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The Impact of Preschool Cognitive Self-Regulation Skills on Future School Adaptation

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ABSTRACT

Identifying reliable predictors of school adaptation during the preschool years is critical for promoting academic and socio-emotional success in early schooling. This longitudinal study examined the predictive role of preschool executive functions on first-grade school adaptation. A sample of 211 Russian preschool children (mean age = 81 months, SD = 4.2; 51% boys) was assessed for cognitive self-regulation using the NEPSY-II battery, which included measures of visual working memory, verbal working memory, inhibitory control, and cognitive flexibility. After transition to first grade, the same participants (mean age = 90 months) were evaluated for school adaptation based on teacher ratings covering engagement, behavior, stress, and social interaction. Data analysis using a generalized linear model revealed that among the EF skills, inhibitory control and verbal working memory significantly predicted school adaptation, while visual working memory and cognitive flexibility did not show a significant contribution. These findings underscore the importance of early interventions targeting specific EF skills to enhance school adaptation and promote long-term academic and social outcomes.

Keywords: *school adaptation, first grade, primary school, executive functions, preschool age*

Introduction

With the transition to first grade, children enter an entirely new social developmental context in which familiar play activities are replaced by structured learning, and their status changes from that of a preschooler to that of a student. Along with new rights and responsibilities, a host of obligatory school rules emerge. Numerous international studies (Chambers et al., 2019; Puccioni et al., 2019; Longobardi et al., 2019) have highlighted the critical importance of this transition from early childhood into the school years for children's future psychological well-being. Children who successfully adapt in first grade tend to achieve higher academic performance, exhibit greater self-esteem, engage more effectively with peers, and have an increased likelihood of future academic and social success, while also being less vulnerable to school dropout (Reynolds, 1989; Haynes, Ben-Avie, & Ensign, 2003). Conversely, students who experience adaptation difficulties during the early stages of education encounter significant challenges in both academic performance and social interactions in later school years (Dunn, 1997; Duncan et al., 2007; Fergusson & Horwood, 1995; Jiang & Cillessen, 2005; Ladd & Price, 1987).

School adaptation is defined as the process by which a child adjusts to new conditions and changes in their environment (Zayed Higher Organization for People with Determination & Ural Federal University, 2024), assumes the role of a pupil, and conforms to the various characteristics of the school setting (Rean, 2021; Turner-Cobb et al., 2008). This adaptation spans all dimensions of mental functioning - including the personal-motivational, volitional, socio-emotional, and cognitive domains (Gagay & Grineva, 2013). The rapidly increasing complexity of the school curriculum, combined with various economic and educational transformations (Vladimirovna, 2025) and insufficiently developed basic social and academic skills in children, may pose significant challenges when they try to keep pace with their peers without professional support (Burmenskaya et al., 2022; Podolskiy et al., 2022).

Understanding the factors that determine successful adaptation to school is paramount for the timely mobilization of a child's educational resources and for identifying potential risks of school maladaptation. However, international research has yet to reach a consensus on the psychological factors that most significantly contribute to successful school adaptation. While some studies emphasize the importance of preacademic and cognitive skills (e.g., Blankson et al., 2017; Mercugliano et al., 2025), others highlight verbal abilities (Rudasill et al., 2006), social competence (Ladd et al., 1987), and numerous other factors. This heterogeneity and lack of coordination in existing studies regarding the primary predictors of school adaptation have resulted in the absence of reliable, scientifically validated methods for risk identification and intervention.

The present study focuses on one such predictor - the level of development of cognitive self-regulation skills, defined as the capacity for voluntary and conscious control over one's behavior, thoughts, and emotions (Zayed Higher Organization for People with Determination & Ural Federal University, 2024). Cognitive self-regulation is one of the most integral indicators of higher mental functioning (Morosanova et al., 2021; Blair & Razza, 2007; Liew, 2012), predicting successful school adaptation (Willoughby et al., 2012; Yeniad et al., 2013), subsequent academic performance (Willoughby et al., 2012), and even socioeconomic status and financial well-being in adulthood (Moffitt et al., 2011). In this study, self-regulation is conceptualized as a set of control mechanisms operating at both biological and behavioral levels, enabling individuals to adaptively manage arousal, attention, emotions, behavior, and cognitive processes in pursuit of goal-directed actions (Vohs & Baumeister, 2004; Calkins & Howse, 2004). The emergence of self-regulation during early childhood can be characterized as the integration of emotional and cognitive regulatory processes, with an effective balance between these systems typically established around the age of six, coinciding with the age at which Russian children generally begin school (Blair, 2002; Calkins & Williford, 2009). This increasing capacity to control attention, memory, behavioral impulses,

negative emotions, and motivation provides a foundation for the formation and maintenance of positive social relationships with teachers and peers, thereby facilitating effective learning and successful school adaptation.

Within cognitive neuroscience, executive functions (EF) are recognized as cognitive regulatory processes comprising a complex and interrelated set of skills, such as working memory (which supports the processing and retention of information necessary for performing current tasks), inhibitory control (which involves restraining impulsive responses), and cognitive flexibility (the ability to switch among different thoughts, rules, or perspectives) (Miyake et al., 2000). Although these components can be considered individually, together they constitute a unified phenomenon in both adults and children (Miyake & Friedman, 2012; Wiebe, Espy, & Charak, 2008), often termed cognitive self-regulation.

Numerous previous studies have convincingly demonstrated that EF play a key role in academic achievement, as measured by standardized achievement tests (Neuenschwander et al., 2012). However, successful adaptation to the school environment involves not only academic accomplishments in subjects such as mathematics, reading, and writing but also socio-behavioral aspects such as classroom engagement, persistence, active participation in learning, and interpersonal relationships with teachers and peers (e.g., Alexander et al., 1993; Valiente et al., 2008). It is this comprehensive profile - rather than merely high academic achievement - that characterizes successful school adaptation. Moreover, the relationship between EF and school adaptation, as opposed to academic achievement alone, has been much less extensively studied (Cao & Yan, 2024). For example, a recent large-scale study by Cao and Yan (2024) demonstrated that EF measured at 54 months predicted academic performance in first grade but did not predict socio-behavioral adaptation (manifested as aggressive or delinquent behavior, difficulties in social interactions, and symptoms indicative of anxiety and depression). The authors noted that parental ratings of children's socio-behavioral performance at home may differ from observations made within the school setting. This limitation highlights the need for further research on school adaptation and its relationship with EF.

Considering that first grade represents one of the most stressful and critical periods for school adaptation, the aim of the present longitudinal study is to analyze the predictive role of EF in determining successful adaptation in first graders. Our hypothesis posits that EF, measured during the preschool period, serve as a significant predictor of successful school adaptation in the first grade because the mechanisms underlying cognitive self-regulation are engaged in various skills and abilities essential for adapting to school, including social, emotional, and verbal competencies (Veraksa et al., 2020).

Materials and methods

Participants and procedure

The study was designed using a longitudinal design with two waves. In the first wave of the study, 211 kindergarteners from Moscow participated (mean age 81 months, SD = 4.2, 51% boys). Participants were assessed on EF parameters. Then, one year later in the second wave of the study, the same participants were already first graders in Moscow schools (mean age 90 months) and were assessed on the level of school adaptation.

Participation in the study was voluntary and without compensation. The parents of the participants signed informed consent for their children's participation in the diagnostic activities. The assessment was conducted individually with each child in a quiet room at the educational institution during the first half of the day.

Measures

Cognitive self-regulation, which was assessed through executive functions (visual and verbal working memory, inhibitory control, and cognitive flexibility), was identified using the neuropsychological test battery NEPSY-II (Korkman et al., 2007). Visual working memory

was measured using the "Memory for Design" subtest, in which participants were briefly shown an image composed of several cards, after which they were required to accurately reconstruct the card arrangement from memory (maximum score: 150). Verbal working memory was assessed using the "Sentence Repetition" subtest, in which participants listened to a series of sentences that increased in complexity with each new example (maximum score: 34). Inhibitory control was determined using the "Inhibition" subtest, which included two tasks: "Naming," in which children had to quickly name figures when presented (for example, when shown a circle - name "Circle," and when shown a square - name "Square"), and the "Inhibition" task, which required them to provide the opposite response (when shown a circle - say "Square," and vice versa), with a maximum score of 20. Cognitive flexibility was measured using the "The Dimensional Change Card Sort" test, consisting of three tasks: sorting cards by color, by shape, and according to a specific rule, with a maximum score of 24 (Zelazo, 2006). All these diagnostic methods for the components of self-regulation have been successfully adapted and validated on a Russian sample (Veraksa et al., 2020).

The school adaptation of first graders was assessed using a teacher questionnaire (Gavrilova et al., 2024). Teachers were asked to evaluate each student on the following categories: engagement (e.g., "The child actively participates in class, raises his/her hand, and responds"), behavior (e.g., "The child violates school behavior rules"), stress level (e.g., "The child appears confused or anxious when answering in front of the class"), and interaction (e.g., "Other children want to interact with the child"). The assessment was conducted on a 4-point scale, where 1 indicated "behavior that is not typical at all," 2 - "behavior that is rather atypical but occurs occasionally," 3 - "behavior that is rather typical and occurs quite often," and 4 - "typical behavior that is observed always or almost always." The final school adaptation score was the sum of the scores from all the scales (maximum score: 64).

Data analytical approach

For the analysis of gender differences, a comparison of means using the Mann-Whitney U test was employed for non-normally distributed data. To examine the contribution of preschool EF parameters to the level of school adaptation in first grade, a generalized linear model (GLM, Identity link function, Gaussian distribution, Wald confidence interval method) was constructed. The GLM is designed for the analysis of non-normally distributed data in the context of regression and allows for the assessment of the contribution of independent variables to the dependent variable (Arnau et al., 2016). The dependent variable in the model was the total school adaptation score in first grade, while the predictors were the scores on the EF components: visual working memory, verbal working memory, inhibitory control, and cognitive flexibility. In addition, the gender and age of the children at the time of the second wave of the study were included in the model to control for gender and age effects on school adaptation. All model covariates were pre-standardized. The GLM model was constructed using the R programming language (version 4.4.0).

Results

In the first stage of data analysis, a preliminary analysis of gender differences using the Mann-Whitney U test (applied due to the non-normal distribution of the data as indicated by the Shapiro-Wilk test results, $W = 0.933$, $p < 0.001$) showed that, regarding school adaptation, girls' scores were significantly higher than boys' scores ($U = 8100$, $p < 0.001$). This confirmed the importance of accounting for the sex factor in modeling EF as predictors of school adaptation in subsequent stages of the analysis.

In the second stage of analysis, a GLM model of school adaptation was constructed. The model predictors were pre-standardized to allow a proper comparison of the obtained estimates. As a result of the GLM analysis ($R^2 = 0.211$; Adjusted $R^2 = 0.211$; $\chi^2 = 7989$; $p < 0.001$; AIC = 1660; BIC = 1685), the following estimates were obtained (see Table 1). Based on the omnibus test results, significant predictors of school adaptation ($p < 0.05$) were verbal working memory ($\chi^2 = 6.54$; $p = 0.011$),

inhibition (χ^2 = 9.5; p = 0.002), and sex (χ^2 = 17.62; p < 0.001). Visual working memory, cognitive flexibility, and age were not found to be significant.

Table 1. Estimates of the parameters of the GLM model of school adaptation based on the EF skills of preschoolers

Parameters	Estimate	St.Error	Exp(B)	95% CI (Lower, Upper)	Z	p
Intercept	83.65	0.83	2.14E+36	(82.01, 85.29)	100.3	<.001
Sex	7.12	1.7	1241.7	(3.79, 10.45)	4.2	<.001
Age	0.75	0.87	2.12	(-0.96, 2.47)	0.86	0.391
Visual working memory	0.38	0.98	1.46	(-1.53, 2.29)	0.390	0.696
Verbal working memory	2.29	0.89	9.84	(0.53, 4.04)	2.56	0.011
Inhibition	2.74	0.89	15.42	(0.99, 4.47)	3.08	0.002
Cognitive flexibility	1.75	0.91	5.79	(-0.04, 3.5)	1.91	0.055

Thus, when evaluating the coefficients of the obtained model (see Table 1), it was determined that, in addition to gender, among the components of preschool EF, inhibitory control is the strongest predictor of first graders' school adaptation, followed by verbal working memory.

Discussion

Successful learning in first grade classrooms requires a good adaptation to the new educational context. This is especially important for children immediately after the transition from preschool to first grade, as these new students must not only cope with the academic tasks of learning to read, write, and solve arithmetic problems, but also meet the behavioral and social demands of the new educational environment (Gavrilova et al., 2024). In view of this, the search for reliable predictors of successful adaptation to school learning appears particularly important. The present study examined the prognostic role of preschool EF components in predicting successful school adaptation in first grade. Previous studies have mainly focused on the predictive role of EF for academic achievement (Bull et al., 2008; Clark et al., 2010; Willoughby et al., 2012), but not for school adaptation in terms of engagement in learning, behavior, social relationships, and stress (Cao & Yan, 2024).

As a result of the two-wave longitudinal study, it was shown that, among all the EF components, the most significant predictive contribution is provided by inhibitory control, followed by verbal working memory. Visual working memory and cognitive flexibility did not show a significant contribution to school adaptation. This finding indicates that not all EF components contribute significantly to the level of first graders' adaptation. The limitation of the study is the exclusive reliance on teacher reports, which may not fully capture the multidimensional nature of cognitive self-regulation and school adaptation. Despite these limitations, the obtained results present important conclusions.

Our results are partially in line with the findings of a recent study by Gagne et al. (2025), which showed that preschool inhibitory control significantly predicted lower levels of externalizing behavior and impaired functioning in primary school. Indeed, previous EF studies have also demonstrated that inhibitory control has a significant impact on social and behavioral adaptation (Vuontela et al., 2013; Blair & Razza, 2007; Hughes et al., 2023; Liu et al., 2019). The primary contribution of inhibitory control can be explained as follows. School entry requires more active control over irrelevant or inappropriate thoughts and actions in order to ensure concentration on learning and successful interaction with peers (Macdonald et al., 2014).

Inhibitory control is associated with academic achievement and positive socio-emotional competence (Raaijmakers et al., 2008; St Clair-Thompson & Gathercole, 2006). Low levels of inhibitory control are linked to behavioral externalization problems and attention deficit hyperactivity disorder (Gagne et al., 2011; Goos et al., 2009).

Similarly to the study of Gagne et al. (2025), visual working memory did not predict school adaptation in our study. This result diverges from some previous studies that have shown a relationship between well-functioning working memory (WM) and good school performance (Aronen et al., 2005; St Clair-Thompson & Gathercole, 2006). Theoretical models and hypotheses emphasize that WM may be one of the EF cognitive abilities that is particularly important for social functioning (Barkley, 1997). Working memory is closely linked with information processing, including the ability to actively hold coherent representations in mind, to search for additional information related to the task at hand, and to make decisions based on the available data (Barrett et al., 2004). As a result, children with insufficiently effective WM may encounter difficulties in maintaining social goals, integrating fragmented pieces of social information, and choosing an appropriate social response. These deficits can complicate the effective resolution of social situations and lead to more negative social interactions in the classroom.

However, there is little empirical evidence supporting a significant role for visual working memory in a child's socio-psychological adaptation at school (e.g., Kofler et al., 2011). In this regard, it seems more plausible that visual working memory is more closely related to a child's academic achievement at school than to school adaptation per se. According to the meta-analysis by Johnson et al. (2010), children with reading difficulties demonstrated verbal working memory results approximately one standard deviation lower than their typically successful peers, and nearly 75% lower in visual working memory. Similarly, children with math difficulties scored one standard deviation lower on tasks involving verbal working memory and half a standard deviation lower on tasks related to visual working memory compared to successful classmates. These data confirm that the capacity of working memory is crucial for academic performance. Thus, the current study aligns with a number of studies such as that of Gagne et al. (2025), which suggest that visual working memory is not one of the significant predictors of school adaptation.

However, in the present study, unlike that of Gagne et al. (2025), both visual and verbal working memory were analyzed, which is a distinguishing feature of the current investigation. As a result, it was shown that verbal working memory turned out to be a significant predictor of first graders' school adaptation. This highlights the importance of taking into account the modality of working memory when analyzing its contribution to students' adaptation. Similar conclusions regarding the importance of visual and verbal working memory for schoolchildren's social functioning were drawn by McQuade et al. (2013), who found that a low level of verbal working memory was associated with increased peer rejection, whereas spatial working memory did not show any significant association with indicators of social problems. Children with a low ability to retain verbal information are likely less capable of effectively engaging in oral communication with their peers, which prevents successful adaptation among classmates within the educational setting. The findings regarding the significance of verbal working memory for successful school adaptation fill existing gaps in current research, such as that of Gagne et al. (2025).

Finally, cognitive flexibility did not show a significant contribution to school adaptation, as it demonstrated a borderline, yet non-significant, level of importance in the constructed prediction model of school adaptation based on EF skills ($p = 0.055$). This result may well change with an increased sample size, as cognitive flexibility appears to be an important skill for a child's successful functioning in an educational environment. The ability to think flexibly in conditions of constant change is critically important (Yeniad et al., 2014). Cognitive flexibility

enables a child to perceive the world from a new, alternative perspective and is critical for adapting to new conditions (Davidson et al., 2006). Children form mental images of various situations and are capable of switching between competing representations, dynamically activating and transforming their notions in response to unpredictable changes in circumstances (Deak & Narasimham, 2003). Thus, cognitive flexibility is an important factor in school readiness (Vitiello et al., 2016) and, apparently, makes an important contribution to school adaptation, the effect size of which should be clarified in subsequent studies.

Conclusions

Thus, the two-wave longitudinal study confirmed the hypothesis that cognitive self-regulation, measured through EF skills, has significant predictive power for forecasting the success of first graders' school adaptation. Children with well-developed inhibitory control and verbal working memory, formed as early as the preschool period, more easily cope with the adaptation to the learning process at the school stage, which substantially reduces the risks of future school maladaptation.

The findings of this longitudinal study allow us to identify these cognitive self-regulation skills as some of the most predictive factors, the measurement of which at the preschool stage, both in the preparatory and senior groups of kindergarten, permits a reliable and significant prediction of the future success of a child's adaptation to school learning in the first grade of primary school. Based on the results obtained, it is recommended to implement evidence-based early intervention and support programs aimed at developing inhibitory control and verbal working memory skills among preschoolers, which, in turn, should contribute to improving their indicators of adaptation to school life in the future.

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