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ORIGINAL RESEARCH

Comparing Executive Functioning in the School Readiness of Hungarian and Kenyan Preschoolers

Stephen Amukune[1,3] · **Gabriella Józsa**[2] · **Krisztián Józsa**[1,4]

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Abstract

Cross-national comparisons represent an avenue for investigating milestones achieved by one region that can help improve standards in another country. This study compares the development of executive functioning in Hungarian and Kenyan preschoolers as they prepare for school readiness. The study's cross-sectional design entailed sampling preschoolers from Hungary ($n=187$) and Kenya ($n=420$) aged between 4 and 8 years nested in 35 classrooms. Preschool class teachers rated the children's executive functioning using the Childhood Executive Functioning Inventory (CHEXI). The two-factor structure of the CHEXI demonstrated a strong measurement invariance for the two countries, Hungary and Kenya. Significant gender differences were noted on both subscales in the Hungarian sample but not in the Kenyan preschoolers. Additionally, no differences were found in the executive functioning of boys from both countries. However, the girls exhibited variances in the inhibition subscale. Contrary to expectations, no linear mixed effects were observed for country or the interactions between age and country apropos difficulties related to inhibition and total executive functioning except for working memory. Better working memory skills noted in the Hungarian sample were attributed to a superior preschool education system.

Keywords Executive Function · CHEXI · School Readiness · Hungary · Kenya

Résumé

Las comparaciones entre países representan una vía para investigar hitos logrados por una región que pueden ayudar a mejorar los estándares en otro país. Este estudio

✉ Stephen Amukune
amukune.stephen@edu.u-szeged.hu

[1] Institute of Education, University of Szeged, 30–34 Petőfi Avenue, Szeged 6722, Hungary

[2] MTA-MATE Early Childhood Research Group, Kaposvár, Hungary

[3] School of Education, Pwani University, Kilifi, Kenya

[4] Institute of Education, Hungarian University of Agriculture and Life Sciences, Kaposvár, Hungary

compara el desarrollo del funcionamiento ejecutivo en preescolares húngaros y kenianos mientras se preparan para la preparación escolar. El diseño transversal del estudio implicó el muestreo de niños en edad preescolar de Hungría (n = 187) y Kenia (n = 420) con edades entre 4 y 8 años anidados en 35 aulas. Los maestros de la clase de preescolar calificaron el funcionamiento ejecutivo de los niños usando la Prueba de funcionamiento ejecutivo infantil. Inventario (CHEXI). La estructura de dos factores del CHEXI demostró una fuerte invariancia de medición para los dos países, Hungría y Kenia. Se observaron diferencias de género significativas en ambas subescalas en la muestra húngara, pero no en los preescolares de Kenia . Además, no se encontraron diferencias en el funcionamiento ejecutivo de los niños de ambos países. Sin embargo, las niñas exhibieron variaciones en la subescala de inhibición. Contrariamente a lo esperado, no se observaron efectos mixtos lineales para el país o las interacciones entre la edad y el país a propósito de las dificultades relacionadas con la inhibición y el funcionamiento ejecutivo total, excepto para la memoria de trabajo. Las mejores habilidades de memoria de trabajo observadas en la muestra húngara se atribuyeron a un sistema de educación preescolar superior.

Resumen

Les comparaisons transnationales représentent un moyen d'étudier les jalons atteints par une région qui peuvent aider à améliorer les normes dans un autre pays. Cette étude compare le développement du fonctionnement exécutif chez les enfants d' âge préscolaire hongrois et kenyans alors qu'ils se préparent à la préparation à l'école. La conception transversale de l'étude impliquait un échantillonnage d'enfants d' âge préscolaire de Hongrie (n = 187) et du Kenya (n = 420) âgés de 4 à 8 ans répartis dans 35 salles de classe. Les enseignants de la classe préscolaire ont évalué le fonctionnement exécutif des enfants à l'aide du Childhood Executive Functioning Inventaire (CHEXI). La structure à deux facteurs du CHEXI a démontré une forte invariance de mesure pour les deux pays, la Hongrie et le Kenya. Des différences significatives entre les sexes ont été notées sur les deux sous-échelles dans l'échantillon hongrois, mais pas chez les enfants d'âge préscolaire kenyans . De plus, aucune différence n'a été trouvée dans le fonctionnement exécutif des garçons des deux pays. Cependant, les filles présentaient des variances dans la souséchelle d'inhibition. Contrairement aux attentes, aucun effet mixte linéaire n'a été observé pour le pays ou les interactions entre l'âge et le pays à propos des difficultés liées à l'inhibition et au fonctionnement exécutif total à l'exception de la mémoire de travail. Les meilleures compétences en mémoire de travail notées dans l' échantillon hongrois ont été attribuées à un système d'éducation préscolaire supérieur.

Introduction

UNESCO (2015) reports that over 550 million children live in low- and middle-income countries (LMIC) in conditions that threaten their health as well as their cognitive and behavioural development (Black et al., 2017; Willoughby et al., 2019). Executive function (EF) appears critical for evaluating the readiness of

children to transition from preschool to regular schooling. Some comparative studies have attended to cultural influences on EFs (Sabbagh et al., 2006; Schirmbeck et al., 2020; Tran et al., 2019). However, scant studies have compared countries in sub-Saharan Africa to European nations. Additionally, most cross-national comparisons have utilised performance-based measures of EF, such as the Stroop task, the Wisconsin Card Sorting Task, and the test of verbal fluency (Toplak et al., 2013). Unlike performance-based measures that assess EF abilities, the ratings used in the present study measure the utilisation of EF skills in schools or at home. Consequently, some authors have reported low correlations between behavioural ratings of EF and performance-based measures (e.g., Camerota, 2018; Catale et al., 2015; Giménez de la Peña et al., 2022Thorell et al.,2010). These reports signify that the two methods tap different cognitive levels, the algorithmic and the reflective. The algorithmic level focuses on numerous studies and concerns how the brain processes information or the degree of efficiency of individual cognitive abilities. The reflective level addresses the achievement of goals because of activities undertaken within a particular system and its associated beliefs (Toplak et al., 2013). The present study is motivated by the paucity of comparative studies attending to the application of EF ratings among preschoolers in different countries.

Executive Functions in Preschool Children

Executive function, also known as executive control, resource-demanding cognition or controlled cognition, is a "higher level" or "meta-" cognitive function that manages other more basic cognitive functions (Alvarez & Emory, 2006; Salthouse, 2007) and the regulation of emotions and attention (Bell & Deater-Deckard, 2007; Bell & Deater-Deckard, 2007; Blair & Diamond, 2008) necessary for purposeful and goal-directed behaviours. Researchers agree that EF has three components cognitive flexibility, working memory and Inhibition (Diamond & Ling, 2019). However, working memory and inhibition are the most common (Miyake et al., 2000).

EF can potentially bolster school readiness in children during their preschool years because EF skills: (1) Develops rapidly during this period; (2) are malleable; and (3) are linked with improved academic and socio-emotional outcomes (Mattera et al., 2021). Further, enhanced EF leads to the improved ability of learners to self-regulate and is associated with adaptive approaches to learning and social-emotional competencies (Blair, 2002; McClelland et al., 2006; Raver & Knitzer,2002). Researchers also agree that EF is essential for children for their successful transition to school (Blair & Razza, 2007; Barrett et al.,2017) and predicts academic achievement and successful adjustment in school (Cragg et al., 2017). Therefore, poor EF will undermine school readiness and success across higher grades (Sung & Wickrama2018).

EF emerges during the first years of life but continues to increase from childhood to adolescence. Children aged three to four years can successfully undertake inhibition tasks such as the Dimensional Change Card Sort (DCCS; Zelazo,2006), where the child is required to sort cards based on colour, size and shape depending on the changing rules. However, they cannot accomplish the day-night task (Carlson, 2005) because of the different response modalities of motor and verbal reactions (Diamond & Taylor, 1996). Inhibition improves between five and eight years (Romine & Reynolds, 2005). By age six, children are ready to use working memory sub-components to solve complex tasks even though their abilities to accomplish simple tasks such as remembering a route and challenging tasks such as complex span tasks develop linearly from age four to 14 (Gathercole et al., 2004). Both inhibition and working memory are prerequisites for accomplishing shifting tasks, which need the information to be mentally retained while the previous practised response is inhibited (Diamond, 2013; Miyake, 2000).

EF has been assessed in LMICs utilising laboratory-based measures despite the demands for behavioural ratings (Isquith et al., 2013; Camerota et al., 2018), which can ascertain EF over an extended period, encompass many participants, and are ecologically valid. The Behavioural Rating Inventory of Executive Functions (BRIEF-P; Gioia et al., 2000) are a widely used tool that includes items for assessing EF and Attention Deficit Hyperactivity Disorder (ADHD). It is also long, comprising 68 items, and costs USD 2 per administration. Apart from its deployment for research purposes, it is widely used to diagnose children at risk of developing ADHD in the future (Camerota et al., 2018; Thorell & Nyberg, 2008). Unlike the BRIEF-P, the Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008) is free to download in several languages and comprises 24 items directed only at EF assessment. Overall, the CHEXI represents a valuable screening tool for predicting academic difficulties in the classroom (Thorell et al., 2013) due to EF impairment, which is critical during the school readiness preparations that form the focus of this study. Moreover, the CHEXI has been validated in Hungary (Józsa & Józsa, 2020) and Kenya (Amukune & Józsa, 2021) to evaluate EF deficits. The factor structure of this instrument has also been replicated in other studies, for example, in the USA (Camerota et al., 2018), France (Catale et al., 2015) and Spain (Giménez de la Peña et al., 2022).

Cross-Regional Variations in the EF development of Preschoolers

Multiple factors explain the differences in EF development in cross-national comparisons of disparate cultures (Nesbitt et al., 2013). Tran et al. (2019) compared EF development among monolingual or bilingual children aged 3–4 years from different cultures in the USA, Argentina and Vietnam. Bilingualism had an effect on inhibition, selective attention, and switching, while culture was pronounced in behavioural response/regulation. In another study, Cook et al. (2019) compared children from a low socioeconomic status (SES) in South Africa to their peers from middle- and high-income strata in Australia and reported that the low SES sample performed better in two of the three assessed EF tasks. Cook and colleagues linked this difference

to routines and rituals in South African culture. Sabbagh et al. (2006) also reported that children from China outperformed their colleagues from the USA on several EF tasks. This result was associated with the Confucian philosophy prevalent in East Asian countries. Further, Chasiotis et al. (2006) observed that Costa Rican and German children performed better on EF tasks assessing conflict inhibition than their peers from Cameroon. This study cited maturation, parental expectations, and SES as some reasons for the notable differences.

Other scholars have found distinctions between countries based on CHEXI ratings. For example, Catale et al. (2015) reported that Belgian children exhibited more inhibitory problems than Swedish children aged between eight and 11 years. Similarly, Thorell et al. (2013) compared the EF of preschoolers in Sweden, Spain, China, and Iran. Swedish children emerged the best in this comparison, followed by the Spanish, Iranian, and Chinese. Chinese high EF deficits were associated with cultural biases. In Thorell and colleagues' study, boys presented with more impaired EF than girls. Camerota et al. (2018) also compared the EF of children from high and low-income households in the USA. Children from high-income households had lower working memory impairments than their low-income peers. This study observed that coming from a low-income household and being a male was a risk factor for behavioural difficulties. Moriguchi et al. (2012) observed in another study that Canadian preschoolers performed better in the social version of DCCS than their Japanese peers. These different results suggest that different underlying contextual factors influence EF development.

Preschools in Hungary and Kenya

According to OECD (2004), the quality of Hungarian preschool education is high due to a superior curriculum comparable to Germany, Norway and Finland. The curriculum provides classroom management of 25 children per class per teacher, usually a graduate and an attendant. The children are exposed to enriched teaching and learning environments offered in Hungarian as the language of instruction, which is also spoken at home (Józsa et al., 2018). The curriculum also emphasises the ability to think flexibly and imagine through a creative curriculum balanced in science and art. It also advocates for social connectedness in child upbringing (Brayfield & Korintus, 2011), which significantly enhances EF skills (Bierman et al., 2008). Preschool teachers in Hungary also enjoy high social prestige, have low job turnover, and their salaries are comparable to their colleagues in elementary school (Koles et al., 2013). Such prestige likely lead to job satisfaction which correlates with positive affection for children during classroom teaching (Mill & Romano-White, 1999). Besides, the government offers an introductory program that reinforces the successful education of children within families and native language education to enhance child-to-child interaction. Special training is also provided to teachers to ensure that disadvantaged children receive professional attention (KSH, 2015). Such training is based on multifunctional programs that engage children and parents, and enrich nutrition and health, aspects that are significant to the development of EF skills (Józsa et al., 2018; Imada et al., 2013).

Conversely, Kenya currently implements a Competency-Based Curriculum (CBC) to develop the potential of individual learners in a holistic and integrated manner to produce intellectually, emotionally, and physically balanced citizens (Republic of Kenya, 2017). The curriculum emphasises applying creative and critical thinking skills in problem-solving, numeracy and literacy, interpersonal relationships, emotional and physical development (KICD, 2017). However, the ratio of teachers to children is 1:53, and the teacher turnover is high (Republic of Kenya,2019), complicating the teacher–child relationship and instructional approaches. Most preschool teachers hold a two-year diploma or a one-year teacher certificate. Moreover, children use their different native languages at home and English or Swahili as a medium of instruction at school. This lingual difference creates barriers for children during classroom instruction and playtime (Wadende et al., 2016), impacting EF development. In addition, 3 out of 10 preschoolers are over age (Uwezo, 2021), some even over ten years who often bully the young, creating unnecessary anxiety. Families residing in cities have adopted western culture, while in rural areas and small urban towns, children are socialised in extended families with little support from the government for preschoolers. A sharp contrast is observed between the school and home environments in some nomadic and pastoralist areas (Ng'asike, 2014).

Cross-national comparisons investigate the effects of educational curricula, government organisations, family structures, social values, and civic norms on the development of children in two or more regions (Schirmbeck et al., 2021). For example, organising a society may influence how teachers plan and implement the curriculum. This is significant in guiding the transportability of programmes across borders. In addition, an effective program in one culture may be used to enhance the development of a struggling program in another early childhood programme.

Goals of the Present Study

The current study adopts a threefold objective. First, to determine the measurement invariance of the CHEXI in the two countries to form the basis of this comparative study. Second, it aims to assess EF in Hungarian and Kenyan preschool samples nested in classrooms. Third, compare and contrast the similarities and differences of EF skills observed in the two countries.

Methods

Participants and Procedure

We recruited 187 preschoolers from a large central county in Hungary aged 4 to 8 years ($M = 6.29$ years, $SD = 1.18$), and 78 were girls (46.7%). All eight preschools were public since few schools are privately managed in Hungary. The sample consisted of 8 preschool classes, one class per preschool. A total of 8 teachers, one teacher per class, rated the children. The participating children were not diagnosed with any disabilities and attended ordinary schools in Hungary. In Kenya, we

recruited 420 children from 27 schools in a large coastal county aged 4 to 8 years ($M = 7.33$ years, $SD = 0.69$); 224 of the sample were girls (53.3%). Of the 27 schools, 12 were private preschools, and 15 were public institutions. Due to large classes in the participating county, 15 children were randomly selected from 27 classrooms while counterbalancing gender. A total of 33 teachers rated the children during the first term of the year.

In Hungary, permission to collect data was granted by the Institutional Review Board of the University of Szeged, Doctoral School of Education and the parents of the children through their respective schools. Selected children were given a letter of consent to take to their parents and guardians. The children whose parents provided written consent were involved in the study. In Kenya, we first obtained Ethical approval from Pwani University and the Kenya National Commission for Science, Technology and Innovation Ethical Review Boards. We further requested permission from Ministry of Education officials and school management to involve teachers in data collection. Selected children were given a note to their parents inviting them to the school. Parents who visited the centre were asked to provide written consent to involve their children in this study.

Measures

Demographics

During recruitment, teachers consulted parents and compared data in the school admission documents concerning age, language, race, and nationality. Medical records available in the school were also checked to confirm that all children during the study period were typically developing. The Kenyan sample also obtained centre registration information to ascertain class enrollment and whether the school was registered as private or public. All children in Hungary spoke Hungarian both at home and in school. In addition, in Kenya, children speak native languages at home, such as Giriama, Chonyi, Kauma, Kikuyu, Luo or Swahili at home and Swahili or English at school. All children had Hungarian or Kenyan nationalities.

The Childhood Executive Functioning Inventory (CHEXI)

CHEXI (Thorell & Nyberg, 2008) is a 24 item questionnaire that encompasses the subscales of inhibition (6 items), working memory (9 items), regulation (5 items), and planning (4 items). Individuals with higher CHEXI scores evince more significant EF difficulties (Camerota et al., 2018). Nevertheless, the factor analysis for this study reduced the four factors to two: inhibition (11 items) and working memory (13 items), which denote the most basic EFs (Catale et al., 2015). CHEXI has been validated and was found suitably reliable in Hungary (Józsa & Józsa, 2020) and Kenya for inhibition ($\alpha = 0.94$ and 0.86, respectively) and working memory ($\alpha = 0.97$ and 0.95, respectively) (Amukune & Józsa, 2021).

Analytic Plan

Descriptive analyses were computed using IBM SPSS 24. The factor analytic approach was used to test the group measurement invariance of the CHEXI across the Hungarian and Kenyan cultural groups. A successful group measurement invariance forms the basis of the comparison (Milfont & Fischer, 2010). Confirmatory factor analysis (CFA) was computed using AMOS version 24, and the following model fit indices, and their cut-off was adopted to assess the model fit: Tucker-Lewis Index (TLI) ≥ 0.90, Root Mean Square Error of Approximation (RMSEA) < 0.08, and CFI ≥ 0.90) (Schreiber et al., 2006; Schumacker & Lomax, 2016). Multi-level analyses were employed to calculate linear mixed-effects models based on maximum likelihood estimations (Twisk, 2006) to examine the differences in the performance of EF skills between the participating Hungarian and Kenyan children. To appropriately model child-level and class-level covariates, we developed a two-level multi-level linear model specification as follows:

$$Y_{ij} = \beta 0_j + \beta_{ij} (X_{ij} - \dot{X}..) + \varepsilon_{ij} \quad (1)$$

where

Y_{ij} is the Child's Executive Function difficulties measured on the $_i$th child nested within the *j*th classroom. Y is not a dichotomous dependent or outcome variable

$\beta 0_j$ is the intercept for the $_j$th classroom,

X_{ij} is the level 1 predictor or covariate (child age and gender),

$\dot{X}$ . . is the grand mean of X_{ij} (the mean age of all children in the sample),

B_{ij} is the regression coefficient associated with level 1 predictor X for the jth level 2 unit (classroom) and

ε_{ij} is the random error associated with the $_i$th level 1 unit nested within the $_j$th level 2 unit

(Sullivan et al., 1999)

Level 1 and level 2 variables were established as follows:

Level 1 variables: CHEXI tests four latent factors: working memory, planning, regulation, and inhibition. However, the validation of CHEXI in Kenya (Amukune & Józsa, 2021) and Hungary (Józsa & Józsa, 2020) yielded an excellent fit for two latent factors, working memory (13 items/variables) and inhibition (11 items/variables). Therefore, EF was assessed based on these two latent factors at the individual level. In addition, inhibition, working memory, and total EF were group mean-centred and treated as the study's dependent variables.

Level 2 variables: Classrooms were treated as level two variables because students were nested in classes. In Kenya, 27 classes were nested from 27 different schools, and eight classes were derived from eight schools in Hungary (one class per school). The intraclass correlation coefficient (ICC) was also used to determine the existence of evidence for substantial clustering within the classrooms that formed the study's level 2 variables. A value above 0.05 was stipulated as the cut-off (Heck et al., 2013). An ICC of 0.142 was obtained for this sample, significantly evidencing that 14.2% of the variation in EF development occurred between the classes.

Table 1 Means, Standard Deviations and Bivariate Correlations for CHEXI Ratings by Teachers for Hungarian and Kenyan Preschoolers

	Hungary	1	2	3	4	5
1	Age					
2	Sex	−0.046				
3	Working memory	−0.191**	−0.166*			
4	Inhibition	−0.073	−0.255**	0.686**		
5	Total EF	−0.153*	−0.222**	0.941**	0.892**	
	M	6.29	-	37.70	32.14	69.84
	SD	1.18		15.44	11.60	24.87
	Range	4–8	1–2	1–5	1–5	1–5
	Reliability of the CHEXI					0.899
	Kenya					
1	Age					
2	Sex	0.026				
3	Working memory	−0.126*	−0.062			
4	Inhibition	−0.097*	−0.101*	0.761**		
5	Total EF	−0.121*	−0.083	0.960**	0.912**	
	M	7.33	-	38.22	32.44	70.66
	SD	0.69		11.22	7.65	17.76
	Range	4–8	1–2	1–5	1–5	1–5
	Reliability of the CHEXI					0.912

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 2 Measurement invariance of the CHEXI across groups

Model	X^2 (*df*)	CFI	RMSEA (90% CI)	TLI	Model comp	ΔX^2 (Δdf)	ΔCFI	ΔRMSEA	ΔTLI
M1 Configural invariance	790.83 (241)	0.949	0.061 (0.057–0.066)	0.946	-	-	-	-	-
M2 Metric Invariance	1507.53 (502)	0.954	0.041 (0.038–0.043)	0.949	M1	716.6 (271)	0.005	0.020	0.003
M3 scalar	1507.5 (524)	0.955	0.039 (0.037–0.042)	0.952	M2	22.15 (22)	0.001	− 0.002	0.003
M4 Residual invariance	1507.53 (548)	0.956	0.060 (0.057–0.064)	0.956	M3	0.03 (24)	0.011	0.006	0.004

In the second step, a *t*-test was performed to examine significant differences based on EF difficulties between Hungarian and Kenyan children. Significant age-related differences between Hungary and Kenya were identified at $t\,(604) = -14.92$,

$p < 0.001$. Age and gender were treated as control variables in all the multi-level analyses because of these differences. The two countries (Hungary and Kenya) and the interaction terms (region and age) were independent variables. The sample size of 164 was enough to yield a medium effect size at a power of 80%, according to calculations performed on G*Power 3.1.9.4.

Results

Descriptive Statistics and Bivariate Correlations

Table 1 displays the descriptives of the study variables across gender and country of origin. Individuals with high CHEXI values exhibit more significant EF impairment (Camerota et al.,2018). On average Kenyan preschoolers were much older than the Hungarian sample and had greater EF difficulties. The reliability of the CHEXI was also good, above the threshold of 0.7. Bivariate correlations indicated a negative association between EF difficulties and age, indicating that EF deficits declined as children advanced with age. However, the inhibition subscale was not significant in the Hungarian sample. In general, significant correlations existed across variables, except for gender. In addition, the correlations were more robust in the Hungarian sample than in the Kenyan sample.

Measurement Invariance of the CHEXI Across the Two Countries

Since there were no missing values and normally distributed data, we used Maximum Likelihood Estimates to test the measurement model of the CHEXI in the Hungarian and Kenyan samples. The two factor models fitted well with the data, for the Hungarian sample, CMIN/DF of 3.08, CFI = 0.93, SRMR = 0.048, and RMSEA = 0.073, and Kenyan sample RMSEA = 0.055, CMIN/DF = 2.97, SRMR = 0.0438 and CFI = 0.95. Based on the factor analysis, we merged the data from samples of the two countries and conducted further analysis to test the measurement invariance of the CHEXI across groups; Hungarian and Kenyan. Initially before developing the configural model the model fit was CMIN/DF = 4.835, CFI = 0.912, TLI = 0.903 and RMSEA 0.08. We later used modification indices to correlate the errors to a better configural model. We, therefore, developed models from configural to residual invariance and compared them. Following Cheung and Rensvold (2002), a model demonstrates measurement invariance if the $\Delta CFI \leq 0.01$(Table 2). Since the measurement invariance was successful, this formed the basis for comparing the two countries.

Table 3 Multi-level Models for Working Memory, Inhibition, and Total Executive functioning

Category	'Null' Model (n = 605) OR (95% CI)		'Final' model (n = 605) OR (95% CI)			
			B	SE B	LBC	UBC
Working memory						
Intercept			56.80**	6.67	43.70	69.90
Gender			− 2.54*	1.02	− 4.54	− 0.54
Age			− 2.00	0.88	− 3.74	− 0.26
Country			1.21	8.29	− 15.09	17.50
Country*Age			− 0.68	1.20	− 3.03	1.68
AIC	4799.120	4776.019				
ICC	0.142	0.137				
Inhibition						
Intercept			44.34**	4.78	34.97	53.73
Gender			− 2.86**	0.72	− 4.29	− 1.43
Age			− 1.02	0.63	− 2.27	0.22
Country*Age			0.22	0.86	− 1.47	1.90
AIC	4392.834	4373.824				
ICC	0.138	0.122				
Total EF						
Intercept			101.15**	10.64	80.26	122.40
Gender			5.40**	1.62	− 8.59	− 2.22
Age			− 3.03*	1.14	5.79	0.25
Country			− 1.90	13.23	27.89	24.08
Country*Age			− 0.46	1.91	− 4.22	3.29
AIC	5355.560	5342.784				
ICC	0.430	0.130				

LBC lower bound 95% confidence interval, *SE* standard error, *LBC*; *UBC* upper bound 95% confidence interval, *AIC* Akaike Information Criterion

*p < 0.05

**p < 0.01

Comparison of EF Difficulties Among Hungarian and Kenyan Preschoolers

The EF difficulties of the Hungarian and Kenyan samples were compared using the *t*-test. The results revealed gender differences in the Hungarian and Kenyan samples. A significant difference was noted in boys and girls in the Hungarian sample. In the working memory scale, Hungarian boys ($M = 39.80$, $SD = 15.75$) and girls ($M = 34.76$, $SD = 14.58$); t (185) = 2.220, $p = 0.028$; d = 0.33. On the Inhibition subscale, boys ($M = 34.59$, $SD = 11.75$) and girls ($M = 28.71$, $SD = 10.53$; t (185) = 3.528, $p < 0.001$; d = 0.53 and total EF difficulties, boys ($M = 74.38$, $SD = 7.92$), and girls ($M = 63.47$; $SD = 23.40$) t (185) = 3.022, $p < 0.001$, Cohen $d = 0.62$. However, no significant difference was observed between boys and girls in the Kenyan sample. Additionally, boys

from Hungary and Kenya evinced no significant differences but distinctions existed in inhibition between girls from the two countries: Hungary (28.72 *SD* = 10.54), Kenya (M = 31.71, SD = 7.56); t (299) = − 2.718, p = 0.007.

Multi-level analysis was employed to calculate linear mixed-effect models and examine the differences in EF deficits between Hungarian and Kenyan children nested in the 35 classrooms. During the development of the models, we chose Fixed Effects to avoid bias created by random effects (Clark & Linzer, 2015). The results of the fixed effects are displayed in Table 3. In addition, we used the Akaike Information Criterion model selection to identify among a set of possible models that best describes the relationship between executive function deficits, gender, age, country and age interaction.

Working memory: The multilevel analysis of working memory difficulties evidenced the significant main effect of age at F (1,605) = 169.53, $p < 0.001$ and gender at F (1605) = 6.229, $p < 0.013$. These outcomes indicated that EF deficits diminished with age. A significant effect was also noted for the children's country of origin calculated at F (1605) = 169.53, $p = 0.021$ after controlling for age and gender. However, the Country x Age interaction was not significant and was computed as F (1605) = 0.322 $p = 0.571$ after controlling for gender.

Inhibition: The multilevel analysis of inhibition demonstrated the significant main effect of age at F (1605) = 169.53, $p < 0.001$ and gender computed at F (1605) = 4.554, $p = 0.033$. No significant effect was found for the children's country of origin: F (1605) = 0.275, $p = 0.600$). The Country x Age interaction was also not significant: F (1605) = 0.063 $p = 0.802$.

Total executive functioning: The multilevel analysis of total EF difficulties displayed a significant main effect of age at F (1605) = 11.60, $p < 0.001$ and gender at F (1605) = 11.09, $p < 0.001$. No significant effect was observed for the children's country of origin: F (1605) = 0.021, $p = 0.886$. The Country x Age interaction was also not significant: F (1605) = 0.322, $p = 0.808$.

Discussion

The present study compared the development of EF skills in Hungarian and Kenyan preschoolers based on CHEXI ratings. It was envisioned that such a comparison would ground the identification of strengths and weaknesses in EF development between the two countries and yield possible suggestions for enhancing EFs. Studies have evidenced that CHEXI is helpful for the assessment of EF difficulties in children. Similar to the present study, such studies have consistently reported a suitable fit to two of the four CHEXI subscales (planning, working memory, regulation, and inhibition): working memory and inhibition difficulties (e.g., Camerota et al., 2018; Catale et al.,2013; Catale et al., 2015; Thorell et al., 2010). To form the basis for the comparison, we conducted a successful measurement invariance of the CHEXI (Milfont & Fischer, 2010), similar to Camerota et al. (2018). The group measurement invariance indicated that the Hungarian and Kenyan samples could be compared based on the CHEXI results. The present study found significant gender differences in EF favouring girls in the Hungarian sample, but no significant difference

was noted between boys and girls in the Kenyan sample. The reasons for the significant gender differences in the Hungarian sample remain unclear. Similar studies in America reported that teachers' EF and academic achievement skill ratings favored girls over boys (Garcia et al., 2019). A similar trend was observed in the Kenyan sample, even though the differences were insignificant. Additionally, no country-related significant difference was noted in EF between the boys, but Hungarian girls were rated better in inhibition than Kenyan girls. Generally, boys were seen as more EF impaired than girls, and this result is aligned with Thorell et al.'s (2013) study comparing Swedish, Spanish, Chinese, and Iranian children and Giménez de la Peña et al. (2022) study in Spain. Besides, Camerota et al. (2018) compared children from low and high-income households in the US and found that boys were more EF impaired than girls. Despite these gender differences, comparison based on EF tasks has shown no significant differences between boys and girls (Giménez de la Peña et al., 2022; Yamamoto & Imai-Matsumura, 2019). A comparison between Hungarian and Kenyan children in the current study revealed that Hungarian preschoolers were better at working memory, but no significant difference was found in inhibition. Preschool children from Hungary evidenced lesser working memory difficulties than children from Kenya; thus, they exhibited improved EF.

Several reasons could explain why the Kenyan sample had higher EF deficits than Hungarian preschoolers. Studies have reported that a superior curriculum, friendly learning environment devoid of stress and anxiety, and family support that guarantees good parenting prevalent in the Hungarian preschool education system enhances EF development (Blair et al.,2011; Casey et al.,2018; Mousavi et al., 2022; Plessow et al., 2011). Moreover, the Kenyan sample was selected from both private and public schools. Therefore, the private school enrollees in the sample could belong to a higher SES. Some authors (e.g., Camerota et al., 2018; Hartanto et al., 2019) have indicated that SES influences EF development. However, Schmitt et al. (2019) reported that SES does not affect cross-cultural EF growth in preschoolers. This aspect requires further exploration by classifying samples from Hungary and Kenya by SES.

The lack of significant differences in the inhibition between Hungarian and Kenyan samples due to their country of origin was not surprising because the two groups were selected from children who were not diagnosed with any cognitive disability. Other studies reported differences in inhibition (e.g., Catale et al., 2015) between Belgium and Sweden but their sample comprised children developing typically for their age and clinical samples diagnosed with ADHD. However, it was the control group that had significant differences. Inhibition is the primary deficit for children with ADHD (Barkley 1997; Thorell et al. 2010). This study by Catale et al.(2015) indicated that the difference between children with ADHD and typically developing ranged between 88 to 94 on the total EF scale, and Thorell et al. (2010) reported 93.3. EF interventions in Kenya have yielded mixed results. For example, the Children's Investment Fund conducted the Tayari (readiness) program in Kenya between 2014 and 2018 (Piper et al., 2018), after which school readiness improved by 5.1 index points. However, EF scores were not associated with the Tayari program (Willoughby et al., 2019). Another study by Willoughby et al. (2021) conducted a cluster randomised controlled trial

employing a RedLight/PurpleLight intervention program as a follow-up to the school readiness enhancement program. Their findings demonstrated null results between the outcomes of the pre-and post-tests of the experimental and control groups. Willoughby and colleagues associated their null results with the measurement of EF and contextual issues.

The findings of the present study have implications for policy and practice. It is critical to determine the EF skills of pupils during school readiness assessments since studies have reported that EF predicts academic achievement (Amukune & Józsa, 2021; Blair, 2017). This finding is helpful for the provision of individualised interventions for the pupils. Such school readiness assessments are more prevalent in Hungary than in Kenya. Taken together, the Hungarian preschool system, child-rearing during preschool years, and preschool organisation are superior to the Kenyan equivalents.

The present study had some limitations. First, the study applied a cross-sectional design based on teachers' ratings alone. Parents accumulate much information about their children at home. Hence, the collection of additional assessments from parents could have evidenced support for the evaluations rendered by teachers. However, Thorell and Nyburg's (2008) study indicated that the ratings of both parents and teachers discharged similar functions. Second, the CHEXI does not incorporate established normative data for comparison by examiners to determine whether their samples exceed clinical standards. This could have aided in identifying children at risk due to EF deficits. Third, the study's sample size in Hungary was smaller than the Kenyan aggregate of participants. Future research initiatives can incorporate the ratings of both parents and teachers using a longitudinal design with a parallel performance-based assessment. In addition, a close focus on the interactions of parents and teachers with children would offer a more comprehensive understanding of cultural influences on the development of EF in Hungary and Kenya.

Conclusion

This cross-cultural study evaluates EF development in preschoolers in Hungary and Kenya based on the CHEXI ratings. CHEXI demonstrated a strong measurement invariance confirming it is a suitable instrument for comparing EF assessments between countries. In both countries, boys were more EF impaired compared to girls. In addition, the Hungarian preschoolers were better at EF development than the Kenyan. This difference can be attributed to the advanced preschool education system, government support for the universal child care system, and Hungary's preschool curriculum. Such deliberate efforts are lacking in Kenya.

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References

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review, 16*(1), 17–42.

Amukune, S., & Józsa, K. (2021). The Childhood Executive Functioning Inventory (CHEXI): Psychometric properties and association with academic achievement in Kenyan First Graders. *Journal of Psychological and Educational Research, 29*(1), 154–176.

Barrett, K. C., Józsa, K., & Morgan, G. A. (2017). New computer-based mastery motivation and executive function tasks for school readiness and school success in 3 to 8 year-old children. *Hurgarian Educational Research Journal, 7*(2), 86–105. https://doi.org/10.14413/HERJ/7/2/6

Bell, M. A., & Deater-Deckard, K. (2007). Biological systems and the development of self-regulation: Integrating behavior, genetics, and psychophysiology. *Journal of Developmental & Behavioral Pediatrics, 28*(5), 409–420.

Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008). Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program. *Development and Psychopathology, 20*(3), 821–843. https://doi.org/10.1017/S0954579408000394

Black, M., Walker, S., Fernald, L., Andersen, C., Digirolamo, A., Lu, C., & Indies, W. (2017). Advancing Early Childhood Development: From Science to Scale 1 Early childhood development coming of age: Science through the life course. *The Lancet*. https://doi.org/10.1016/S0140-6736(16)31389-7

Blair, C. (2002). School readiness as propensity for engagement: Integrating cognition and emotion in a neurobiological conceptualization of child functioning at school entry. *American Psychologist, 57*(2), 111–127. https://doi.org/10.1037/0003-066X.57.2.111

Blair, C. (2017). Educating executive function. *Wiley Interdisciplinary Reviews: Cognitive Science, 8*(1–2), e1403.

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology, 20*(3), 899–911.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78*, 647–663.

Blair, C., Granger, D. A., Willoughby, M., Mills–Koonce, R., Cox, M., Greenberg, M. T., Kivlighan, K. T., Fortunato, C.K., & FLP Investigators. (2011). Salivary cortisol mediates effects of poverty and parenting on executive functions in early childhood. *Child development, 82*(6), 1970–1984.

Brayfield, A., & Korintus, M. (2011). Early childhood socialisation: Societal context and child-rearing values in Hungary. *Journal of Early Childhood Research, 9*(3), 262–279. https://doi.org/10.1177/1476718X11402444

Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology, 28*(2), 595–616.

Catale, C., Lejeune, C., Merbah, S., & Meulemans, T. (2013). French adaptation of the Childhood Executive Functioning Inventory (CHEXI): Confirmatory factor analysis in a sample of young French-speaking Belgian children.*European Journal of Psychological Assessment, 29*(2), 149–155. https://doi.org/10.1027/1015-5759/a000141

Catale, C., Meulemans, T., & Thorell, L. B. (2015). The childhood executive function inventory: Confirmatory factor analyses and cross-cultural clinical validity in a sample of 8-to 11-year-old children. *Journal of Attention Disorders, 19*(6), 489–495.

Camerota, M., Willoughby, M. T., Kuhn, L. J., & Blair, C. B. (2018). The Childhood Executive Functioning Inventory (CHEXI): Factor structure, measurement invariance, and correlates in US preschoolers. *Child Neuropsychology, 24*(3), 322-337.

Casey, B. J., Cannonier, T., Conley, M. I., Cohen, A. O., Barch, D. M., Heitzeg, M. M., Soules, M. E., Teslovich, T.,Dellarco, D. V., & Garavan, H. (2018). The adolescent brain cognitive development (ABCD) study: imaging acquisition across 21 sites. *Developmental cognitive neuroscience, 32*, 43–54.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural equation modeling, 9*(2), 233-255.

Clark, T. S., & Linzer, D. A. (2015). Should I use fixed or random effects? *Political Science Research and Methods, 3*(2), 399–408. https://doi.org/10.1017/psrm.2014.32

Cook, C. J., Howard, S. J., Scerif, G., Twine, R., Kahn, K., Norris, S. A., & Draper, C. E. (2019). Associations of physical activity and gross motor skills with executive function in preschool children from low-income South African settings. *Developmental Science, 22*(5), e12820. https://doi.org/10.1111/desc.12820

Cragg, L., Keeble, S., Richardson, S., Roome, H. E., & Gilmore, C. (2017). Direct and indirect influences of executive functions on mathematics achievement. *Cognition, 162*, 12–26. https://doi.org/10.1016/j.cognition.2017.01.014

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135–168.

Diamond, A., & Ling, D. S. (2019). Review of the evidence on, and fundamental questions about, efforts to improve executive functions, including working memory. In A. Diamond & D. S. Ling (Eds.), *Cognitive and working memory training* (pp. 143–431). Oxford University Press.

Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to ?Do as I say, not as I do? *Developmental Psychobiology, 29*(4), 315–334. https://doi.org/10.1002/(SICI)1098-2302(199605)29:4%3c315::AID-DEV2%3e3.0.CO;2-T

Garcia, E. B., Sulik, M. J., & Obradović, J. (2019). Teachers' perceptions of students' executive functions: Disparities by gender, ethnicity, and ELL status. *Journal of Educational Psychology, 111*(5), 918–931. https://doi.org/10.1037/edu0000308

Gathercole, S. E., Pickering, S. J., Ambridge, B., & Wearing, H. (2004). The structure of working memory from 4 to 15 years of age. *Developmental Psychology, 40*(2), 177.

Giménez de la Peña, A., López-Zamora, M., Vila, O., Sánchez, A., & Thorell, L. B. (2022). Validation of the Spanish version of the Childhood Executive Functioning Inventory (CHEXI) in 4–5 year-old children. *Anales De Psicología, 38*(1), 101–109. https://doi.org/10.6018/analesps.453171

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). Test review behavior rating inventory of executive function. *Child Neuropsychology, 6*(3), 235–238.

Hartanto, A., Toh, W. X., & Yang, H. (2019). Bilingualism narrows socioeconomic disparities in executive functions and self-regulatory behaviors during early childhood: Evidence from the early childhood longitudinal study. *Child Development, 90*(4), 1215–1235. https://doi.org/10.1111/cdev.13032

Heck, R. H., Thomas, S. L., & Tabata, L. N. (2013).*Multilevel and longitudinal modeling with IBM SPSS.* Routledge. https://doi.org/10.4324/9780203701249

Imada, T., Carlson, S. M., & Itakura, S. (2013). East-West cultural differences in context-sensitivity are evident in early childhood.*Developmental Science, 16*(2), 198–208.https://doi.org/10.1111/desc.12016

Isquith, P. K., Roth, R. M., & Gioia, G. (2013). Contribution of rating scales to the assessment of executive functions. *Applied Neuropsychology: Child, 2*(2), 125–132.

Józsa, G., & Józsa, K. (2020). A gyermekkori (CHEXI) és a felnőttkori (ADEXI) végrehajtó funkció kérdőívek magyar nyelvre történő adaptációja. [Hungarian adaptation of the Childhood Executive Functioning Inventory (CHEXI) and the Adult Executive Functioning Inventory (ADEXI)]. *Magyar Pedagógia*, *120*(1), 47–69. https://doi.org/10.17670/MPed.2020.1.47

Józsa, K., Török, B., & Stevenson, C. (2018). Preschool and kindergarten in Hungary and the United States: A comparison within transnational development policy. *International Journal of Educational Development, 62*, 88–95. https://doi.org/10.1016/j.ijedudev.2018.03.001

KICD. (2017). *Curriculum Design for Preprimary II*. Kenya Institute of Curriculum Development (KICD). https://KICD.ac.ke/wp.content

Koles, B., O'Connor, E. E., & Collins, B. A. (2013). Associations between child and teacher characteristics and quality of teacher–child relationships: The case of Hungary. *European Early Childhood Education Research Journal, 21*(1), 53–76. https://doi.org/10.1080/1350293X.2012.760337

KSH. (2015). *Helyzetkép a kisgyermekek napközbeni ellátásáról, 2014. [Overview of early childhood care]. (In Hungarian).* Hungarian Statistical Office. https:// www.ksh.hu/docs/hun/xftp/stattukor/

Mattera, S., Rojas, N. M., Morris, P. A., & Bierman, K. (2021). Promoting EF with preschool interventions: Lessons learned from 15 years of conducting large-scale studies. *Frontiers in Psychology, 12*, 640702. https://doi.org/10.3389/fpsyg.2021.640702

McClelland, M. M., Acock, A. C., & Morrison, F. J. (2006). The impact of kindergarten learning-related skills on academic trajectories at the end of elementary school. *Early Childhood Research Quarterly, 21*(4), 471–490.

Mousavi, S. Z., Farhadi, N., & Gharibzadeh, S. (2022). Socioeconomic Status and Childhood Executive Function: Differing Conceptualizations, Diverse Assessments, and Decontextualized Investigations. *Integrative Psychological and Behavioral Science*. https://doi.org/10.1007/s12124-022-09680-w

Milfont, T. L., & Fischer, R. (2010). Testing measurement invariance across groups: Applications in cross-cultural research. *International Journal of Psychological Research, 3*(1), 111–130.

Mill, D., & Romano-White, D. (1999). Correlates of affectionate and angry behavior in child care educators of preschool-aged children. *Early Childhood Research Quarterly, 14*(2), 155–178.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*(1), 49–100.

Moriguchi, Y., Evans, A. D., Hiraki, K., Itakura, S., & Lee, K. (2012). Cultural differences in the development of cognitive shifting: East-West comparison. *Journal of Experimental Child Psychology, 111*(2), 156–163. https://doi.org/10.1016/j.jecp.2011.09.001

Nesbitt, K. T., Baker-Ward, L., & Willoughby, M. T. (2013). Executive function mediates socio-economic and racial differences in early academic achievement. *Early Childhood Research Quarterly, 28*(4), 774–783. https://doi.org/10.1016/j.ecresq.2013.07.005

Ng'asike, J. T. (2014). African early childhood development curriculum and pedagogy for Turkana nomadic pastoralist communities of Kenya.*New directions for child and adolescent development, 2014*(146), 43-60.https://doi.org/10.1002/cad.20072

OECD. (2004). *Early childhood education and care policy: Country note for Hungary*. Paris: OECD Directorate of Education.

Plessow, F., Fischer, R., Kirschbaum, C., & Goschke, T. (2011). Inflexibly focused under stress: acute psychosocial stress increases shielding of action goals at the expense of reduced cognitive flexibility with increasing time lag to the stressor. *Journal of cognitive neuroscience,23*(11), 3218-3227.

Raver, C. C., & Knitzer, J. (2002). Ready to enter: What research tells policymakers about strategies to promote social and emotional school readiness among three-and four-year-old children.

Republic of Kenya. (2017). Basic Curriculum Framework (p. 147). Kenya Institute of Curriculum Development(KICD). https://www.kicd.go.ke

Republic of Kenya. (2019). Basic Education Statistical Booklet. Ministry of Education. https://www.education.go.ke/images/Approved_Basic_Education_Statistical_Booklet_2019_approved_compressed.pdf

Romine, C. B., & Reynolds, C. R. (2005). A model of the development of frontal lobe functioning: findings from a meta-analysis. *Applied Neuropsychology, 12*(4), 190–201. https://doi.org/10.1207/s15324826an1204_2

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). The development of executive functioning and theory of mind: A comparison of Chinese and US preschoolers.*Psychological science, 17*(1), 74-81.https://doi.org/10.1111/j.1467-9280.2005.01667.x

Salthouse, T. A. (2007). Implications of within-person variability in cognitive and neuropsychological functioning for the interpretation of change. *Neuropsychology, 21*(4), 401.

Schirmbeck, K., Rao, N., & Maehler, C. (2020). Similarities and differences across countries in the development of executive functions in children: A systematic review. *Infant and Child Development, 29*(1), e2164.

Schirmbeck, K., Rao, N., Wang, R., Richards, B., Chan, S. W. Y., & Maehler, C. (2021). Contrasting executive function development among primary school children from Hong Kong and Germany. *European Journal of Psychology of Education, 36*(4), 923–943. https://doi.org/10.1007/s10212-020-00519-9

Schmitt, S. A., Korucu, I., Purpura, D. J., Whiteman, S., Zhang, C., & Yang, F. (2019). Exploring cross-cultural variations in the development of executive function for preschoolers from low and high socioeconomic families. *International Journal of Behavioral Development, 43*(3), 212–220. https://doi.org/10.1177/0165025418785469

Sullivan, L. M., Dukes, K. A., & Losina, E. (1999). An introduction to hierarchical linear modelling. *Statistics in Medicine, 18*(7), 855–888. https://doi.org/10.1002/(SICI)1097-0258(19990415)18:7%3c855::AID-SIM117%3e3.0.CO;2-7

Sung, J., & Wickrama, K. A. (2018). Longitudinal relationship between early academic achievement and executive function: Mediating role of approaches to learning. *Contemporary Educational Psychology,54* 171–183. https://doi.org/10.1016/j.cedpsych.2018.06.010

Thorell, L. B., & Nyberg, L. (2008). The Childhood Executive Functioning Inventory (CHEXI): A new rating instrument for parents and teachers. *Developmental Neuropsychology, 33*(4), 536–552.

Thorell, L. B., Eninger, L., Brocki, K. C., & Bohlin, G. (2010). Childhood Executive Function Inventory (CHEXI): A promising measure for identifying young children with ADHD?.*Journal of Clinical and Experimental Neuropsychology, 32*(1), 38–43. https://doi.org/10.1080/13803390902806527

Thorell, L. B., Veleiro, A., Siu, A. F., & Mohammadi, H. (2013). Examining the relation between ratings of executive functioning and academic achievement: Findings from a cross-cultural study. *Child Neuropsychology, 19*(6), 630–638.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54*(2), 131–143.

Tran, C. D., Arredondo, M. M., & Yoshida, H. (2019). Early executive function: The influence of culture and bilingualism. *Bilingualism: Language and Cognition, 22*(04), 714–732. https://doi.org/10.1017/S1366728918000160

Twisk, J. W. R. (2006). Applied multilevel analysis: A practical guide. *Cambridge University Press*. https://doi.org/10.1017/CBO9780511610806

UNESCO. (2015). *Education for all global monitoring report, 2000–2015*. Unesco Publishing.

Uwezo. (2021). Are all our Children Learning? Uwezo 7th Learning Assessment Report. Usawa Agenda. usawaagenda.org

Wadende, P., Oburu, P., & Morara, A. (2016). African indigenous care-giving practices: Stimulating early childhood development and education in Kenya. *South African Journal of Childhood Education,6*(2), 1–7.

Willoughby, M. T., Piper, B., King, K. M., Nduku, T., Henny, C., & Zimmermann, S. (2021). Testing the efficacy of the red-light purple-light games in preprimary classrooms in Kenya. *Frontiers in Psychology, 12*, 633049. https://doi.org/10.3389/fpsyg.2021.633049

Willoughby, M. T., Piper, B., Oyanga, A., & Merseth King, K. (2019). Measuring executive function skills in young children in Kenya: Associations with school readiness. *Developmental Science*. https://doi.org/10.1111/desc.12818

Yamamoto, N., & Imai-Matsumura, K. (2019). Gender differences in executive function and behavioural self-regulation in 5 years old kindergarteners from East Japan. *Early Child Development and Care, 189*(1), 56–67. https://doi.org/10.1080/03004430.2017.1299148

Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. *Nature protocols,1*(1), 297–301. https://doi.org/10.1038/nprot.2006.46