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Executive functions of preschoolers with different levels of cultural congruence

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ABSTRACT

This study investigated the relationships between executive functions of children aged 5–6 and the level of their cultural congruence, that reflects the extent to which behaviour of a child corresponds to a set of cultural rules, typical for this age in this culture. The main components of executive functions (working memory, cognitive flexibility and inhibitory control) were measured by the Russian versions of the NEPSY-II subtests and the DCCS test. For the cultural congruence assessment, the parent ‘Questionnaire for Studying Children’s Compliance with Rules in a Normative Situation’ was applied. There were 113 preschoolers from Kazan, Tatarstan Republic, Russia (57 boys and 56 girls, 66 months on the average) and 113 mothers (from 24 to 44-years-old, 36 years on the average) in the study. Three levels of cultural congruence were singled out – ‘high’, ‘medium’ and ‘low’. The results showed that children with a ‘high’ level of cultural congruence develop inhibitory control to a greater extent, while children with a ‘low’ level of compliance develop cognitive flexibility. A lowest level of executive functions was found in the group with the ‘medium’ level of cultural congruence.

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Preschool age; cultural congruence; executive functions; normative situation; compliance with rules

Introduction

The role of culture in the development of executive functioning has raised great interest amongst researchers in recent years. Executive functions (EF) are discussed as a cognitive aspect of the self-regulation of goal-relevant and non-reactive behaviour (Engle, Kane, and Tuholski 1999; Kane et al. 2001; Nozadi et al. 2015). They include cognitive skills, allowing adaptive changes to be made in the physical and social environment (Moriguchi et al. 2012). In published international studies EF appear to be a summative concept comprising a number of functions such as planning, working memory, inhibition, cognitive flexibility, initiation and monitoring of action (Norman and Shallice 1986; Welsh, Pennington, and Groisser 1991; Pennington 1997; Diamond 2006). Miyake et al. (2000), whose concept we use in our research, examined the structure of three frequently postulated executive

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functions among the sample of adults – shifting between mental sets or tasks (Shifting), updating and monitoring of working memory contents (Updating), and inhibition of pre-potent responses (Inhibition) – at the level of latent variables. They managed to prove that EF may be characterised as separable but related functions that share some underlying commonality (the concept of unity and diversity) (Miyake et al. 2000). Lehto et al. (2003) revealed similar regularities among the sample of children of 8–13 years and labelled the interrelated factors, which resembled those obtained by Miyake et al. (2000), as Working Memory, Inhibition and Shifting. The ‘unity-and-diversity’ model also was tested for the exploration of EF at the preschool age in many other researches (for example, Diamond and Lee 2011; Veraksa et al., *in press*).

Cross-cultural studies of executive functions

Contemporary cross-cultural studies discover the context-sensitive nature of Working Memory, Inhibition and Shifting (Sabbagh et al. 2006; Oh and Lewis 2008; Lewis et al. 2009; Moriguchi et al. 2012; Imada, Carlson, and Itakura 2013; Ellefson et al. 2017). In particular, Sabbagh et al. (2006) found that oriental preschoolers outperform western children in all measures of executive functioning. Another group of researchers completed several consecutive studies investigating working memory, inhibitory control, delay inhibition and set shifting among the sample of Korean, English, Chinese and Japan preschoolers of 3–5 years. They revealed that the measures of all components of the EF (working memory, inhibitory control and shifting) in the group of Asian children tended to show higher levels of performing than those of English speaking children (Oh and Lewis 2008; Lewis et al. 2009). Moriguchi et al. (2012) evaluated the social transmission of disinhibition among the samples of 3–4 years old children being raised in cultures that emphasise ‘independency’ (Canada) and ‘interdependency’ (Japan). Their results show that both groups performed similarly on the DCCS task, but Japanese children were significantly more influenced by another individual’s executive actions. Authors assume that to become a member of an interdependent society a child has to attune his/her activity to the executive actions of others in their social environment.

The conceptualisation of cultural congruence

The cross-cultural studies mentioned above are based on the underlying assumption that children of a certain culture have the same level of belonging to the culture. At the same time, there are studies that emphasise that the extent to which a child enters the cultural ‘normative situation’ (Veraksa 2000), follows the expectations of a significant other (Trommsdorff 2009), internalises cultural rules (Grusec and Goodnow 1994) and therefore gets ‘congruent’ to this culture (Baynova and Mustafin 2016), may vary. Vygotsky and Luria describe this process as if the cultural environment was growing inside a child and his/her behaviour becomes social, cultural not only by its content but also by its mechanisms (1993). Through the process of this ‘growing inside’ in the situation of social interaction a culture transmits a certain norm of social behaviour (Veraksa 2000), that influences the development of separate mental functions (Zaks 2014). Cultural congruence is an indicator of a child’s behaviour coherence to a set of cultural rules as a system of typical normative situations that characterise social situation of development in a

certain age (Bayanova 2017). Thus, cultural congruence reflects the extent to which behaviour of a child corresponds to cultural expectations.

The present study

Based on the results of cross-cultural studies it is possible to assume that children of a certain culture with different levels of cultural congruence might have different EF levels. Nevertheless, the link between EF and the extent to which a child of a certain culture belongs to this culture was barely studied. '... Relations between social interactions and EF are largely terra incognita' (Hughes and Ensor 2009, 36).

The problem explored in the current study is: are there any links between the extent to which a child is congruent to the culture and the development of his/her EF? What are the specifics of these relationships? Are they gender specified? These questions stem from the hypothesis, that there are positive links between the factors of cultural congruence and the EF level of a child.

Materials and methods

Participants

The participants were 113 children and their 113 mothers: preschoolers attending kindergartens in Kazan (57 boys and 56 girls) at the ages of 5–6 years old ($M = 66$ months) and mothers, whose ages ranged from 24 to 44 years old ($M = 36$ years). The families who took part in the study have an average socio-economic status.

Procedure

Mothers were informed of the structure and the content of the study. They completed a written agreement concerning the participation of their children in the study. Parents were guaranteed that the results would be confidential and would not be divulged. The study was approved by the Ethics Committee of the Faculty of Psychology at Lomonosov Moscow State University (the approval No: 2018/41).

All the EF tasks were performed in the second half of the school year, during two individual meetings with each child (each lasting 15–20 min), in a quiet room of a child's kindergarten. A child could stop it if he/she felt bored or tired. The assessment was carried out by specially trained psychologists.

Mothers completed a questionnaire which explored children's compliance with rules in a normative situation. Sixty-one of them filled in the questionnaire at home while 52 did so in the kindergarten.

Measures

Measures of compliance with rules in a normative situation

Questionnaire for Studying Children's Compliance with Rules in a Normative Situation. The questionnaire (Baynova and Mustafin 2016) is based on the definition of cultural congruence and enables definition of the level of socialisation of a child in his/her cultural

environment. The questionnaire assesses the compliance with rules in a normative situation and includes 56 statements that describe the child's behaviour in different situations. According to factor analysis, the authors determined four substantive factors describing the rules in normative situations, which are typical of the preschool age: 'obedience, compliance with expectations of adults' (orientation of the child to interaction with adults and compliance with adult expectations, for example: 'The child is honest with adults'), 'safety' (adherence to rules to prevent predominantly physical injury, for example: 'The child does not play with matches'), 'self-service, hygiene' (compliance of the child with the rules of personal care, for example: 'The child always brushes his teeth') and 'self-control' (compliance of the child with the rules providing for accuracy, attentiveness, emotional control, for example: 'The child is attentive'). To estimate the degree of compliance, parents have to assess each statement marking 'definitely no' (scored 0), 'probably no' (scored 1), 'probably yes' (scored 2), 'generally yes' (scored 3) or 'definitely yes' (scored 4). The degree of compliance was calculated in points. The maximum number of points on a scale 'obedience, compliance with expectations of adults' was 56, on a scale 'safety' – 76, 'self-service, hygiene' – 52 and 'self-control' – 40. Psychometric evaluation of this questionnaire, conducted by Baynova and Mustafin (2016), revealed a high level of discrimination, reliability and validity of the technique, which allows us to consider it as a measurement of cultural congruence for 5–6-year-old children.

Measures of executive functions

The test battery consists of the tasks which explore three main EF components of children: working memory, inhibitory control and cognitive flexibility. The majority of methods (except for the DCCS task) applied in the study are Russian versions of subtests from the NEPSY-II complex, which is designed to evaluate the mental development of children between 3 and 16 years old (Korkman 1999; Korkman, Kirk, and Kemp 2007). According to the authors of this complex, it is based on the cultural-historical activity theory largely represented in the works of Luria. Previous research has shown the possibility of using these methods on Russian children (Cheie et al. 2015; Almazova, Bukhalenkova, and Veraksa 2016; Veraksa et al. 2016; Veraksa, Bukhalenkova, and Kovyazina 2018).

The subtest Sentence Repetition (SR) is aimed at assessing verbal working memory. This method consists of 17 sentences that gradually increase in their complexity (sentences become longer and syntactically more complex). A child is asked to reproduce each sentence immediately after it has been presented. Each correct repetition of the sentence is scored 2. If a child makes one or two mistakes, the sentence is scored 1, if there are many more mistakes at the attempt, the sentence is scored 0 points. Accuracy scores are calculated in the Total Score (max=34 points).

The subtest Memory for Designs (MD) is aimed at assessing visual working memory. A child is shown a grid with four to eight designs on a page, which is then removed from the view. A child selects the designs from a set of cards and places the cards on the grid in the same location as previously shown. For each task, 2 points were awarded for each correctly chosen card, 1 point for each correctly indicated place and 2 bonus points were given if a child correctly selects and places the card. All points for four trials are calculated in the Total Score (max = 120 points).

The subtest Inhibition is aimed at assessing the inhibitory control. In this method for the first task the child is presented a series of 40 shapes (squares and circles) and is asked to

name the shape as soon as possible (Naming). For the second task (Inhibition) the child has to switch to an alternate response ('circle' instead of 'square' and vice versa). The number of not corrected by a child errors and the completion time (in sec) to both tasks were recorded. The Inhibition subtest is measured by six indicators: Naming Uncorrected Errors (max = 40), Naming Corrected Errors (max = 40), Naming time (in sec), Inhibition Uncorrected Errors (max = 40), Naming Corrected Errors (max = 40) and Inhibition time (in sec).

The Dimensional Change Card Sort task (DCCS) (Zelazo 2006) is aimed at assessing cognitive flexibility. Children are asked to sort a series of bivalent test cards (red rabbits and blue boats): in the first task – according to colour (PreSwitch – 6 cards); in the second task – according to shape (PostSwitch – 6 cards); and at the third task – according to a complex rule (cards with black borders sort according to a colour and cards without it – according to a shape) (Borders – 12 cards). The accuracy score (number of card sorted by child correctly) for each task was calculated and presented as a Total Score (max = 24 points).

Data analysis

First, the results of Questionnaire for Studying Children's Compliance with Rules in a Normative Situation were exposed to the procedure of cluster analysis (method of K-medium). It allows us to divide all the data into three groups having different levels of cultural congruence (according to the maximum likelihood method). We named the selected clusters as groups with 'high' (27 children), 'medium' (52 children) and 'low' (34 children) levels of cultural congruence (Table 1). All differences between pairs of the groups are significant (the Kruskal–Wallis test, $p \leq 0.0001$).

Second, the indicators of working memory (Sentence Repetition and Memory for Designs total scores), inhibitory control (Uncorrected Errors and Time) and cognitive flexibility (DCCS total score) among three defined groups of children with different levels of cultural congruence were compared (Kruskal–Wallis one-way analysis of variance (comparison of several groups) and Mann–Whitney U-test (pairwise comparison of the groups) were applied (Table 2). On the next step One-way ANOVA method was used to analysis of gender differences in pre-schoolers cultural congruence and EF.

For the statistical analysis SPSS 21.0 program for Windows was used.

Table 1. Mean values and standard deviations of compliance factors in the groups with different levels of cultural congruence.

	'Low' (n = 34) Mean, Std. Deviation	'Medium' (n = 52) Mean, Std. Deviation	'High' (n = 27) Mean, Std. Deviation	Total (n = 113) Mean, Std. Deviation	Kruskal– Wallis, p
Obedience (max.56)	32.26, 6.08	40.52, 4.51	49.74, 7.74	40.24, 8.67	0.000
Safety (max.76)	33.82, 8.67	51.67, 6.31	64.63, 7.19	49.40, 1, 3.58	0.000
Self-service (max.52)	26.00, 6.83	34.04, 6.09	41.89, 4.91	33.50, 8.39	0.000
Self-control (max.40)	22.97, 5.07	29.71, 3.77	35.93, 7.31	29.17, 7.02	0.000

Table 2. Comparison of EF indicators between groups with different levels of cultural congruence (Kruskal–Wallis criteria).

	'Low' <i>n</i> = 34		'Medium' <i>n</i> = 52		'High' <i>n</i> = 27		Kruskal– Wallis, <i>p</i>
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	
Memory for Designs Total score	72.19	19.73	65.32	18.33	70.96	17.88	
Sentence Repetition Total score	16.85	5.58	18.71	4.90	18.15	3.35	
DCCS PostSwitch	5.56	1.37	5.25	1.70	4.52	2.23	0.048
DCCS Total score	19.32	3.37	18.38	3.14	17.11	3.68	
Naming Uncorrected Errors	0.58	1.15	0.68	1.57	0.20	0.65	
Naming Corrected Errors	1.42	1.41	1.24	1.27	0.68	0.80	
Naming Time	44.27	11.75	50.80	15.06	45.44	9.15	
Inhibition Uncorrected Errors	2.00	3.25	2.04	4.25	0.64	2.27	0.010
Inhibition Time	57.76	14.99	63.88	14.78	61.36	14.86	

Results

EF of the groups with different levels of cultural congruence

The results revealed that children with 'low' level of congruence outperform children with a 'high' level in sorting cards according to shape (DCCS method, PostSwitch): 5.56 and 4.52 on an average, respectively (Mann–Whitney U-test, $p = 0.019$).

The least number of uncorrected errors in the Inhibition subtest were made by children with a 'high' level of cultural congruence ('high' level group – 0.64, 'medium' – 2.04 and 'low' – 2.00 errors; Mann–Whitney U-test, $p \leq 0.01$). No significant differences in Inhibition time among groups were found.

Gender differences

Gender differences of cultural congruence

The results show that girls are significantly much more obedient and compliant with the expectations of adults than boys (42.1 and 38.5, respectively; $F = 5.07$, $p = 0.026$). Girls, as compared to boys, have significantly higher level of adherence to the rules of safety regulation (52.5 and 46.5, respectively; $F = 5.73$, $p = 0.018$). At the same time, there were no evident differences between groups as to the levels of 'self-service, hygiene' and 'self-control'.

The gender distribution between different clusters was tested and it was revealed that gender distribution is irregular (Chi-Square, $p = 0.001$). The 'high' group consists of 6 boys and 21 girls, 'medium' – of 34 boys and 18 girls. The number of boys and girls in the 'low' group was approximately equal (18 boys and 16 girls). Girls were distributed more evenly across clusters, whereas boys basically shared 'medium' and 'low' groups.

Gender differences in the level of executive functioning

The comparison of the levels of EF between groups of boys and girls reveals that girls outperform boys in the overall indicator of visual working memory (Memory for Designs Total score: 72.04 and 65.25, respectively; $F = 4.039$, $p = 0.047$) and have a higher level of

cognitive flexibility (DCCS Total score: 19.09 and 17.51, respectively; $F = 5.759$, $p = 0.018$). They are also significantly quicker than boys (Naming, Time: 44.26 and 49.82 s on an average, respectively; $F = 5.737$, $p = 0.018$) and make fewer corrected errors in the Naming task of the Inhibition method (Naming Corrected Errors: 0.93 and 1.47, respectively; $F = 5.258$, $p = 0.024$). The rest of the compared indicators of EF (the level of verbal working memory, the number of uncorrected mistakes in Naming and Inhibition tasks) did not significantly differ between the groups of boys and girls.

Discussion

The current study provides new data about the connections between EF and the cultural congruence at preschool age. We hypothesised that the features of EF significantly vary in preschoolers with different levels of cultural congruence. This hypothesis was supported as we managed to distinguish groups of children with 'high', 'medium' and 'low' levels of compliance who differed in their features of EF development.

In our research it was revealed that children with a 'high' level of cultural congruence outperform others in the level of inhibitory control, whereas preschoolers of the 'low' group of cultural congruence have better developed cognitive flexibility. The group with a 'medium' level of cultural congruence was characterised by a lower level of cognitive flexibility and inhibition than the 'low' group and by a lower level of cognitive control than the 'high' group.

It is interesting to note that the results received vary from those obtained by other researches, who report that low cognitive component of EF of preschool children is associated with poor behavioural regulation of preschoolers and low compliance with rules (McGlamery et al. 2007; Brock et al. 2009; Williford et al. 2013). In our research the link between a level of EF and a level of compliance with cultural rules is ambiguous: the culture sets the rules of the normative situation, and children, contacting to a rule, differently develop their executive functions, acquiring a certain pattern of executive functioning. It is possible to assume that the influence of the culture may be mediated by the 'developmental niche' of a child (Super and Harkness 1997; Albert and Trommsdorff 2014), where the parenting practices have a greater impact (Karreman et al. 2006; Calkins and Hill 2007; Veraksa 2014; Sobkin et al. 2016). In particular, in one of the previous studies (Sobkin et al. 2016) the connection between the parental style of mothers and the successfulness of completing the EF tasks by their children was revealed. It was shown that children of the mothers who follow authoritarian parental style better coped with sorting the cards according to the shape (DCCS task), than children of mothers who adhere the democratic style of parenting. It is obvious that children's compliance with rules in a normative situation is a huge part of parent's expectations. However, if we see that children of the 'low' and 'high' groups of cultural congruence have a better level of the development of EF, than several questions appear regarding the 'medium' group: To what degree do rules in a normative situation or parent's demands toward children to abide by the cultural rules contribute to the development of EF of a child? Why do children of the 'medium' group of cultural congruence have a worse level of the development of EF? The answers to these questions have to be found. We may assume that children of the groups with the 'high' and 'low' levels of cultural congruence are more sensitive to the culture, than children of the 'medium' level group. We may suppose, that despite the

low level of their congruence, children of the 'low' congruence level group know cultural rules well enough: this group of children can be particularly sensitive to how the cultural rules can be circumvented. The violation of the norm probably requires a certain level of regulation in order to switch between situations, where disobedience is possible (for example, at home) or not (for example, in the kindergarten). Using additional questionnaire for the kindergarten teachers in subsequent research may help to clear this relationship between 'low' level of cultural congruence and relatively 'high' level of cognitive flexibility.

As we explored the differences of EF between clusters of cultural congruence and between girls and boys, it was possible to notice that gender differences discriminate from the differences between clusters. This allows us to draw a conclusion that the gender composition of the clusters does not affect the differences in EF between them.

Another notion of our work is that girls in comparing to the boys have a better level of visual working memory, cognitive flexibility and inhibitory control. These results generally are in line with the previous results received in Russia (see, Veraksa, Bukhalenkova, and Kovyazina 2018). Similar results were obtained by Matthews, Ponitz, and Morrison (2009), who pointed out that girls outperformed boys in both objective measuring and teachers' reports of self-regulatory behaviour in the classroom. Sobkin et al. (2016) found out that girls show better self-control than boys: they better concentrate attention in completing tasks, make less mistakes and do less self-corrections in Inhibition subtest. Many other studies (for example, Olson and Kashiwagi 2000) stress no evident gender differences in the levels of cognitive regulation in children of preschool age. It was discovered that although preschool teachers in Germany and Iceland rated girls as demonstrating significantly stronger self-regulation than boys, this difference was not evident in a more objective, direct measurement of self-regulation (Cornwell, Mustard, and Parys 2013; Von Suchodoletz et al. 2013). We also found out that gender distribution between different clusters of cultural congruence was not even: girls dominated in the group of a 'high' level of congruence, whilst boys prevailed in the group of a 'low' level of congruence. The 'medium' group included boys and girls in equal proportions. These uneven distribution may indicate gender differences in the pressure of cultural norms and demands toward boys and girls and can be analysed through the cultural patterns of Tatarstan.

Limitations and future research

This study has some limitations. It should be noted that it examined only preschoolers from Tatarstan, a national republic in Russia that has its own unique culture and rules of normative situations. Based on the analysis of the plots of folk tales and ethnographic studies of the modern period it was found (Lopukhova and Gulova 2001; Lopukhova 2007) that gender models of Tatar and Russian cultures are different. Separate activity of men and women are traditionally characterised for Tatar people. It leads to the forming of homogeneous sex groups, where men as well as women have to develop the whole spectrum of psychological qualities (such as activity, self-control, dominance, obedience). In Russian culture men and women traditionally have closer social relationships that lead to the necessity to develop complementary psychological qualities (Lopukhova 2007; Valeeva and Gafurov 2017). So, it would be relevant to verify our findings of the research in a different cultural environment.

Another limitation concerns the way we tested children's compliance with the rules. It was measured in accordance with mothers' reports; we did not interrogate fathers or teachers in kindergartens (the questionnaire was developed for parents' assessment). Future studies might include different ways of measuring the compliance with rules in a normative situation to generate more data on the subject. In addition, such meaningful factors of social situation of child development as family structure, number of kids, mother's education were not considered. Effect of all this factors could be investigated in future research.

Practical implementation

By this study we have once again demonstrated that culture influences the formation of EF. More over our study proposes the classification of levels of cultural congruence in children, and indicates the significant connection between EF and a level of congruence of preschoolers of one culture. Despite the fact that there are many studies in the field of EF and their relationship with different cultural models as well as studies about socialisation of children's self-regulation in cultural contexts, the relationship between a way which a child uses to contact a cultural rule, thus becoming congruent to own culture, and the developmental pattern of his/her executive functioning was not studied yet. We have found that the link between cultural congruence and the features of EF has more complicated character than we hypothesised. By 'high' level of executive functioning not only children with a 'high' level of cultural congruence, but, as it turned out, children with a 'low' level of cultural congruence were described: children with a 'high' level of compliance with cultural rules develop executive control to a greater extent, while children with a 'low' level of compliance develop cognitive flexibility.

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