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"Complete the Drawing!": The Relationship between Imagination and Executive Functions in Children

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Abstract: An indirect connection between executive functioning and imagination was revealed earlier in the study of pretend play. This study aimed to explore the relationship between imagination and executive functions in children. Two-hundred-six typically developing children aged 6–7 years were assessed with main executive functions (working memory, inhibition, and cognitive flexibility) and nonverbal imagination (imagination flexibility, image detailedness, image creation strategy, and originality coefficient). Three General Linear Models were built to examine the relationship between executive functions and imagination among children, controlling for age and gender. The obtained results indicate a positive correlation between such characteristics of imagination as originality and flexibility with visual-spatial working memory and cognitive flexibility. However, the data also show that the children who creatively approach the production of new images often experience difficulties with inhibition tasks. The results are interpreted in the context of the educational system and cultural specificities.

Keywords: imagination; creativity; originality; executive functions; working memory; cognitive flexibility; inhibition

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1. Introduction

Imagination is traditionally understood as a universal creative ability that allows the production of new images, combinations, and conjunctions [1,2]. However, its cognitive function is mentioned in research works less frequently [3–5]. Nevertheless, the role of imagination in cognitive activity is of high significance, as by its virtue, we can see the connections and laws of the world around us through images [6,7].

In the scope of various approaches, different functions and definitions of imagination were developed [8]. For example, Gestalt psychology regards imagination as a confrontation of an innate ability to perceive the structures of the phenomenal field with the real objects [9,10]. This confrontation provides the work of such functions of imagination as the solution of cognitive problems, the visualization of ideas, and the search for (and finding) creative answers. Psychoanalysis considers imagination as a tool for building imaginary constructs that release internal tension, which performs mainly a passive protective function (transfiguration or substitution of painful memories, for example) [11]. In the earliest stages of his work on the theory of cognitive development, Piaget understood imagination to represent our reality, associated with subjectivism and distortion of the image of the objective world [12]. Later, this approach switched to the function of imagination as using an idea for anticipating and forecasting the situation dynamics or the behavior of objects [13]. In its turn, cultural-historical psychology understands imagination differently [14]. Vygotsky emphasized that the imaginary images come from the world of adults [15]. Therefore, the development of imagination is related to speech and is taking place within the process of communication with others. From this perspective, the most outstanding function of imagination is the symbolic one. It allows the reflection of reality through sign activity and symbolic forms (i.e., speech, writing, playing, and drawing) [16,17]. The communicative aspect of imagination is no less important because, in this case, imagination is connected with creativity and is directed towards people. Last but not least is the anticipating function: imagination contains the idea and the representation of the goal of one's actions. In his works on the psychology of art, Vygotsky concluded that our imagination works the most productively under the condition of "unity of affect and intelligence." [18]. This means that including all personal experiences is required (intellectual, emotional, and behavioral) [19].

Two types of imagination can be distinguished: passive (daydreaming, dreams) and active (creative production of images) [20]. The latter is related to a person's productive, creative activity and implies the novelty and originality of the new images. This type of imagination is highly required under uncertainty and for the solution of open-ended tasks [3,21]. As may be supposed from their name, these tasks usually do not have ready solutions and allow a person to respond creatively [22]. Nowadays, an extensive range of personal and professional challenges can be categorized as open-ended [23,24]. Uncertainty and openness related to their solving require imagination's active involvement [25,26]. However, in many countries, the development of imagination and creativity is not set as a separate goal within the general education system [27,28]. More often than not, this development finds support in the context of informal and supplementary education, which is determined by the changes in the labor market and, therefore, new professional criteria and requirements [29–31]. For instance, so-called soft skills recently came into the focus [32,33]. They can be purposefully developed using training and self-education in adulthood but are less commonly addressed in school and preschool ages. Even though imagination formation prerequisites appear, all this requires special attention in preschool years [34].

Almost all psychologists, whose research interests included the ontogenesis of mental development, pointed out an active work of imagination in preschool years [10–12,35]. Imagination is entwined into different types of children's activities, first including play. To develop imagination naturally, one needs to create conditions that would support and encourage this development in the earliest stages of personality formation and cognitive, emotional, and behavioral patterns [34]. The reason is that it is the joint input of emotional and intellectual spheres that can enrich the processes of creativity and cognition. Still, it is almost untrainable in a formalized way [36]. Probably, this is why in adult age many find "learning how to be creative" so challenging [37].

This study aimed to explore the relationship between imaginative processes and executive functions in children. Executive functions were chosen as a subject of this research for two reasons. First, preschool education on a global level is inclining in the direction of cold (working memory, inhibitory control, and cognitive flexibility) and hot (reward- or affective-related) executive function development [38–40]. Previous research demonstrated that executive functions are essential for people in purposeful problem solutions [41,42]. In this view, it is interesting to examine if there is any contribution of imagination (primarily involved in solving open problems and problems with the conditions of uncertainty) in executive functions (mainly used for traditional cognitive tasks). An indirect connection of regulation and imagination was revealed before, in the study of pretend play and pretense representation, as methods of executive function training [43–46]. It is explained by the fact that, in play, imagination gives the child an opportunity to act indirectly on a symbolic level through play actions [47–49], or the link between creativity and executive functions has been analyzed in an adult sample [50–52]. Secondly, our theoretical interest is based on Luria's ideas of [53] on the stages of open problem-solving. This researcher suggested three stages: (1) orientation in the problem conditions and goal setting, (2) selection of one of the possible strategies of problem-solving, and (3) implementation of the chosen strategy. Luria also emphasized that of all three, only the first stage requires imagination and the involvement of the person's creative potential.

Meanwhile, the second and the third stages are related to the work of executive functions only. Therefore, our central hypothesis for this study will be that a higher level of imagination development entails demonstrating a higher level of executive function development. The way to prove it will be implementing more complex play and creative ideas with children with a higher level of imagination development. Essential executive functions are also involved in this process.

2. Materials and Methods

Two-hundred-six typically developing children of preschool age participated in the study (53% are boys). At the study's baseline, the age of children was 6–7 years (M = 78.3, SD = 4.34 months). All children attended municipal kindergartens during the research. To provide sample homogeneity from the perspective of socioeconomic status, the entire sample population came from the kindergartens in bedroom communities where most families belonged to the middle class (in Russia, children attend the nearest preschool institutions to their permanent residence address). All parents signed written consent for their children to participate in the study before starting. Moreover, before the diagnostic procedures began, experimenters also asked for oral permission from the child. This procedure was organized in two sessions with a few days break in-between. The duration of the diagnostic interview did not exceed 20 min. The study and consent procedures were approved by the Ethics Committee of Department of Psychology at Lomonosov Moscow State University (the approval No: 2018/41).

Complete the Drawing technique [8] was used for the imagination measurement. The operational definition of imagination in this tool is the capability to create original images. Stimuli consisted of 10 cards, with one unfinished figure on each. The diagnostic procedure was individual. A child was asked to complete each figure to create a whole image. All the children were presented with the same sequence of cards, one by one. Drawings were made in pencil with no possibility of changing or erasing the lines. No time limits were set. Four measures were assessed based on the results of the technique: (1) flexibility—the number of images drawn by each child, which are unique in content and the principle of completing the figure (0–10 points); (2) image detailedness of the pictures—the degree of detail in the drawings reflecting the child's ability to create elaborated ideas and implement them (average score based on all pictures); (3) image creation strategy—the number of "inclusions" of the initial figure into the final image as a secondary element (for example, when a circle becomes a car wheel) instead of using it as the main element (for example, turning a circle into a sun) (0–10 points); (4) originality coefficient—the number of unique images created by each child, different from other drawings by the same participant, and from the productions of other children from their group, based on the same figure.

Memory for Designs [54] to evaluate visual-spatial working memory (max 116 points) with two parameters to consider: memorization of "images" (the task was to select some pictures following an example from a batch of similar pictures) and memorization of spatial locations of the pictures (children had to remember the exact position of the cards).

Dimensional Change Card Sort (DCCS) [55] to evaluate cognitive flexibility. DCCS requires that the child sorts cards; there are three rounds, and rules change for them. Firstly, sorting must be performed based on the color of the picture (pre–switch trial), then on the shape (switch trial), and the last round combines contradictory rules: sorting should be based either on the color of the shape, depending on the presence of a frame in the picture (post–switch trial). For further analysis, we used the total score (the range consisted of 0–24 points).

Statue [54], (3) that allows assessment inhibition (body persistence) (max 30 points). It requires a child to silently maintain a static body position with the eyes closed for 75 s. The child is instructed not to respond to sound distracters, which the experimenter makes four times. Four scores were computed for the Statue subtest—statue, body movement, eye-opening and vocalization, and a total score. The tester recorded the child's number of movements in five-second intervals (e.g., head-turning, eyes opening or vocalizing and laughing).

Jamovi software (The jamovi project, Sydney, Australia, version 1.6), was used for all analyses in the current study. The first step was a descriptive statistic to analyze the data structure and preliminary analyses to check for gender differences in the development of the imagination and executive functions to include them in further analysis. The main analysis was based on General Linear Models. It assessed the relationships between imagination variables (imagination flexibility, image detailedness, image creation strategy, originality coefficient) and executive function variables (visual-spatial working memory, cognitive flexibility, inhibition). Three General Linear Models were built, controlling for age and gender. An alpha level of 0.05 was used for all statistical tests. Partial eta square (partial η^2) was reported to estimate effect size. According to the rules given by Cohen [56] for the eta-squared effect, size interprets as follows: $\eta^2 \leq 0.01$ as small, $\eta^2 \geq 0.06$ as a medium, and $\eta^2 \geq 0.14$ as large effect sizes.

3. Results

3.1. Descriptive Statistics and Preliminary Analyses

Descriptive statistics for all study variables are presented in Table 1. We analyzed gender differences in the development of imagination and executive functions to include them in our further analysis. One-Way ANOVA (Welch's) compared boys' and girls' results by indicated variables. Significant differences were discovered for flexibility, of all the imagination parameters (F (1.197) = 7.29, p = 0.008). The girl's drawings also repeated themselves less, both in content and in the principle of completing the figure (M = 9.05, SD = 1.35), than in the case of the boys (M = 9.50, SD = 0.98). Image detailedness showed a certain difference as well, which was close to significant (F (1.202) = 3.43, p = 0.066). Again, the girls' drawings were a bit more detailed (M = 2.89, SD = 1.08) than the boys' productions (M = 2.60, SD = 1.09). We included the child's gender as a covariate in the further analysis to control the potential level of its influence on the relationships under study. No differences were revealed in the score for executive functions (visual-spatial working memory, cognitive flexibility, inhibition) of boys and girls (p > 0.05).

Table 1. Descriptive statistics for all study variables.

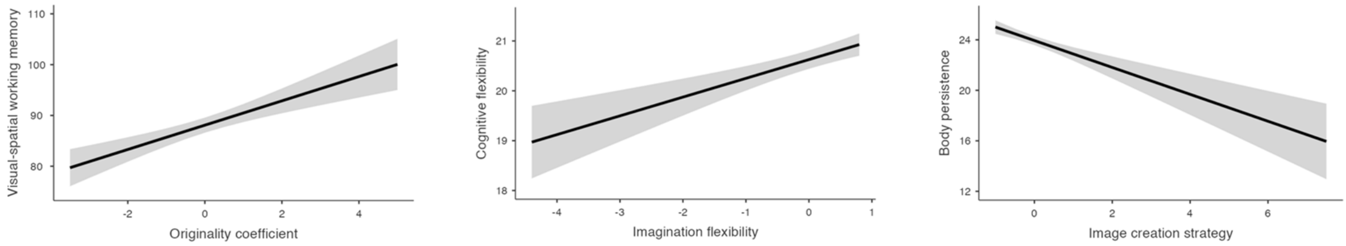
	N	Mean	Median	SD	Min	Max
Flexibility	206	9.26	10.00	1.21	5	10
Image detailedness	206	2.74	2.60	1.09	1	7
Image creation strategy	206	0.84	1.00	1.04	0	8
Originality coefficient	205	4.28	4.00	1.73	0	9
Visual-spatial working memory	203	88.35	88.00	19.42	47	120
Cognitive flexibility	206	20.61	21.00	2.66	12	24
Inhibition	204	24.18	25.00	4.79	6	30

3.2. Imagination and Visual-Spatial Working Memory

Separate general linear model was built to examine the relationship between children's visual-spatial working memory and imagination ("working memory" ~ 1 + "gender" + "Imagination flexibility" + "Image detailedness" + "Image creation strategy" + "Originality coefficient" + "age"). The analysis showed that, when controlling for age and gender, visual-spatial working memory was not significantly related to any imagination variable.

3.3. Imagination and Cognitive Flexibility

Separate General Linear Model was built to examine the relationship between children's cognitive flexibility and imagination ("cognitive flexibility" ~ 1 + "g" + "Imagination flexibility" + "Image detailedness" + "Image creation strategy" + "Originality coefficient" + "Age"). Model info based on ANOVA Omnibus tests (SS = 65.629, df = 5, F = 1.55, p = 0.176, η^2p = 0.038, R-squared = 0.0377; Adjusted R-squared = 0.0134). The analysis showed that, when controlling for age and gender, cognitive flexibility was significantly impacted by the imagination flexibility (see Figure 1b). Children, whose drawings repeated themselves less in the content and the principal of completing the figure, had a better developed ability for cognitive switching (F (1.205) = 5.57, η^2p = 0.023, p = 0.019). Relationships of other imagination variables to cognitive flexibility were not significant (p > 0.05).



(**a**) (**b**) (**c**)

Figure 1. Relationship between executive functions and imagination among 6–7 years-old children, when controlling for age and gender: (**a**) Visual-spatial working memory; (**b**) cognitive flexibility; (**c**) inhibition. Color reflects standard errors of the mean.

3.4. Imagination and Inhibition

Separate general linear model was built to examine the relationship between inhibition and imagination (Inhibition ~ 1 + Gender + 'Imagination flexibility' + 'Image detailedness' + 'Image creation strategy' + 'Originality coefficient'). Model info (SS = 325.01, df = 6, F = 2.82, $p = 0.012$, $\eta^2 p = 0.092$, R-squared = 0.0921; Adjusted R-squared = 0.0594). The analysis showed that, when controlling for age and gender, inhibition was significantly related to the image creation strategy (see Figure 1c). An important imagination parameter—the strategy of inclusion of the initial figure into the final image (instead of using it as the main element)—turned out to be correlated negatively with the children's scores in the inhibition task. The participants who included the offered figure in their creative image demonstrated lower inhibition than the children who completed the figures without more complications ($F (1.205) = 7.25$, $\eta^2 p = 0.045$, $p = 0.008$). The relationship between other imagination variables and inhibition was not significant ($p > 0.05$).

4. Discussion

The analysis confirmed our assumption about the existence of a relationship between imagination and executive functions in preschool age. The obtained results indicate a positive relationship between such characteristics of imagination as originality and flexibility with visual-spatial working memory and cognitive flexibility. However, the results on inhibition turned out to be quite a surprise. Contrasting to visual-spatial working memory and cognitive flexibility, children with a better-developed imagination had a much lower score.

Study results confirm our hypothesis that a higher level of imagination development entails demonstrating a higher level of executive function development. Most probably, an advanced and rich imagination (in particular, the flexibility and the detailedness of created images) provides children with an ability to invent more complex play and creative ideas, which can only be implemented with the active participation of basic executive functions [53]. This turned out to be true for visual-spatial memory and cognitive flexibility. However, as mentioned before, this data also indicates that the children who approach the production of new images creatively and can go beyond the first-level associations often experience difficulties with inhibition tasks. This unexpected outcome contradicts our general study hypothesis. Nevertheless, there are several ways of its interpretation.

First, inhibition is a more emotionally driven psychological process compared to the rest of the executive functions understudy. One could assume that a child's weak skills to control emotional reactions cause a more significant affect when performing a creative task. Since that creative approach to a new image implies a higher level of involvedness and liberation from one-size-fits-all solutions, an insufficient emotional regulation can play against the child. This is because both cognitive and emotional processes are included in creating an original image. Secondly, in Russia, children's emotional development is considered less critical than cognitive and behavioral aspects in preschool education [57]. Children's behavior and interaction are subject to numerous rules in kindergarten, and breaking these rules is not welcomed or even judged by adults [58]. Therefore, children gradually become used to the fact that the adult sets the rules and norms and try their best to comply [59]. Another research that demonstrated that Russian preschoolers were much more advanced in developing ethical emotions (than their German, Italian, Chinese, or Brazilian peers) also confirms this assumption [60]. At the age of 5–6 years (instead of 7–9 in the above-listed countries), Russian preschoolers clearly demonstrated that unacceptable behavior resulted in negative emotions. On the other hand, positive emotions were caused by ethically approved deeds. One could suggest that children associated the performance of the task offered by an adult with other kindergarten-based situations. Therefore, they did it in the "safest", non-creative way. Meanwhile, children with weak inhibition preserved the ability to demonstrate certain freedom and originality in the performance of that creative task, since weak inhibition is associated with behavioral deviations and problems with following the rules.

Several factors could limit the generalizability of the results. First of all, only children of the same age (6–7 years old) from a monolingual urban environment and attending kindergarten participated in the study. In addition to the characteristics of pre-school education in the country of study (described above), the findings may also be culturally related. The 6-D model of cultural aspects of countries [61] indicates a high rate of uncertainty avoidance in Russia. In other words, members of this culture feel threatened by ambiguous or unknown situations. This feature can significantly shape children's imagination development and the educational practices supporting it [62,63].

The results' educational implications indicate the critical role of imagination development at preschool age not only for the development of creative thinking but also for the development of executive functions. The cultural-historical approach considers the image essential for regulating human behavior and cognitive and emotional processes. The research results confirm that the detailing and originality of the imagination do contribute to executive functions. Practitioners' attention to this result may be because, traditionally, the development of imagination has taken place within children's joint creative or play activities. Today, these activities are primarily superseded by children's use of digital devices. Thus, instead of independently creating a creative image and bringing it to life, children interact with ready-made digital products and therefore lose the opportunity to develop imagination and original ideas.

Further research is needed to establish the influence of culture, educational practices, and other factors that may impact the relationship between imagination and executive functions in children. A promising area of study is also whether the intensity of children's use of digital devices affects the development of imagination. If so, what are the mechanisms of this influence?

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