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The Relationship of Effortful Control to Academic Achievement via Children's Learning-Related Behaviors

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Abstract

Effortful control (EC) is a temperamental self-regulatory capacity, defined as the efficiency of executive attention [1], which is related to individual differences in self-regulation. Although effortful control covers some dispositional self-regulatory abilities important to cope with social demands of successful adaptation to school, such as attention regulation, individual differences in EC have recently been associated with school functioning through academic achievement including the efficient use of learning-related behaviors, which have been found to be a necessary precursor of learning and they refer to a set of children's behaviors that involve organizational skills and appropriate habits of study. Therefore, the aim of this study is to review the literature on EC's relationship to academic achievement via learning-related behaviors, which reflect the use of metacognitive control processes in kindergarten and elementary school students. The findings indicate that EC affects academic achievement through the facilitation of the efficient use of metacognitive control processes.

Keywords

Academic Achievement, Effortful Control, Learning-Related Behaviors,

Metacognitive Control, Self-Regulation

1. Introduction

The term *temperament* refers to individual differences in thinking, feeling, and behaving that reflect "the relatively enduring biological makeup of the organism, influenced over time by heredity, maturation, and experience" [2].

Although the construct of temperament is significantly associated with the construct of personality, temperament is usually studied earlier than personality in the life course and is mainly shaped more by hereditary than environmental influences. Furthermore, temperament tends to reflect basic biological processes more than do the refined cognitive structures, such as metacognitive strategies, schemas, goals, and coping styles, which form the basis of personality in adulthood [3].

2. Effortful Control

Effortful control (EC) is a temperamental self-regulatory capacity, defined as "the efficiency of executive attention—including the ability to inhibit a dominant response and/or to activate a subdominant response, to plan and to detect errors" [4]. EC includes an attentional component (e.g., the ability to shift or focus attention when it is necessary) and a behavioral component (e.g., the ability to activate or inhibit behavior in accordance with the needs of the situation) [2] [5]. Therefore, in general, among the measures of effortful control are included measures that assess attentional regulation (*attentional shifting* and *attentional focusing*, called *attentional control*) and/or behavioral regulation (called *inhibitory control*), and, sometimes, measures of the ability to activate behavior when needed (called *activation control*), for example when need to persist on a task [6]. It seems that effortful control is composed of heterogeneous components and each of them has its own value.

Specifically, EC has been assessed either by temperament questionnaires (e.g., Children's Behavior Questionnaire, CBQ) [7] [8] or by measures such as delay of gratification, persistence on boring tasks, and tasks that require intentional inhibition or activation of behavior [9] [10], or by observational measures (e.g., Effortful Control Battery, ECB) [11]. As regards the factor structure of the Children's Behavior Questionnaire (CBQ) [8], in which parents serve as raters, factor analyses have identified a general factor of effortful control (with loadings from attentional shifting, attentional focusing, inhibitory control, and perceptual sensitivity) distinct from factors of surgency (with positive loadings from activity level, positive anticipation, high-intensity pleasure/sensation seeking, impulsivity, smiling/laughter, and a negative loading from shyness) and negative emotionality (with positive loadings from shyness, discomfort, fear, anger/frustration, sadness, and a negative loading from soothability/falling reactivity) [2].

It seems that, in contrast to reactive and automatic dimensions of temperament (e.g., surgency, negative affectivity, behavioral inhibition), EC, as part of executive attention, pertains to the ability to willfully or voluntarily inhibit, activate, or modulate attention and behavior, as well as executive functioning tasks of planning, detecting errors, and integrating information relevant to selecting behavior [2]. Furthermore, the attainment of executive/metacognitive tasks often requires the inhibition of emotions, mainly ones of negative valence. Consequently, the ability to focus attention away from distressing reactions facilitates planning and pursuing long-term objectives. The relevance of emotional control in metacognition is most profound in planning, where a distant goal needs to be maintained in the presence of other competing options of action [12]. Researchers claim that inhibitory control could be a predictor of conscientiousness [13] [14]. Therefore, EC has been viewed as closely related to Big Five Conscientiousness [2] [5] and the core function of this temperament component is the goal-directed self-regulation of more reactive affective, behavioral, and attentional processes [1] [6].

It should be noted that, although intentionally managed *inhibition* (or *inhibitory control*) is one of the components of EC [2], effortful self-regulation should be differentiated from the construct of *control* (*inhibition or restraint*) [15]. According to Eisenberg and colleagues [15], inhibition also may be involuntary or automatic and, therefore, not under voluntary control. Optimal emotion-related regulation, which involves EC, is expected to be flexible and intentionally modulated so a person is not overly controlled or out of control. Self-regulated individuals are believed to be able to react in a spontaneous way when they are in contexts where such reactions are acceptable and, in parallel, to be able to effortfully inhibit their approach (or avoidant) tendency when is appropriate [15].

As EC permits flexible inhibition of over-reactive tendencies, it is expected to play a primary role in certain aspects of life (such as expression of emotions, modulation of emotion-related activities, internalization of rules, and self-regulation) and to be a predictor of a wide range of developmental—cognitive, social, emotional, and moral—outcomes. In specific, the role of EC seems to be important for a broad range of children's functioning, such as negative emotionality, behavior problems, psychopathology, academic performance, school readiness, conscience, empathy, prosocial behavior, social relationships with parents and peers, resilience, social competence, and adjustment, as well [6] [15] [16] [17] [18]. Furthermore, recently there has been increased interest in the role of effortful control in developmental disorders, such as attention-deficit hyperactivity disorder (ADHD) and autism spectrum disorders (ASD) [11] [19] [20].

However, it is not clear which view (as uni-dimensional or as multi-dimensional/heterogeneous construct) of EC could offer more refined explanations for its role in the prediction of the aforementioned varying developmental outcomes. Gusdorf and colleagues (2011) [11] found that the Effortful Control Battery (ECB) assesses two higher-order constructs: self-control and attention/ motor control. Kochanska and colleagues (2000) [13], taking into account the "hot" vs. "cool" distinction—which was firstly included in Mischel's framework on "hot" and "cool" self-control [21] proposed four key functions that are included in EC: 1) delaying, which represents the "hot" dimension of EC, and 2) motor inhibition, 3) suppressing-initiating response to signal, and 4) effortful attention, which represents the "cool" dimension of EC.

As regards the "hot" vs. "cool" distinction, it should be noted that Metcalfe and Mischel (1999) [21] proposed the existence of 1) a "hot", emotional system that urges a person to approach a desirable stimulus, and 2) a cool, cognitive system which executes top-down control over the hot system. Correspondingly, "hot" EC tasks tend to contain an emotional component—for example, an affectively positive or negative consequence: delay of gratification is the most typical "hot" task. On the contrary, "cool" EC tasks tend to demand a more abstract form of self-regulation, including inhibition (Go-No Go) and effortful attention (Stroop-like tasks) [22].

There is mixed and not still integrated evidence for the possibility that different types of EC may differentially predict diverse developmental outcomes and this controversy in the literature concerns the issue of uni-dimensional vs. multi-dimensional structure of effortful control. Specifically, Allan and Lonigan (2011, 2014) [23] [24] suggested that a one-factor model of EC may be more parsimonious than the multi-dimensional "hot" and "cool" models for which Brock, Rimm-Kaufman, Nathanson, and Grimm (2009) [25] found that can fit data well. The aforementioned controversy and the models of EC as heterogeneous construct have also been enhanced by the more recent finding that children's scores in "hot" EC tasks predict behavior problems but not academic performance, while their scores in "cool" EC tasks predict academic performance, but not behavior problems [22]. Given the different and essential implications of EC for a wide range of diverse developmental outcomes [6] [11] [15] [16] [17] [18], it is clear that more research is needed to investigate the issue of homogeneity versus heterogeneity of EC.

3. Effortful Control, Executive Function, and Metacognition

There are some constructs that resemble EC pertaining to personality/temperament models and cognitive/neuropsychological models focusing on executive functions. According to a taxonomy, provided by Nigg (2000) [26] [27] and linking temperamental, neural, and cognitive views of these models, Rothbart's temperamental concept of EC can be associated with executive functions and with neurological regions reflecting prefrontal cortical circuits.

As one of the temperament components, EC is viewed as having some constitutional basis and as being an individual-difference variable that is relatively stable across time and contexts [6], although it is now well-known that temperament components do change [3]. EC is not often observed by caregivers until the toddler and preschool years. It usually becomes more stable (across time and situation) throughout early development and more pronounced throughout childhood and beyond [18] [28] [29]. As already mentioned, the main components of EC include attentional focusing (AF) that is, the tendency to maintain attentional focus upon task-related channels, and inhibitory control (IC), or the capacity to both plan and suppress inappropriate approach responses under instructions [30]. These abilities, which can be observed by parents in daily situations, are proposed by leaders in EC research to reflect individual differences in the efficiency of the executive attention network, whose function is to monitor and resolve conflicts between other brain networks [31].

Attentional functions are different from the rest of cognitive functions in that they underlie and maintain the activity of the cognitive functions. Taking into account the computer analogy, attentional functions serve as command operations, calling into play one or more cognitive functions [32]. Attention includes two aspects: *voluntary* (e.g., controlled processes) and *reflex* (e.g., automatic processes). It also includes the capacities both for *disengagement to* shift focus and for *responsivity* to sensory or semantic stimulus characteristics. "At its core, attention includes both perceptual and inhibitory processes—when one attends to one thing, one is refraining from attending to other things" [32] [33].

Attentional functions that are related to the executive attention network overlap with the broad domain of executive functions (EFs) in childhood [34]. *EFs* is an umbrella term that refers to a set of heterogeneous, higher-order cognitive processes which are involved in goal-directed, flexible, and adaptive behavior, that is mainly triggered in novel, challenging, and complex situations [35]. Because of their high association with the prefrontal cortex, EFs have been considered top-down processes [36] and, according to Zelazo (2015) [37], the situations in which the application of executive functions' top-down regulation is useful could vary on a continuum from purely cognitive challenges (calling for "cool EFs") to motivationally important situations (calling for "hot EFs"). There is some conceptual overlap among research on EFs and temperament-based approaches to children's self-regulation [4]. In specific, in Rothbart's approach [34] of temperament, individual differences in EC can influence behavior in cognitive and affective contexts, as well. Since EFs can mainly be described by their cognitive and volitional character [38], it seems that it is the cool system of effortful control that overlaps with them. Taking together, the temperamentally based concept of EC and the neurocognitive concept of EF are important aspects of self-regulation and seem to share important features [39] [40] [41].

Caregiver ratings of EC have been found to be associated with a variety of so-called executive function tasks and both EC and EF have been found to demonstrate similar developmental trajectories through childhood [41] [42]. Although the correlations between these two constructs are rather modest in magnitude and the predictive validity that they provide for academic performance is independent [16] [18] [43] [44], EC and EF are very similar to each other in terms of attentional processes, but also as regards the ability to inhibit an impulsive response in favor of a most appropriate one [45] [46]. Researchers suggest that the strength of the relations between EC and EF is influenced by the instruments used for their measurement and by the operational definition of these instruments, as well. In contrast with the lack of correlations that were obtained among performance on computerized tasks, parents' reports of EC were found to be related, to a considerable degree, to metacognition and behavioral regulation components of EF that were assessed via the Behavior Rating Inventory of Executive Function (BRIEF) [47].

It is noteworthy that the cognitive ("cool") character of executive functions and their use in situations that aim at the improvement of cognitive and behavioral performance are main similarities to the concept of metacognition (MC) [48]. *Metacognition*, as well as EF, is also a term that refers to the so-called "higher-order cognitive processes"—such as monitoring, controlling steering, and adapting encoding, storage, and retrieval of information—which play a critical role in children's development of self-regulated behavior and thinking [48] [49]. Except for declarative metacognition (declarative knowledge about cognition, learning, and memory), MC also includes procedural metacognition (self-reflective, higher-order cognitive processes which are used for regulating ongoing cognitive processes) [50] [51] [52]. Procedural metacognition includes the processes of metacognitive monitoring (such as subjective assessments of ongoing cognitive activities), and metacognitive control (such as the regulation of current cognitive activities: selecting material for review while studying, switching between strategies, differentially allocating study time to the learning material, correcting of errors, withdrawing answers, or terminology memory search [53] [54].

The structural equation modeling technique has revealed that—at least in early and middle childhood—there is a substantial link between EF and metacognitive control, while metacognitive monitoring is not related to EF. The aforementioned finding indicates that EF and procedural metacognitive control—and not procedural metacognitive monitoring—seem to share the managing aspect of higher-order cognitive processes [49] [55] [56]. Another reason, for which metacognitive control is expected to be associated with EF, is that it involves processes that build on metacognitive monitoring and put executive functions into action [12]: for example, children's flexible strategy use may rely on their inhibitory control skills, as a child has to inhibit a previously used strategy when she/he understands that this strategy is not adaptive any more in a specific task context [42] [49] [55] [57].

Note that there is also a link between MC and motivation that has been supported by several researchers [58] [59] [60] [61] [62] and the definition of motivation in the context of MC refers to "beliefs and attitudes that affect the use and development of cognitive and metacognitive skills" [61]. Since MC includes affective and motivational states, it also entails the management of affective states. Metacognitive strategies may improve persistence and motivation in a challenging task context, and emotion-related self-regulation refers to monitoring and regulating the impact of emotions and motivational states on performance [58] [59]. This emotion-related self-regulation parallels the regulation of cognition involved in the executive functioning dimension of MC [63]. Individual differences in emotion-related self-regulation are at least partly due to individual differences in temperament [64] and have been associated with academic performance [65]. Eisenberg and colleagues (2010a) [1] argue that the sub-skill of EC (defined as the efficiency of executive attention) is related to individual differences in the aforementioned form of self-regulation and suggest that EC is indirectly associated with academic success through motivation.

4. Metacognition, Executive Function, and Effortful Control: Their Relationships to Academic Achievement and Learning Related Behaviors

Both constructs—MC and EF—are highly relevant to the domain of academic achievement [48]. Declarative metacognition has been found to affect performance indirectly, while procedural metacognition affects performance directly [48] [66]. Procedural metacognition has been found to have an essential effect on academic achievement on reading, writing, mathematics, science, and general knowledge tests [53] [67]-[72]. Note that research [55] has indicated that the links between metacognition and achievement might be bi-directional, at least for younger children.

EF as a unified/uni-dimensional construct has been found to be a good predictor of academic achievement in a lot of longitudinal studies. Specifically, executive functions can explain 5% - 36% of the variance in early academic achievement and the effect of EF for school achievement has been found to be both direct and indirect [55] [73] [74] [75] [76].

EC plays an important role in school functioning (academic achievement and school adaptation) [64] [65]. Many researchers have argued that emotional competence and processes involving executive attention are important for academic success [77]. According to Zhou, Main, and Wang (2010) [78], students with high EC likely perform better academically than their counterparts with low EC due to their greater ability to focus, maintain, self-regulate their attention, and inhibit prepotent responses as needed. Eisenberg and colleagues (2010a, 2010b) [1] [64] explain this link as follows: children high in EC can manage their attention, behavior, and emotions and they are likely to act in socially appropriate ways with teachers and peers to maintain attention when engaged in academic tasks. In fact, engagement in school and positive relationships with teachers and peers are predicted to engender classroom participation. This increased motivation leads to higher school performance [63] [65] [79] [80] [81].

Although EC covers some dispositional self-regulatory abilities important to cope with social demands of successful adaptation to school, continued success in the academic domain does not depend only on classroom behavior such as engagement, motivation, and classroom participation. It also depends on learning-related behaviors (LRBs), which are especially relevant to classroom participation [81].

Learning-related behaviors, in specific, have been found to be a necessary precursor of learning and academic achievement as well [82] [83]. They refer to a set of behaviors that involve organizational skills and appropriate habits of study. More specifically, learning-related behaviors comprise abilities such as listening to instructions, following directions, attending to teacher's explanations, carefully analyzing problems before solving them, the accomplishing of tasks even in a limited period of time, participating in teamwork, and striving even on non-preferred subjects [84]. These strategies involve the acquisition, organization, and retention of information in an intentional and purposeful way, and require self-regulatory behaviors such as initiative, persistence, or goal setting [85], whose efficiency of use largely depends on metacognitive control processes.

EC and learning-related behaviors are two constructs that reflect aspects of self-regulatory skills and therefore, they have unique contributions to academic achievement via different mechanisms. EC tends to regulate approach and withdrawal behavioral tendencies via attentional, inhibitory control, and effortful activation mechanisms which are reported by parents. On the other hand, LRBs are reported by teachers and refer to the actual behaviors that children exhibit in coping with academic tasks. Learning-related behaviors reflect the use of metacognitive abilities [86] and motivation [82]. To sum up, it appears that the use of metacognitive control processes altogether with a high degree of engagement in coping with academic tasks as reflected in learning-related behaviors seems to constitute a crucial factor for higher academic achievement [82].

EC mechanisms also interact with cognitive processing in the school context [87] and individual differences in self-regulation abilities could influence higher-order cognitive processes. Some evidence supports the hypothesis that components of EC are positively related to reading, math, and linguistic abilities [88]. Blair and Razza (2007) [16] found that preschoolers' inhibitory control was related to their emerging math abilities in kindergarten. Similarly, fall assessments of EC have been predictive of spring assessments of vocabulary and math [89].

However, despite the unique, direct contribution of EC to academic achievement, this contribution is also possible to be mediated by LRBs. Learning-related behaviors have been found to constitute a more proximal gateway to classroom learning compared to effortful control skills because they support effortful participation in learning situations and increase the child's exposure to classroom instruction [90]. EC and LRBs have also been found to be partially interrelated. The positive association that has been found between EC and LRBs could be explained in part by their underlying mechanisms. More specifically, executive control skills are believed to underlie or overlap partly with EC and LRBs [91] [92] [93].

In sum, the aforementioned studies have suggested that individual differences in EC have been associated with school functioning not only through social adaptation and motivation but also through academic achievement including the efficient use of LRBs. Taking into account that there is still little empirical evidence addressing the question of to what extent learning-related behaviors/abilities (study skills) are associated with EC, the aim of this review is to provide an overview of the studies that have investigated the mediational role of metacognitive strategies, as this is reflected through LRBs, in the relationship between effortful control and academic achievement.

5. Method

In order to conduct the present literature review, the databases Pubmed, PsychInfo, and Scopus were searched for relevant literature in March 2022. The following keywords were used: effortful control and metacognition skills OR metacognitive strategies OR metacognitive study strategies OR metacognitive study skills and academic achievement OR school performance. After an extensive screening procedure, a total of 3 studies were selected for further analysis.

A detailed description of the screening process is illustrated in Figure 1.

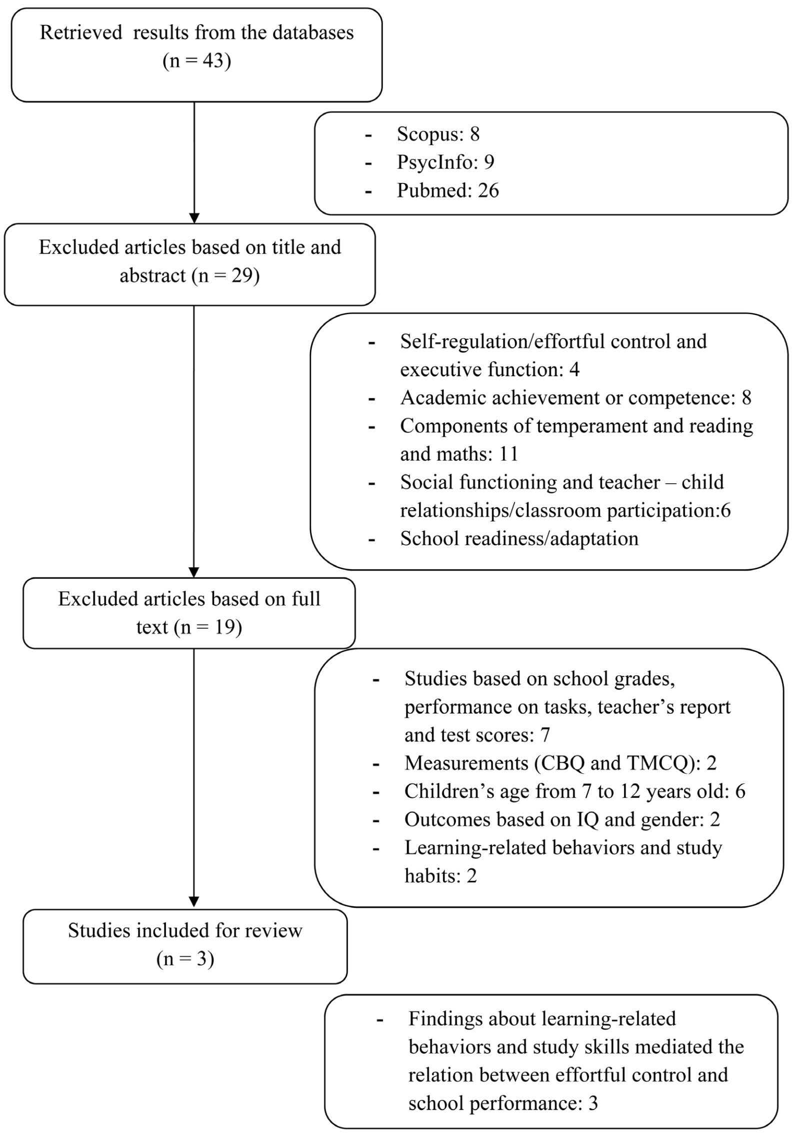

Figure 1. Diagram of the process of studies' selection.

6. Results

The first study that we included was conducted by Neuenschwander and collaborators (2012) [83]. The study related different aspects of self-regulation (temperamental effortful control and executive functions) to different aspects of adaptation to schools, such as learning-related behaviors, school grades, and performance on standardized achievement tests. One of the major aims of this study was the investigation of the kind of effect (direct or indirect via LRBs) of executive functions (EF) and effortful control (EC) on mathematical, reading, and writing skills of students during their transition to elementary school. The participants were Swiss children and their ages corresponded to kindergarten and first years of elementary school. Four hundred and fifty-nine children's (Mean age = 7.4-year-old) adaptation to school were measured in domains of math, reading, and writing by tests and teacher's grades, too. The results of a one-year longitudinal study revealed that the contributions of temperamental effortful control to school grades were fully mediated by children's learning-related behaviors. Thus, children whose parents rated them as having reliable EC in their everyday lives also show increased LRBs in classrooms during the first two years of elementary school that were rewarded with high grades. On the other hand, the contributions of EFs to school grades were partially mediated by children's learning-related behavior as well. Furthermore, EFs predicted performance in standardized achievement tests. Controlling for fluid intelligence did not change the pattern of prediction. In conclusion, both aspects of self-regulation were shown to be important for fostering early learning and good classroom adjustment in children.

The next study was conducted by Sánchez-Pérez *et al.* (2015) [94] concerning the investigation of the specific contribution of two different components of EC (namely, attentional focusing and inhibitory control) to children's mathematics achievement. The sample was composed of 142 children (68 boys) aged 9 - 12-year-old. Two pathways were tested through which effortful control components would contribute to mathematics performance in primary school children, as measured through a standard test and via a teacher's report. In the first pathway, the authors hypothesized that academic peer popularity would mediate the association EC—mathematics achievement, and in the second pathway model the meditational factors proposed were non-verbal intelligence and study skills. The role of gender and SES was also considered in this study. The results showed that only attentional focusing—and not inhibitory control—contributed significantly to the variance of children's mathematics achievement. Also, meditational models showed that the relationship between effortful attentional self-regulation and mathematics achievement was mediated by academic peer popularity, as well as by intelligence and study skills.

The last study that was included in this review was also conducted by Sánchez-Pérez and collaborators (2018) [84] to identify factors that contribute to individual differences in school functioning (academic achievement and social adaptation). The authors proposed a model including direct effects of effortful control on academic achievement and social adaptation at school and partially mediated by learning-related behaviors (LRBs), as well. In this study, the meditational role of LRBs was tested in a Spanish sample of elementary students (N = 142; 74 boys) from grade 2 to grade 6. According to the authors, the proposed model may be especially relevant for explaining student's school functioning at these ages because both effortful control and learning-related behaviors largely depend on the executive control process and middle childhood is crucial for the development of metacognitive monitoring and the study of control processes [95]. Students' EC was rated by parents and LRBs by teachers. Children's academic achievement was measured through standard tests and grades. Structural equation models that were run controlling gender, intelligence, age, socioeconomic status, and school showed that EC was positively and directly related to social adaptation in school. EC was also indirectly related to academic achievement and social adaptation through LRBs.

To sum up, a total of 3 studies that have investigated the relationship of EC to academic achievement via learning-related behaviors and study habits that reflect the efficient use of metacognitive strategies have been analyzed. The total sample size of these studies varied from 142 [84] [94] to 459 children (Neuenschwander *et al.*, 2012) and the age from 5 to 12 years old. Based on their

Table 1. Characteristics of the three studies.

Study	Sample size	Mean Age	Measures	Control Variables	Metacognitive strategies related effects
Neuenschwander *et al.*, 2012	459	4 - 8 year - old	Executive Functions-3 tasks (Backward Color Recall task, adapted version of Fruit Stroop task & Cognitive Flexibility task)-CBQ-VSF-Test of Nonverbal Intelligence-Curriculum-based standardized achievement tests/grades for mathematics, reading & writing-scale of learning-related behavior (one-dimensional instrument)	Gender/age effects	Learning-related behaviors
Sanchez-Perez *et al.*, 2015	142	9 - 12 year - old	Temperament in Middle Childhood Questionnaire (parent report)-teacher's report & standard Woodcock-Johnson test-Non-verbal Intelligence	Gender SES	EC in acquisition of general cognitive skills (IQ)-academic-related skills (study skills: organization, retention of information, goal setting)-metacognition and control processes
Sanchez-Perez *et al.*, 2018	142	6 - 12 year - old	Temperament in Middle Childhood Questionnaire (parent report)-Study Skills scale (BASC-Spanish version)-report cards (teacher evaluation)-math tests from Woodcock-Johnson III-Social Skills and Aggression scales (BASC-teacher report)	Cognitive abilities SES Gender	LRBs-Organizational skills and positive study habits

findings, it appears that individual differences in EC have been associated with academic performance through metacognitive monitoring and control processes and not only through social competence. The use of metacognitive abilities altogether with a high degree of engagement in coping with academic tasks as reflected in learning-related behaviors seems to constitute a crucial factor for higher academic achievement [83]. (An overview of the characteristics of the above-analyzed studies is presented in **Table 1**.

7. Conclusions

The aim of the current review was to present an overview of the available scientific evidence on the relationship of effortful control to academic achievement via procedural metacognition and specifically, learning-related behaviors (metacognitive control strategies). We analyzed three studies and their findings provide some promising evidence regarding the indices of EC that are related to students' academic competence for performing well.

In some of the three studies, there was an administration of questionnaires for parents, while others used tests for students as well as grade point averages that targeted all aspects of EC mechanisms to academic outcomes through learning-related behaviors, metacognition, and executive control processes. The samples of all studies consisted of pre-school and mainly school-age children. Through reading, writing, and mathematics researchers measured school functioning and more specific academic achievement. In any case, all studies came to the same outcome, that is, the significant effect of this temperamental self-regulatory capacity, namely EC, on academic achievement via learning-related behaviors that reflect efficient use of metacognitive control strategies.

This finding could be explained as follows: It is well-known that EFs and metacognition are related under the umbrella concept of cognitive self-regulation as the main similarity of EFs to MC is their cognitive ("cool") character [55]. Specifically, there is a substantial link between executive function and procedural metacognitive control because EF is necessary for metacognitive control at the basic level of any self-regulated cognitive task: for example, inhibition facilitates hesitation and interruption [49] [55] [56]. Moreover, EC and EF are very similar to each other—mainly in terms of attentional processes and inhibitory control, which constitute the "cool" aspects of effortful control. Since the "cool" aspects of EC have been found to predict academic performance [22], it is possible this "cool" system of EC affects academic achievement through the facilitation of the efficient use of metacognitive control processes (such as the regulation of current cognitive activities: selecting material for review while studying, switching between strategies, differentially allocating study time to the learning material, correcting of errors, withdrawing answers, or terminology memory search) [53] [54] [55] which are related to the learning-related set of behaviors.

Taking into account that the temperamentally based concept of effortful control and the neurocognitive concept of executive function are important aspects of self-regulation and share important features—such as the executive functioning dimension of metacognition [45] [96] [97] [98] [99] [100], it is possible that, similarly to "cool" EF, "cool" EC is also related to MC under the more abstract form of cognitive self-regulation. It is noteworthy that, although more research is needed to investigate the issue of homogeneity versus heterogeneity of EC, the aforementioned possibility supports the models of EC as a multi-dimensional/ heterogeneous construct.

In summary, the aforementioned results should be interpreted with caution. The available number of analyzed studies is very limited and the method varies among these studies. However, these findings enhance the role of EC as a predictor of a wide range of developmental outcomes as they indicate an expansion of effortful control's effect on emotion-related self-regulation and cognitive self-regulation. Therefore, future research should overcome the limitations of the available studies in order to gain a better understanding of the relationships between EC and the academic achievement component of school functioning through the use of metacognitive control processes.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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