	3	4377	–.11 (–.19, –.03)	76
Cigarette smoking	-	-	-	-	-	-	-	-	2	6094	–.09 (–.11, –.07)	0	4	22,796	–.17 (–.20, –.13)	81
Sleep quality	1	4109	–.23 (–.26, –.20)	0	2	5132	–.13 (–.22, –.03)	0	1	4109	–.23 (–.25, –.20)	0	-	-	-	-
Physical illness symptoms	1	86	–.28 (–.46, –.07)	0	1	1023	–.13 (–.19, –.07)	0	1	2230	–.16 (–.20, –.12)	0	4	2650	–.05 (–.07, –.04)	0

Note: Externalizing problems refers to disruptive and aggressive behavior problems; internalizing problems refers to emotional or psychological states related to depression, withdrawal, anxiety, loneliness, or suicidal thoughts; *k*, number of studies; *n*, number of pooled participants; *r*, mean effect size expressed as Pearson correlation; CI, confidence interval; I^2, heterogeneity estimate expressed as a percentage.

Figure 1

Flow diagram of the screening process