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Cognitive flexibility and academic performance of children in care and children from a community sample: the contrasting mediator effect of task persistence

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ABSTRACT

Objective: This study investigated the role of cognitive flexibility and temperament as predictors of academic performance, in children in care and children from a community sample, longitudinally. Also, it examined the mediating role of child's temperament in the relationship between cognitive flexibility and academic performance, as well as between-group differences.

Method: Participants were 46 children in care and 48 children from a community sample, aged 6 to 10 years. Cognitive flexibility, temperament, and academic performance were assessed with the Raven's Colored Progressive Matrices set B (RCPM-B), the Portuguese version of School-Age Temperament Inventory (SATI), and the competence academic scale (CAS) of the Portuguese version of the Social Skills Rating System – Teacher Form (SSRS-T), respectively.

Results: Cognitive flexibility was a significant predictor of academic performance only for children in care. In both groups, negative reactivity and task persistence predicted academic performance, and children's task persistence mediated the relationship between cognitive flexibility and academic performance. However, a between group difference was observed in this mediation: in addition to the mediation effect observed in both groups, a direct effect was also found in the in-care group.

Conclusions: These findings highlight the importance of promoting cognitive and task persistence competencies in normative and at-risk populations.

KEY POINTS

What is already known about this topic:

- (1) Cognitive abilities are widely recognized as a determinant factor for academic performance in both nonclinical and at-risk populations.
- (2) The predictive effect of temperament on school academic performance is widely described.
- (3) Cognitive flexibility difficulties and poor academic performance among children in care are widely documented.

What this study adds:

- (1) In the in-care group, cognitive flexibility predicted academic performance one year later, but this longitudinal prediction was not significant for the community sample group.
- (2) The mediating role of temperament dimensions in the relationship between cognitive flexibility and academic performance was examined and only task persistence showed a significant mediation effect in both groups.
- (3) This mediation effect was different between groups, as, in addition to the mediator effect observed in both groups, a direct effect was found in the in-care group.

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Cognitive flexibility; temperament; academic performance; mediation model; residential care

Introduction

Schools are important contexts for children's development, as they foster their learning and social experiences, influence their self-perceptions and affect their life courses (Baker et al., 2008; Chen et al., 2020). School confronts children with major developmental challenges, both in the social and academic arenas. It acts as a protective factor, while providing them the

opportunity for developing relevant skills/abilities and sense of efficacy, as well as to negotiate social relationships (Osher et al., 2014).

Academic performance plays an important role in child development, as academic skills, namely in reading and mathematics, have long term effects on educational attainment, performance and income at work, physical health, socioemotional adjustment and

longevity (Calvin et al., 2017; Kuncel & Hezlett, 2010; Peng & Kievit, 2020; Wrulich et al., 2014). It may be defined as the result of learning produced by the quantity or quality of a child's work in specific subject matters (Howie & Pate, 2012; Lamas, 2015). On the contrary, poor academic performance is as a risk factor for developing emotional and/or behavioural problems (Millones et al., 2015). Children with low academic performance often experience displeasure, lack of motivation and poor self-esteem, which make them more prone to use drugs (Vaughn et al., 2015), alcohol (Bryant et al., 2003), and to exhibit disruptive and antisocial behaviours (Joffe & Black, 2012). In accordance, interventions focused on academic performance may impact behavioural and socioemotional adjustment (Kremer et al., 2016), which emphasizes the importance of studying academic performance and its underlying factors.

The association of cognitive abilities (i.e., cognitive flexibility) (Alves et al., 2017; Calvin et al., 2017; G. Lemos et al., 2018; Peng et al., 2018) and temperament (Bryce et al., 2018; Buhs et al., 2018) and academic performance has been described. Cognitive flexibility plays a particularly important role, as it is a form of "meta-control" (Goschke, 2003; Hommel, 2015) that supports children's emotional and behavioural regulation while performing school tasks, along with their acquisition and consolidation of abstract learning (Nesayan et al., 2019). Equally, evidence supports the effect of temperamental reactivity on children's learning and academic performance, as the appropriate regulation of positive emotions can promote motivation towards learning, as well as school engagement (Ato et al., 2020). Additionally, children with high levels of effortful control, which includes emotion, behaviour, and attention regulation, tend to be more engaged in learning and social challenges at school (Checa & Abundis-Gutierrez, 2017; Checa & Rueda, 2011; Galián et al., 2018)

The current study investigates the role of cognitive flexibility and temperament factors as predictors of academic performance, longitudinally. It also examines whether these factors have a different predictor effect for children in care and for children from a community sample.

Residential care in Portugal and the relationship with academic performance

European countries follow different evidence-based practices concerning child welfare (Grietens, 2013; Pinto & Luke, 2022). When children are removed from their biological families and it is necessary to provide them out-of-home care, most countries prioritize foster

care, instead of residential care (del Valle & Bravo, 2013; Pinto & Luke, 2022). Although the Portuguese Child Protection Law reflects this preference, almost all children are placed in institutions when removed from their biological families (Departamento de Desenvolvimento Social/Unidade de Infância e Juventude do Instituto da Segurança Social, 2021). The main legal reasons for Portuguese children to be drawn from their birth families are negligence (71%), followed by psychological abuse (10%), physical abuse (4%), sexual violence (2%), and other reasons (i.e., temporary lack of family support, child disruptive behaviours and abandonment by the biological family) (13%).

Residential care is one of the main measures to support and protect children and young people at risk. The total number of children in care has been increasing over the past decade (Pinto & Luke, 2022) and it is thus crucial to further understand the developmental characteristics of children living in institutions. Despite the negative effects on children's development, residential care provides an ecological approach to analyse the effects of early adverse experiences on specific developmental processes, such as on academic performance (Soares et al., 2019).

According to official data (Departamento de Desenvolvimento Social/Unidade de Infância e Juventude do Instituto da Segurança Social, 2021), in Portugal, in 2020, 90% of the children in care aged between 6 and 9 years were attending the elementary school (i.e., 1st to 4th grade), which are appropriate values considering the children's age. However, from the 838 children and adolescents who were attending the elementary school, only 67.2% were aged between 5 and 9, and the remaining 32.8% were aged between 10 and 18 years. More concerning, only 36% of the adolescents aged between 15 and 17 living in institutions were attending high school. It appears that children in care tend to repeat grades and to be faced with school failure, and the difficulties resulting from increased academic challenges tend to become more severe along the developmental pathway.

In the past decades, studies reported high rates of poor academic performance in children living in residential care (Berridge, 2007; Goddard, 2000; Vinet & Zhedanov, 2011). Longitudinal studies show that the educational gap between children with adverse family experiences and their peers tends to begin at a young age, increase as they get older, and persist through their developmental pathways (Berlin et al., 2019). Residential care has a devastating effect on children's attainment in reading, writing and mathematics (Connelly & Chakrabarti, 2008; Forrester et al., 2009). The reasons for the poor academic achievement have

been discussed and generated controversy, with many alternative proposals focused differentially on pre-care factors and in-care factors. Some authors argue that this gap is mainly explained by the weaknesses of the care system (Berridge, 2007), while others defend that it is mainly related to the characteristics of children's family environments (Jackson, 2007). These contradictory positions, along with the lack of longitudinal data on the individual characteristics underlying poor academic performance in children in residential care, outline the relevance of understanding the factors associated with their academic performance. Importantly, the strength of the relationship between living in residential care and poor academic performance appears to decrease as other factors, such as cognitive flexibility and temperament, are considered (Vinet & Zhedanov, 2011).

The effect of cognitive flexibility on academic performance

Cognitive abilities are widely recognized as a determinant factor in the quality of learning (Alves et al., 2017; G. Lemos et al., 2018; Spinath et al., 2006; Sternberg et al., 2001; Strenze, 2007) and academic performance (Calvin et al., 2017) in both nonclinical and at-risk populations (Peng et al., 2018). Children use cognitive abilities, particularly cognitive flexibility, to learn academic skills and perform academic tasks (Evans & Stanovich, 2013; Peng et al., 2018; Peng & Kievit, 2020). Cognitive flexibility refers to a set of competencies related to abilities such as cognitive shifting and task switching that acts as a form of "meta-control" (Goschke, 2003; Hommel, 2015). It allows children to change goals and tasks according to the rules (Braem & Egner, 2018). In the academic sphere, cognitive flexibility helps children learn abstract concepts, as well as to regulate their emotions and behaviour, while participating in classwork, which leads children with increased cognitive performance to achieve greater academic results (Nesayan et al., 2019). It is as a strong predictor for reading abilities, namely reading comprehension and word reading (Cartwright et al., 2017; Colé et al., 2014) as well as mathematics achievement (Stad et al., 2018) in school-aged children.

Difficulties in cognitive flexibility among children in care are widely documented, as they continue exhibiting severe cognitive difficulties long after they have been removed from their birth families (Cowell et al., 2015; Rutter et al., 2010). They tend to score significantly below the norms on standardized tests assessing cognitive functioning and academic performance, as cognitive difficulties tend to have a negative effect

on academic performance (Crozier & Barth, 2005). In accordance, childhood abuse and neglect often impair cognitive flexibility abilities, which then negatively impacts academic performance (Spann et al., 2012).

The effect of temperament on academic performance

Temperament refers to individual differences in personality of the infant and young children, such as reactivity and self-regulation, which are related to maturity and experience (MacNeill & Pérez-Edgar, 2020; Rothbart, 1981). In the current study, the dimensions of temperament proposed by McClowry (1995) were considered: negative reactivity (also defined as emotionality), task persistence, approach/withdrawal (also defined as sociability), and activity. According to McClowry (1995), these are the four temperament dimensions that appear in a more consistent way in this research field. Furthermore, these dimensions concern specifically school-age children, contrary to most temperament models which refer to infancy and toddlerhood (Goldsmith et al., 1987; Mcdevitt & Carey, 1978), and, at this age, temperament impacts children's social interactions, as well as their adjustment to family and school environment (McClowry, 1995; Nasvytienė & Lazdauskas, 2021; Rothbart & Jones, 1998)

Negative reactivity reflects the frequency and intensity children express negative affections. Task persistence indicates children's self-direction and involvement while performing a task or other responsibilities. Approach/withdrawal refers to the initial response of children when dealing with unknown people or new situations. Lastly, activity is associated with the level of motor movement (Augustine et al., 2017).

The association between temperament and academic performance is well documented (Al-Hendawi, 2013; Chong et al., 2019), and the dimensions of temperament seem to unequally contribute to explain children's academic performance.

Specifically, increased levels of negative reactivity had been significantly related to poor academic achievement (Blair & Razza, 2007; Hintsanen et al., 2012; Valiente et al., 2008; Zhou et al., 2010), while the role of positive emotionality is still unclear (Ato et al., 2020). A longitudinal study found that temperamental negative emotional reactivity (e.g., anger) assessed at age 2 was negatively associated with children's social skills at age 7, which, in turn, were positively associated with academic performance and negatively associated with school problems at age 10 (Dollar et al., 2018). The authors also reported that

temperamental positive emotional reactivity was not associated with children's social skills or academic performance. In line with these results, a meta-analysis performed by Nasvytienė and Lazdauskas (2021) shows that there is an inverse relationship of negative affectivity with children's academic performance.

Task persistence is another temperament dimension playing a significant role on academic performance (Lima et al., 2010; McClowry, 1995). It is related to effort and determination when dealing with challenges (Skinner et al., 2008; Tiina & Jari-Erik, 2000; Yen et al., 2004; X. Zhang et al., 2011). Task persistence was positively associated with children's reading skills (Mägi et al., 2018) and mathematics performance (Töeväli & Kikas, 2017), while the lack of persistence was associated with poorer academic performance (Al-Hendawi, 2013). Importantly, task persistence was found to be a strong longitudinal mediator for academic performance and educational attainment in children living in poverty (Whipple & Evans, 2016).

Regarding the approach/withdrawal dimension, social withdrawal (i.e., less sociability) is associated with decreased academic performance (Stenseng et al., 2022). Indeed, reserved behaviour (e.g., low engagement) in the classroom tends to have a detrimental effect on learning and academic performance, as academic success requires classroom participation, collective proficiency and adjusted social responses (Eisenberg et al., 1998). In this same line, Hall et al. (2016) found that higher levels of social withdrawal in kindergarten predicted lower reading abilities at the second grade in primary school, when controlling for kindergarten literacy. Hence, building positive social bonds is associated with positive educational outcomes, namely with academic performance (Korpershoek et al., 2020).

With regard to activity, evidence supports the existence of a positive association between increased motor proficiency (i.e., the ability to modulate motor activity levels according to the environmental demands) and academic performance (C. Cameron et al., 2016), as fine motor skills are positively associated with academic performance in mathematics and reading, particularly during the early years of school (Macdonald et al., 2018). Of note, motor abilities are associated with a range of academic skills, which include decoding letters and words, solving quantitative problems and writing (C. Cameron et al., 2016). A study found that the implementation of motor activity programs lead to improvements in academic performance in children attending primary school (Valentini & Galli, 2018). In contrast, weak motor skills

are associated with poorer academic outcomes (Murrah, 2010).

The current study

Despite the evidence on the association between cognitive and temperament factors with academic performance, the mediating role of these factors as longitudinal predictors of academic performance in school-age children is far from clear (Nasvytienė & Lazdauskas, 2021). Also, research outlining the role of cognitive and temperament factors related to academic performance in children in care is still scarce. Initially, this study objectives were twofold: to investigate the longitudinal prediction of cognitive flexibility on academic performance, and to explore between-groups differences. Children's cognitive measures were collected. A year later, we recognize the importance of children's temperament on academic performance. Hence, at the second data collection time point, temperament and academic performance were assessed. The design of this study thus motivated a mediating research question: for temporal reasons, cognition was a possible predictor of both temperament and academic performance. In addition, academic performance was the main outcome of the study. Therefore, we examined whether temperament could be an intermediate variable in this process.

We expect children in care to present lower scores in cognitive flexibility, task persistence, approach/withdrawal, and academic performance measures, along with higher scores in negative reactivity and activity, compared to children from the community sample. We also hypothesize that increased cognitive flexibility, task persistence, and approach/withdrawal, as well as lower activity positively predicts academic performance, and that higher negative reactivity predicts poorer academic performance, in both groups. Additionally, greater lengths of institutionalization are expected to negatively affect academic performance.

Materials and methods

Participants

Participants in this study were described elsewhere (see Sousa et al., 2021). Fifty children in care and 50 children from a community sample were recruited to participate. From these, 46 in-care (22 boys) and 48 children from a community sample (23 boys), matched in age and sex (Table 1), were enrolled. Four in-care children were excluded, as they were adopted or returned to their birth families. Two children from the

Table 1. Descriptive statistics and between-group differences.

	In-care Group ($N_i = 46$)	Community Sample ($N_c = 48$)	Between-group differences Estimate		
			All ($N = 94$)	Girls ($N_g = 49$)	Boys ($N_b = 45$)
	<i>Freq./M (SD)</i>	<i>Freq./M (SD)</i>			
Sex (Female)	24	25	.004		
Age	7.56 (.92)	7.60 (.94)	.005	-.02	.03
Type of Maltreatment (Negligence)	22	0			
Length of Institutionalization (>15 months)	25				
<i>Cognitive flexibility (Time 1)</i>					
RCPM-B	4.35 (2.49)	5.79 (2.43)	.29**	.20	.38*
<i>Temperament dimensions (Time 2)</i>					
Negative reactivity	2.48 (.85)	2.15 (.82)	-.14*	-.23*	-.06
Task persistence	3.44 (.93)	3.63 (1.00)	.06	.12	-.01
Approach/Withdrawal	3.37 (.76)	3.38 (.81)	.004	.03	-.03
Activity	2.42 (.76)	2.15 (.91)	-.12	-.17	-.08
<i>Academic performance (Time 2)</i>					
Global performance	2.83 (.95)	2.94 (.91)	.04	.09	-.01
Portuguese performance	5.61 (1.88)	5.77 (1.64)	.03	.05	.003
Mathematics performance	5.50 (1.93)	5.83 (1.93)	.06	.05	.06
Intellectual functioning	2.91 (1.02)	3.08 (.79)	.06	.10	.01

Abbreviations: *M* = Mean, *SD* = Standard deviation, *Freq.* = Frequency, *N* = sample size, N_i = Number of children in the In-care group, N_c = Number of children in the Control group, N_g = Number of girls in the whole sample, N_b = Number of boys in the whole sample. Between-group differences were conducted through regression modelling, using a suitable distribution for each variable: for binary data (sex) we used a binomial distribution, for positive discrete data (age, cognitive RCPM-B scale, and academic performance) we used the CMP distribution, and for general positive continuous data (temperament subscales) we used the Tweedie family of distributions. Significance: * $p < .05$, ** $p < .01$.

community sample were excluded, because they changed to another school or parents did not give consent to their participation.

Children in care were removed from their biological families to residential care due to Court order, following the referral by the Child Protective Services, after suffering abuse or neglect. More precisely, 22 suffered negligence (48%), and 17 were subjected to physical and emotional/psychological maltreatment and negligence (37%) (no information was available for 7 children). Children were selected from a list provided from the Ministry of Social Affairs concerning the Portuguese residential care institutions. Twenty-five children (54%) were living in residential care for more than one year and 18 (39%) for less than one year (no information was available for three children).

Children from the community sample were recruited at seven public schools in the north of Portugal (Porto metropolitan area). All of them lived with their birth families and did not experience abuse or neglect or presented developmental delays.

Measures

Socio-demographic information

A questionnaire was used to collect information on the children and families' demographics. It allowed to obtain information on the institutionalization process, contacts with the biological family, social support network and children's medical history (illness/physical problems). The elementary school teacher and the

main caretakers of the institutions completed the questionnaire, respectively for the in-care and community sample groups.

Cognitive flexibility

Children's cognitive flexibility was assessed using the Raven's Colored Progressive Matrices (RCPM) (Raven et al., 1998; Simões, 1995). It measures intellectual functioning in children aged between 5 and 11 years. The RCPM is composed of 36 non-verbal items organized in three sets of 12 items, composing the series RCPM-A, RCPM-Ab and RCPM-B. For each item, children were asked to choose, from six possibilities, the one that correctly completed the image presented. The total RCPM score is obtained by summing the scores from the series RCPM-A, RCPM-Ab and RCPM-B (maximum 36 points). Each series measures distinct intellectual abilities: the RCPM-A the ability to identify sameness, the RCPM-Ab visuo-perceptual competencies and the RCPM-B analogical and conceptual thinking (Ambra et al., 2016). Only the RCPM-B is considered to reflecting cognitive flexibility and problem-solving abilities, which are commonly associated with learning and academic performance (Magalhães et al., 2020; Ropovik, 2014). Cronbach's alpha yielded good consistency results for all RCPM series (RCPM-A $\alpha = .82$; RCPM-Ab $\alpha = .87$; RCPM-B $\alpha = .87$). Other studies also showed that the RCPM has a good inter-item consistency and split-half reliability across age levels (Cotton et al., 2005; Simões, 1995), supporting that the factors concerning the three series can be used as a means of

screening children's cognitive developmental stage (Muniz et al., 2016).

For the purpose of this study, only the RCMP-B score was considered. Evidence alerts to the use of all items of the RCPM (Fajgelj et al., 2010), as some of them are extremely easy, a fact that may lead to ceiling effects, jeopardizing the measurement of the test. In this sense, we investigated possible ceiling effects in the three series. According to Uttl (2005) ceiling effects occur "when a substantial proportion of individuals obtain either maximum or near-maximum scores and cannot demonstrate the true extent of their abilities, resulting in score distributions that are compressed at the upper end of performance" (p. 460). We used the guidelines described by the author to examine the existence of ceiling effects. He suggests that significant ceiling effects occur when the standardized difference [(Maximum – Mean)/SD] is approximately 2 or smaller. Significant ceiling effects were found for RCPM-A (1.9) and for RCPM-Ab (1.8); no evidence of a ceiling effect was found for the RCPM-B (2.8), commonly recognized as the most difficult set (Uttl, 2005).

Temperament

Children's temperament was assessed using the Portuguese version of School-Age Temperament Inventory (SATI) (Lima et al., 2010; McClowry, 1995). SATI assesses temperament dimensions in children aged between 8 and 11 years. It comprises 38 items, measured on a 5-point Likert scale (1 = *never* to 5 = *always*). Four subscales derive from it: negative reactivity, task persistence, approach/withdrawal, and activity. The total score of each subscale is obtained by summing the points in each item and dividing it by the total number of items pertaining to each subscale. Cronbach's alpha yielded high consistency results for all subscales (negative reactivity $\alpha = .96$; task persistence $\alpha = .97$; approach/withdrawal $\alpha = .88$, and activity $\alpha = .88$). However, the total scale score did not yield acceptable reliability (.62) and thus, it was not considered in this work. Studies on the psychometric properties of the SATI original version provided additional support for its reliability and validity (Lima et al., 2010; McClowry, 1995; McClowry et al., 2003).

Academic performance

To assess children's academic performance, Competence Academic Scale (CAS) of the Portuguese version of the Social Skills Rating System – Teacher Form (SSRS-T) (Gresham et al., 1990; M. S. D. Lemos & Meneses, 2002) was used. SSRS-T assesses social behaviours of children and adolescents aged between 3 and 18 years old. It consists of three scales: Social

Skills Scale, Problems Behavior Scale and Academic Competence Scale. For the purpose of this study, only the Academic Competence scale was considered. It includes six items assessed in a 5-point Likert scale (1 = *worse than average* to 5 = *better than average*) concerning global academic performance (when compared to peers), intellectual performance (when compared to peers), mathematical competencies (considering what might be expected at the child's school level), performance in mathematics (when compared to peers), competencies in reading/Portuguese language (when compared to peers) and performance in reading/Portuguese language (considering what might be expected at the child's school grade). The subscales mathematical competencies and performance in mathematics were summed, as well the subscales competencies in reading/Portuguese language and performance in reading/Portuguese language, to obtain the total performance in mathematics and in reading/Portuguese, respectively. Cronbach's alpha yielded excellent consistency results for the academic competence scale ($\alpha = .97$). Other studies also support the SSRS-T internal consistency (Clark et al., 1985; Gresham et al., 1987a) and construct validity (Elliott et al., 1988; Gresham et al., 1987b; M. S. D. Lemos & Meneses, 2002).

Procedure

This study was reviewed and approved by the Ethics Committee where it was conducted. The procedures regarding this study are similar to another study from the research team and are described elsewhere (see Sousa et al., 2021). Importantly, in-care children and the community sample children's parents provided written informed consent for the children's participation, in accordance with the Declaration of Helsinki. While for children in care, caregivers answered the questionnaires, for the community sample children, teachers did it. As explained elsewhere (Sousa et al., 2021), caregivers answered the questionnaires for the children in care, because of two main reasons: 1) children's families were not available, and 2) the contact with children's teachers depended on the institution caregiver contact, which was not always feasible. Because of this, for the community sample children, teachers were asked to fill in the questionnaires, foreseeing an attempt to standardize the informants across groups.

In the first assessment (Time 1), children were assessed with the RCPM, lasting approximately 15/20 minutes. One year later (Time 2), institutions and schools were again contacted, and caregivers and

teachers were asked to answer the SATI and the CAS. Completing the questionnaires lasted 10/15 minutes each time.

Statistical analyses

A deadline for data collection and the minimum sample size were defined, when designing this study. More precisely, we intended to recruit as many participants as possible within the established period and, at the end of that period, we would only proceed with the data collection if the number of participants was greater than, or equal to, the minimum sample size defined.

The minimum sample size was defined as the number necessary to ensure sufficient power to detect, at least, large effect sizes. This number was estimated using the R package WebPower (Z. Zhang et al., 2018). As data would be analysed through linear models, a regression effect power analysis was conducted, selecting with 80% of power, 5% of type I error probability, and a large effect size $f^2 = 0.35$ (Cohen, 1988). This analysis showed that a minimum of 25 subjects in each group was required to proceed with the study. It is worth noting that, using similar conditions, a minimum of 50 subjects in each group would provide enough power to detect medium effect sizes.

Statistical analyses were performed using R statistical environment (R Studio, version 3.6.2, R Development Core Team, 2019), through the following packages: glmmTMB (Brooks et al., 2017), lavaan (Rosseel, 2012), and semTools (Pornprasertmanit et al., 2013). We investigated all possible mediator effects of the temperament in the relationship between cognitive flexibility and academic performance. Before proceeding with further analysis, to obtain standardized path coefficients, all continuous variables were standardized and centred. Bootstrapped standard errors have been computed (Hancock & Liu, 2012; Shrout & Bolger, 2002). After obtaining the mediation model, further analysis was conducted to investigate whether the mediation effect was moderated by group, that is, whether the previous mediation effect was significantly different for the two groups.

The significance level was set at $\alpha = .05$. Descriptive statistics were performed. Between-group comparisons regarding sex, age, and cognitive, temperament and academic performance measures were conducted using regression modelling with the most suitable distribution for each variable – a binomial distribution for binary data (sex), Conway-Maxwell-Poisson (CMP) distribution for positive discrete data (age, cognitive flexibility and academic performance),

the Tweedie family of distributions for general positive continuous data (temperament subscales). Correlation analysis was conducted to investigate the association between variables. CMP regression modelling was performed to analyse the predictor effect of sociodemographic data (sex and age), cognitive and temperament measures on children's academic performance. Additionally, the type of maltreatment (negligence; physical and emotional/psychological maltreatment and negligence) and length of institutionalization (less than 15 months: $N = 18$; or more than 15 months: $N = 25$; cut-off defined according to Tottenham et al. (2010) – see Table 1) were investigated as predictors for the in-care group. For the cognitive and temperament variables, this analysis was separated by group. Each predictor was analysed separately.

Results

Cognitive flexibility, temperament, and academic performance

Between-group comparisons are depicted in Table 1. In-care children and the community children significantly differed in cognitive flexibility (assessed in Time 1), with community sample children scoring higher than in-care children in the RCPM-B. Between-sex comparisons indicated that community sample boys outperformed in-care boys. No significant differences were observed between girls regarding cognitive flexibility.

Concerning temperament (assessed in Time 2), in-care children presented greater negative reactivity than community sample children. Particularly, in-care girls presented greater negative reactivity than community sample girls. No significant differences were observed in the other temperament subscales, nor between boys.

Association between cognitive flexibility, temperament, and academic performance

Table 2 shows the correlation matrix between cognitive flexibility, temperament, and academic performance.

Significant associations were observed between the temperament subscales and the academic performance subscales as well. The RCPM-B was a significant longitudinal predictor of children's academic performance and the following temperament dimensions: task persistence, negative reactivity, and activity. Of note, significant positive associations were

Table 2. Correlations between the main variables of the study.

	1	2	3	4	5	6	7	8	9	10
1. Age (Time 1)	1									
2. RCMP-B (Time 1)	.18	1								
3. Task Persistence (Time 2)	.06	.34**	1							
4. Activity (Time 2)	.01	-.26**	-.34**	1						
5. Negative reactivity (Time 2)	-.08	-.28**	-.59***	.55***	1					
6. Approach/withdrawal (Time 2)	.02	.02	.17	.12	-.15	1				
7. Global academic performance (Time 2)	.01	.33**	.59***	-.08	-.28**	.18	1			
8. Performance in Portuguese (Time 2)	-.01	.30**	.59***	-.13	-.33**	.15	.89***	1		
9. Performance in mathematics (Time 2)	-.01	.36***	.60***	-.07	-.34**	.12	.89***	.85***	1	
10. Intellectual performance (Time 2)	.03	.35***	.55***	-.09	-.33**	.09	.85***	.81***	.83***	1

Significance: ** $p < .01$., *** $p < .001$.

observed between temperament dimension task persistence and all academic performance subscales.

Predictors of academic performance

The effect of cognitive flexibility and temperament dimensions as predictors of academic performance are presented in Table 3.

Cognitive flexibility predicted all academic performance outcomes but only for children in care, as no significant effects were observed for the community sample group.

Regarding temperament, negative reactivity predicted poorer global performance, reading Portuguese language and mathematics performance in the community sample children. For children in care, negative reactivity predicted poorer mathematics and intellectual functioning. Task persistence was positively predicting all academic performance outcomes in both groups. No significant effects were obtained for activity and approach/withdrawal for in-care children. For the community sample, approach/withdrawal was positively predicting mathematics outcomes.

For children in care, the length of institutionalization (>15 months) was negatively affecting mathematics and intellectual functioning outcomes of academic performance. No significant effects were observed between type of maltreatment and academic performance.

Moderated mediation model

As explained above, the relationship between cognitive flexibility and academic performance was further examined by analysing the mediation of the temperament dimensions. Among the four dimensions, a unique significant mediator effect was observed: task persistence mediated the relationship between cognitive flexibility and all academic performance outcomes (Figure 1), for the whole sample.

This mediation model was further investigated, dividing the sample into groups (in-care and community sample). More precisely, we questioned whether this effect persisted in each group separately. The answer to this question was positive, that is, it was observed a significant indirect effect

Table 3. Predictor effects on academic performance.

Academic Performance (Time 2)	Length of institutionalization (>15 months)	Group	RCMP-B (Time 1)	Temperament dimensions (Time 2)			
				Negative reactivity	Activity	Task Persistence	Approach/withdrawal
Global performance	-.08	In-care	.06**	-.09	.01	.22***	.04
		Community sample	.03	-.13*	-.05	.19***	.10
Portuguese performance	-.09	In-care	.05**	-.11	-.01	.23***	.07
		Community sample	.02	-.14**	-.07	.17***	.05
Mathematics performance	-.17*	In-care	.06**	-.14*	-.02	.25***	-.04
		Community sample	.03	-.15*	-.02	.20***	.12*
Intellectual functioning	-.15*	In-care	.06**	-.16**	-.06	.24***	.02
		Community sample	.02	-.08	-.01	.13***	.05

Age, Sex, and Type of maltreatment (children that suffered from negligence or from physical and emotional/psychological maltreatment and negligence) did not show significant effects (in any case). Thus, for simplification, these variables are not shown in this table. **Predictor effects were assessed using Conway-Maxwell Poisson regressions with a unique predictor.** Significance: * $p < .05$, ** $p < .01$., *** $p < .001$.

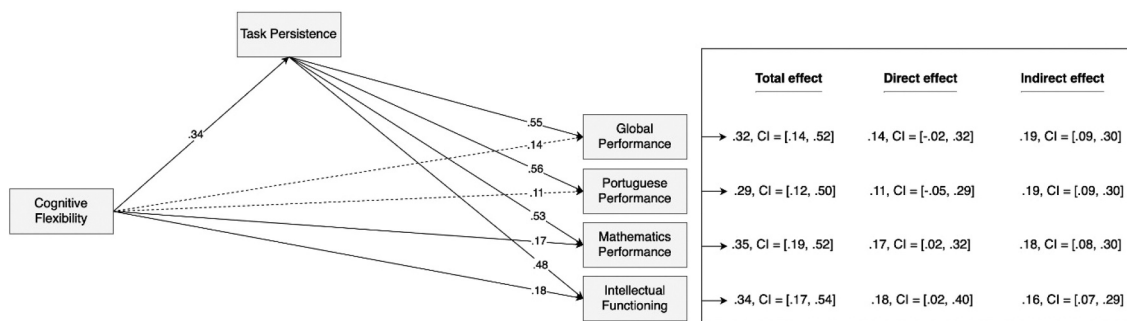


Figure 1. The mediating role of temperament dimension task persistence in the relationship between cognitive flexibility and academic performance.

Note. Each rectangle denotes an observed variable (factor score). All endogenous variables are associated with errors which, for the sake of simplicity, are not shown in this figure. Arrows represent relationships and the attached values are the unstandardized path coefficients. All lines are significant, except the dashed ones. Significance was assessed through the 95% bootstrap confidence interval (CI): intervals that do not include zero indicate significant values. The total effect is the sum of the direct and indirect effects.

of cognitive flexibility on academic performance through task persistence, in both groups. Then, we asked whether the mediation effect was significantly different across groups. The answer to this question was also positive, as in addition to the mediation effect observed in both groups, a direct effect was also found in the in-care group. Therefore, in the in-care group, cognitive flexibility affected academic performance in two different ways: directly and indirectly, through task persistence. In the community sample group, only the indirect effect mediated by task persistence was observed. The corresponding moderated mediation model is schematically outlined in Figure 2.

Discussion

The present study examined, longitudinally, the effect of cognitive and temperament factors on academic performance and how they may be differently contributing to academic performance, in a Portuguese sample of children in care and children from a community sample. Furthermore, the mediating role of temperament in the relationship between cognition and academic performance was investigated.

Overall, three key aspects must be highlighted: i) cognitive flexibility, temperament, and academic performance differed according to the children’s group (i.e., in care and community sample children) and gender; ii) temperament dimensions had a differential

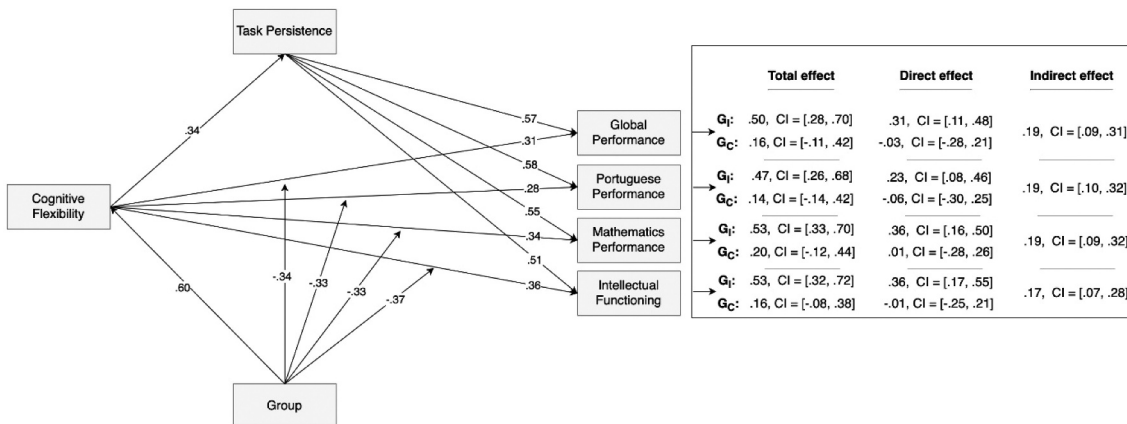


Figure 2. Conceptual form of the moderator mediation model.

Note. G_I denotes the In-care Group and G_C denotes the Control Group. Each rectangle denotes an observed variable (factor score). All endogenous variables are associated with errors which, for the sake of simplicity, are not shown in this figure. Arrows between variables represent relationships and the attached values are the (standardized) path coefficients. Arrows targeting relationships represent moderator effects and, in each case, the attached value is the direct effect of the interaction term (Group x Cognitive flexibility) on the corresponding academic performance. All lines are significant, except the dashed one. Significance was assessed through the 95% bootstrap confidence interval (CI): intervals that do not include zero indicate significant values. The total effect is the sum of the direct and indirect effects.

predictive effect on academic performance in both groups, and iii) the mediator effect of task persistence between cognitive flexibility and academic performance is different in each group.

Differences in cognitive flexibility, temperament, and academic performance

As expected, children from the community sample exhibited increased cognitive flexibility compared to children in care, and community sample boys showed more cognitive flexibility than in-care boys. These are in line with numerous evidence showing that cognitive difficulties are common among children in care when compared to children living with their biological families (Cowell et al., 2015; Rutter et al., 2010).

Additionally, children in care showed greater negative reactivity than children from the community sample. Difficulties in emotion regulation in children living in residential care are well documented, as their adverse family experiences are strongly associated with increased emotional dysregulation, often leading to socioemotional adjustment problems (Eisenberg et al., 2001, 2010; Rutter et al., 2010; Sousa et al., 2021). In addition, in-care girls presented greater negative reactivity than community sample girls, while no significant differences were observed in the other temperament subscales, nor between boys. Research shows that, compared to girls, boys tend to present higher levels of arousal, in infancy, and less inhibitory control, in early childhood (Brody, 1999; Chaplin, 2015). This may be related to cultural beliefs on children's gender differences in emotion expression, as girls are often expected to show cheeriness or sadness, whereas boys are expected to be stronger and calmer, showing anger, if necessary (Chaplin & Aldao, 2013). This may explain why institutional caregivers may have perceived dysregulated emotional reactions as atypical and disruptive in girls.

No group differences were observed in academic performance. Possibly, the relationship between institutionalization and academic performance is affected by other variables playing a significant role in this association, such as cognitive flexibility (Cartwright et al., 2017; Colé et al., 2014) and temperament (Galián et al., 2018), which may help children deal in a more effective way with learning and school tasks. Another possible explanation may be the potential protective effect of residential care, as some studies highlight the positive effects of residential settings on children's developmental outcomes (Knorth et al., 2008; Little et al., 2005; Perry et al., 2019; Wendt et al., 2019). If children establish secure and stable

relationships in the institutions, they will possibly develop resilience strategies which help them cope with academic challenges and demands, thus having a potential positive impact on their academic performance.

Predictors of academic performance

For children in care, cognitive flexibility predicted all academic performance outcomes. This result suggests that cognitive flexibility plays a significant role in children's learning and academic performance (Nesayan et al., 2019), affecting reading abilities, namely reading comprehension, word reading (Cartwright et al., 2017; Colé et al., 2014), as well as mathematics achievement (Stad et al., 2018).

As for temperament, negative reactivity negatively predicted global academic performance, reading/Portuguese language, and mathematics performance in children from the community sample. For children in care, negative reactivity predicted poorer mathematics and intellectual functioning outcomes. These results are consistent with studies showing that negative emotion reactivity has an adverse effect on academic performance (Dollár et al., 2018). Contrarily, task persistence positively predicted all academic performance outcomes in both groups, which is in accordance with other evidence showing a positive association between this temperament dimension and children's reading skills (Mägi et al., 2018) and mathematics performance (Tõeväli & Kikas, 2017). This is in line with research showing that the degree of children's self-direction, while performing school tasks, seems to help them keep focused and goal-oriented (Lima et al., 2010; McClowry, 1995), and deal with academic difficulties and challenges (Skinner et al., 2008; Tiina & Jari-Erik, 2000; Yen et al., 2004; X. Zhang et al., 2011).

In children from the community sample, approach/withdrawal positively predicted mathematics outcomes. Children's withdrawal is possibly linked to increased levels of self-control, as well as lower levels of impulsive behaviours, which seems to impact academic performance (Herman et al., 2018). Thus, increased sustained attention and self-regulation may have helped children deal with school challenges, particularly those associated with mathematics tasks, which tend to be highly complex and structured (Duckworth et al., 2019).

Activity was not a significant predictor of academic performance. Other evidence shows a positive association between motor proficiency and academic performance (C. Cameron et al., 2016; Macdonald et al., 2018) and that weak motor skills are associated with poorer academic outcomes (Murrah, 2010). Nevertheless, our results may be explained by how the level of motor

activity is defined according to the McClowry's temperament model (1995), as this dimension reflects the child's proneness to motor activity (Lima et al., 2010), which may not be linearly associated with adjusted or maladaptive developmental outcomes.

For children in care, greater lengths of institutionalization negatively affected mathematics and intellectual functioning outcomes of academic performance. It appears that prolonged times of institutionalization negatively affects academic performance, as higher rates of poor academic performance (Berridge, 2007; Goddard, 2000; Vinet & Zhedanov, 2011), attainment in reading, writing and mathematics (Connelly & Chakrabarti, 2008; Forrester et al., 2009) have been reported in children with longer lengths of residential care. This is in accordance with other findings showing that the length of institutionalization is associated with greater socioemotional adjustment problems, in that prolonged periods of institutional rearing are associated with poorer developmental outcomes (Sousa et al., 2021; Tottenham et al., 2010).

Moderated mediation model

Task persistence mediated the relationship between cognitive flexibility and all academic performance outcomes. That is, increased cognitive flexibility promoted greater task persistence one year later, which in turn improved academic performance, in the whole sample. These results emphasize the importance of children's task persistence, when dealing with classroom tasks. The degree of children's self-direction, while performing specific tasks or assuming responsibilities (Lima et al., 2010; McClowry, 1995), the effort and determination when dealing with challenges (Skinner et al., 2008; Tiina & Jari-Erik, 2000; Yen et al., 2004; X. Zhang et al., 2011) seem to play a significant role on successful academic performance (Al-Hendawi, 2013; Mägi et al., 2018; Töeväli & Kikas, 2017; Whipple & Evans, 2016).

Importantly, the mediator effect of task persistence between cognitive flexibility and academic performance was different between groups. In children living in institutions, in addition to the mediation effect, a significant direct effect of cognitive flexibility on academic performance was observed. In the community sample group, this direct effect was not observed, which means that cognitive flexibility affected academic performance only indirectly (i.e., only when task persistence was considered as mediator). This seems to indicate that, for children in care, cognitive flexibility is possibly more important to successful academic performance than for children from the community sample. Cognitive flexibility may act as a protective factor for children in care, as it probably

promotes their resilience and socioemotional adjustment (Harpur et al., 2015; Khambati et al., 2018). This may be occurring, because children in care use cognitive flexibility to improve self-direction and effort, while performing academic tasks.

Besides, the differential role of cognitive flexibility in academic performance between in care children and children living with their biological families may help to further understand the specific characteristics of in care children's developmental pathways. It is possible that cognitive flexibility has a differential expression in children in care, as they seem to use their cognitive abilities in a specific way to improve their academic performance (Holmes et al., 2018; Slade & Wissow, 2007). Cognitive flexibility is closely linked to the abstract reasoning and the executive functions (i.e., the conscious control of action and thought) (Bennett & Müller, 2010) that seems crucial for academic success (Feng et al., 2020), such as mathematics (Markovits & Doyon, 2011). Therefore, children with higher levels of cognitive flexibility may perform better in tasks requiring these abilities, which, in turn, positively impacts their learning and academic performance.

This study adds to other evidence providing some clues related to intervention with children living in residential care, as for these children cognitive flexibility seems to play a significant role in academic performance. The practical and social implications are highlighted, as it is important to develop interventions focused on the promotion of cognitive abilities, mainly those related to learning and academic success, such as cognitive flexibility, abstract reasoning, and executive functions. As cognitive competencies are closely linked to temperament dimensions, such as task persistence, promoting these will possibly have positive effects on in-care children's academic outcomes.

Some research support the protective effect of residential care (Knorth et al., 2008; Little et al., 2005; Perry et al., 2019; Wendt et al., 2019), mostly when specific interventions, such as specific care programs or provisional services, are implemented (R. J. Cameron & Das, 2019; Cox et al., 2018; Grey et al., 2018; Liddle et al., 2018; Marvin et al., 2017; Sinclair et al., 2016). Training programs, along with structural changes in care environment, are associated with children's positive developmental outcomes, namely in the cognitive dimension (Chernego et al., 2018; Hermenau et al., 2017). Hence, helping children establishing secure relationships, by promoting changes in the institutions so that they become a pleasant, stimulating, and safe environment, will possibly help children improve their self-regulation and cognitive abilities and, as consequence, their academic performance.

Limitations and future studies

The reduced number of children enrolled in each group is a limitation of this study. Future studies should consider a larger sample to confirm these findings and to analyse the effect of different types of maltreatment. In addition, it will be relevant to consider the same informants for both groups, as the choice of distinct informants can lead to a bias in the analysis of perceptions on the child's behaviour. To include qualitative measures, such as observation and interviews with the institutional caregivers and the teachers will also be useful to further understand the expression of temperament dimensions and their specific effects on academic performance. In addition, it would be important to study the mediation of task persistence in the relationship between cognitive flexibility and academic performance, comparing in-care and children from the community sample, as they get older, as the academic tasks become increasingly more challenging.

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Consent to participate

Informed consent was obtained guaranteeing confidentiality, anonymity, and the right to not participate or discontinue participation in the study.

Data availability statement

The data that support the findings of this study is available upon request to the corresponding author. The data is not publicly available due to privacy or ethical restrictions.

Ethics approval

The study was approved by the ethical board of the Faculty of Psychology and Sciences of Education of the University of Porto. The approval is not numbered.

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