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ORIGINAL PAPER

Play to Foster Children's Executive Function Skills: Exploring Short-and Long-Term Effects of Digital and Traditional Types of Play

Aleksandr N. Veraksa[1] · Nikolay N. Veresov[2] · Vera L. Sukhikh[1] · Margarita N. Gavrilova[1] · Valeriya A. Plotnikova[1]

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Abstract

The purpose of this study was to determine what types of play ensure stable progress in executive functions in preschoolers. Experimental design included six study groups according to the type of play: role play (Free Play group, Adult-Directed Play group, Child-Directed Play group), play with rules, digital play, and control group. All groups were equalized based on the initial level of executive functions. One hundred and thirty-six senior preschoolers aged five to seven years attended 14 play sessions, 20–30 min each. The post-tests on executive functions were conducted immediately after the end of training and 4 months later. The results have shown a sustainable positive effect on the executive functions development for role play and play with rules, while digital play have shown a lasting result only for inhibition. In addition, long-term effects of role play and digital play were significantly higher than in control group. These data point to the developmental potential of role play and play with rules in working with preschoolers.

Keywords Developmental psychology · Preschool age · Cultural-historical approach · Experimental research · Play · Executive function

Resumen

El objetivo del presente estudio fue determinar los tipos del juego que aseguran el desarrollo estable de las funciones ejecutivas de los niños preescolares. El diseño experimental se concluyó en seis grupos de estudio, según el tipo de juego: juego de roles (grupo de juego libre, grupo de juego dirigido por adultos, grupo de juego dirigido por los niños), juego con reglas, juego digital, y grupo de control. Todos los

✉ Vera L. Sukhikh
sukhikhvera@gmail.com

[1] Laboratory of Childhood Psychology and Digital Socialization, Federal Scientific Center of Psychological and Multidisciplinary Research, Moscow, Russia

[2] Department of Psychology, Monash University, Melbourne, Australia

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grupos fueron igualados en función del nivel inicial de funciones ejecutivas. Ciento treinta y seis niños preescolares de edades comprendidas entre cinco y siete años asistieron a 14 sesiones de juego, de 20 a 30 minutos cada una. Las pruebas posteriores de funciones ejecutivas se realizaron inmediatamente después de finalizar la formación y cuatro meses después. Los resultados demostraron un efecto positivo y estable en el desarrollo de las funciones ejecutivas en el juego de roles y en el juego con reglas, mientras que el juego digital demostró el efecto duradero sólo en el caso de la inhibición. Además, los efectos a largo plazo del juego de roles y del juego digital fueron significativamente mayores que en el grupo de control. Estos datos subrayan el potencial del desarrollo del juego de roles y del juego con reglas al trabajar con niños en edad preescolar.

Abstrait

L`objectif de cette étude était de déterminer quels types de jeux assurent un progrès stable des fonctions exécutives chez les enfants d'âge préscolaire. La conception expérimentale comprenait six groupes d'étude selon le type de jeu : jeu de rôle (groupe de Jeu Libre, groupe de Jeu Dirigé par un Adulte, groupe de Jeu Dirigé par l'Enfant), jeu équitable, jeu numérique et groupe témoin. Tous les groupes ont été égalisés en fonction du niveau initial des fonctions exécutives. Cent trente-six enfants d'âge préscolaire âgés de cinq à sept ans ont participé à 14 séances de jeu de 20 à 30 minutes chacune. Les post-tests sur les fonctions exécutives ont été réalisés immédiatement après la fin de la formation et 4 mois plus tard. Les résultats ont montré un effet positif durable sur le développement des fonctions exécutives pour les jeux de rôle et les jeux équitable, tandis que le jeu numérique n'a montré un résultat durable que pour l'inhibition. De plus, les effets à long terme des jeux de rôle et des jeux numériques étaient significativement plus élevés que dans le groupe témoin. Ces données soulignent le potentiel de développement des jeux de rôle et des jeux avec des règles dans le travail avec les enfants d'âge préscolaire.

Introduction

Executive functions (EF) are a cluster of cognitive processes that regulate thinking and behavior to achieve specific goals (2012b; Diamond, 2012a). According to the Miyake model, EF skills include working memory, cognitive flexibility, and inhibitory control (Miyake et al., 2000). Working memory refers to the ability to simultaneously hold target memory items and use them when performing a task. Cognitive flexibility provides focus and/or allows one to switch attention in changing conditions. Inhibitory control determines the ability of a child to inhibit impulsive reactions. In a broader context, EF can be considered as a variety of psychological processes that require purposeful regulation of cognitive processes. They are mainly formed by cultural norms, knowledge and values (Doebel, 2020). From this point of view and according to Vygotsky (Vygotsky, 2004), EF can be represented as a system indicator of the voluntary character of higher mental functions (HMF).

The developmental level of EF in childhood is a significant predictor of the acquisition of basic mathematical concepts (Clements et al., 2016; Jarvis & Gathercole 2003; Veraksa et al., 2022), speech development (Kovyazina et al., 2021; Nilsen & Graham, 2009) and academic performance in school (Best et al., 2011; Morosanova, 2021). EF develop as children grow older (Best et al., 2011; Huizinga et al., 2006). The formation of some more complex cognitive executive processes, for example, planning and goal setting, lasts up to the age of 25 years (Best & Miller, 2010). However, the most intense formation period for EF is preschool age (Fleer et al., 2017a, 2017b, Zelazo & Carlson, 2012). In addition to psychophysiological and genetic factors, the development of EF is conditioned by the environment and the unique experiences of the child. In other words, EF are amenable to targeted training or correction (Bronson, 2000; Diamond & Lee, 2011; Veraksa et al., 2022). Therefore, the search and design of effective tools for the EF development seem to be an extremely urgent goal for the modern preschool education system.

Play as a Tool for Supporting the Development of EF in Early Childhood

According to research, play is an effective way to develop EF in early childhood along with sports, dance, or training classes (2012b; Blair, 2017; Bodrova & Leong, 2006; Diamond, 2012a; Fleer et al., 2020; Shaheen, 2014). However, the great advantage of play is that, compared to other means of improving EF, it is a natural activity for a child; it occurs spontaneously and not only brings pleasure, but also benefits development (Elkonin, 1999; Fleer et al., 2017a, 2017b; Thibodeau et al., 2016; Vygotsky, 2016).

The concept of 'play' can denote different types of child's play activities. Nevertheless, such a generalization may be too rough. Therefore, it is essential to differentiate between the two concepts: play and game. One of the most effective approaches to the theoretical analysis of play as a phenomenon is considered a cultural-historical approach. It not only has great theoretical potential, but also offers an arsenal of tools for analyzing play as a phenomenon (Smirnova et al., 2008; Veraksa et al., 2022; Vygotsky, 2016). According to Vygotsky (2016), game is a certain situation, material or virtual content, while play is a system of rules, roles, narratives and play actions (Vygotsky, 2016). Games vary significantly in their characteristics and allocated parameters. For example, shooting games are not the same as sports simulation digital games. This does not allow us to determine exactly how the psychological development takes place in the game. Meanwhile, according to Vygotsky's conception, every play is characterized by (1) an imaginary situation; (2) rules and roles; (3) play actions (Vygotsky, 2016). Play creates a zone of proximal development by changing the subordination between rules and roles: first the roles dominate over the rules, then the rules begin to dominate over the roles (Veresov & Veraksa, 2022). Therefore, consideration of play phenomenon provides the opportunity to determine its mechanisms of psychological development in the study.

Recently, digital play has also taken its place among various traditional types of play, and it is becoming part of children's daily experience all over the world (Smirnova, 2019; Veresov & Veraksa, 2022). In modern research, the three most

common types of play are *role play, play with rules,* and *digital play* (2012b; Bredikytte & Hakkarainen, 2011; Diamond, 2012a; Gashaj et al., 2021; Oers, 2014). Based on the studies conducted, their impact on the development of EF in children aged 5 to 7 years varies. In this study, the intervention was designed based on those three types of play.

Role Play

Role play is a culturally determined type of child's activity, where they reenact various areas of real life in conditioned situations, that is, they master social roles and communication skills. From the point of view of the cultural-historical approach, role play has the most significant impact on the mental development at preschool age and the most substantial developmental potential for the EF (Bredikytte & Hakkarainen, 2011; Elkonin, 1999; van Oers, 2014; Veresov et al., 2021; Vygotsky, 2004;). Empirical studies confirm the positive impact of role play on the development of EF (2017b; Fleer et al., 2017a; Thibodeau-Nielsen et al., 2020; Veraksa et al., 2022; Veresov et al., 2021). Three key aspects of role play determine its development potential: imaginary situation (Veraksa, 2022; Vygotsky, 2016), acting out different characters (Dickinson et al., 2019; Goldstein & Lerner, 2018; Vasc & Lillard, 2019); rules determined by accepted roles (Bierman et al., 2016; Veresov et al., 2021).

A rich and developed role play demands a lot from a child: to have an idea of the diversity of the surrounding reality, be familiar with a wide range of characters and be able to create and keep in mind an imaginary situation, come up with and develop a plot, accept and follow a chosen character, organize the playing space and select appropriate attributes, use substitute objects, cooperate with peers (Elkonin, 1999; Veraksa, 2022). An adult as a carrier of cultural experience and knowledge can enrich children's play, give examples of actions, roles, and plots. Therefore, the participation of an adult in children's role play can affect its course, scale and richness and, therefore, to some extent, influence the development of EF in children (Veresov et al., 2021).

Play with Rules

Play with rules is a type of play that imposes rules that must be followed throughout the play. The advantage of this type of play for the EF development is that it allows to vary the complexity of the tasks for cognitive regulation by adding new game components, changing and complicating motor or cognitive guidelines (Savina et al., 2017). This allows to regulate and increase the activation level of working memory, cognitive flexibility and inhibitory control. According to some studies, training self-regulation through play with rules shows positive results for knowledge of rules of conduct, working memory for numbers, the ability to switch between verbal and motor actions and inhibitory control (Bukhalenkova et al., 2020; Röthlisberger et al., 2012; Savina et al., 2017; Traverso et al., 2019). However, for example,

in the experiment of McClelland and colleagues (2019), the impact of play with rules on the EF development has been only registered as a trend.

Digital Play and Digital Games

Digital games are programs that organize and direct the play process on various electronic devices. Modern research in the field of EF development shows that digital games have a positive effect on working memory in children (Bergman Nutley et al., 2011; Di Lieto et al., 2020; Thorell et al., 2009), as well as cognitive flexibility and inhibition (Veraksa et al., 2022). However, some studies have documented that the positive short-term effect of digital games on working memory disappears in the long-term if the exposure to the games ceases (Bergman Nutley et al., 2011). The heterogeneous results are probably due to the fact that digital simulators, on the one hand, provide intense engagement, but on the other, they tend to train one specific skill instead of a combination of different EF (Diamond & Ling, 2016). Although contemporary research focuses on investigating digital games, from the point of view of the cultural-historical approach, it is digital play that should be considered as a tool for the psychological development in early childhood (Veresov & Veraksa, 2022). Digital games are virtual content having a purpose and objective, pre-determined settings, rules, steps, actors, etc. While digital play is a system of rules, roles, narratives and play actions.

Therefore, the first aim of the current study was to analyze the influence of the three mentioned types of play (role play, play with rules, digital play) on the EF development from the perspective of the cultural-historical approach. According to the cultural-historical approach, EF are further considered not as a set of cognitive and behavioral skills, but as a system indicator of the voluntary character of HMF.

Sustainability of Effects of Play Intervention

The results of the studies mentioned above confirm the significant impact of role play, play with rules and digital play on the EF development in the short-term (2012b; Bukhalenkova et al., 2020; Diamond, 2012a; Thibodeau-Nielsen et al., 2020; Veraksa et.al, 2022). However, these results were obtained in cross-sectional studies or experiments with a single post-test, and therefore they did not provide an opportunity to study the psychological development of a child in all its complexity and dynamics. The data obtained in such studies do not reflect systemic developmental changes. Within the framework of a single experiment, a psychological change or a new structure can be considered a developmental result only if it meets the principle of sustainable results (Veresov, 2015; Vygotsky, 1984). This principle was proposed by Veresov based on the L.S. Vygotsky's experimental genetic method and his understanding of development as a complex process of qualitative changes in the structure of human consciousness (Veresov, 2014, 2015; Vygotsky, 1984).

According to this principle, there are two outcomes of designing a conditioned developmental situation within an intervention: a sustainable and unsustainable result. The unstable developmental result refers to superficial and short-term

changes in mental functioning, "which do not lead to qualitative shifts in the system of mental functions and in the personality structure" (Veresov, 2015, p. 124). For example, the results of an intervention may significantly exceed the current capabilities and needs of the child, which will not allow them to take hold in natural activity outside the experiment. Or, conversely, an intervention could only lead to quantitative changes. In this case, once the intervention has stopped, the developmental effect levels, so the child returns to the initial point of development or progresses only slightly. Sustainable developmental results, on the other hand, are changes that persist even after the intervention stops. Sustainability of developmental results indicates that the design of the experimental conditions has been effective and that there has been a qualitative shift in development. Therefore, when organizing an experimental study, it is important to take into account the principle of sustainability of developmental results. One example of this principle is Vygotsky's research on the development of cultural memory in children (Vygotsky, 2004, pp. 180–182). Children had to memorize a set of individual words using images. When a child has to memorize a word with the help of an unrelated image (for example, the word "theater" with the help of the "crab on the shore" image), a special auxiliary structure can help to do that ("a crab looks at the rocks at the bottom of the sea, it's beautiful, it's like a theater for the crab"). Memorization obtains a qualitative new form: the child begins to actively create new auxiliary structures in other situations and, thereby, masters the process of memorization.

There are theoretical grounds to believe that play-based intervention can have a lasting effect on the EF development. In terms of the cultural-historical approach, play activity in the preschool period is considered as a factor contributing to the formation of new psychological structures, that is, as a factor ensuring the reorganization of the entire psychological system of the child (Elkonin, 1999). In play conditions, children can do more than in any real situation, which allows them to hone their ability to voluntarily control their cognitive and behavioral processes (Istomina, 1998). In play, children voluntarily train their regulatory functions in various ways, and the acquired skills can be later transferred onto real life activities. Children also deepen their understanding of social roles, norms and values, which, in turn, can foster using EF in ways that are consistent with cultural contexts (Doebel & Lillard, 2023). All this suggests that at least some types of play provide systemic shifts in children's development and contribute to the formation of sustainable training results. However, this assumption needs experimental verification. The following is a brief review of studies that analyzed the results of delayed EF tests.

The sustainability of the effect of pretend play on EF skills was explored in the study by Thibodeau-Nielsen et al. (2020). Fantastical Pretense Play showed significant increase in EF, while Realistic Pretense and Non-Imaginative Play did not have any significant impact on the development of children's EF. However, the delayed post-test was conducted only 2 weeks after the interventions, which was not enough to assess the stability of the results. In Rosas et al. (2019) the performance on the EF in the experimental group (which played games aimed at developing three EF components) stayed higher than in the control group even after 8 months following the pre-test. The study by Rueda et al. (2012) revealed that children who played computerized exercises were able to activate the executive attention network faster

and more efficiently than the untrained children. The effect persisted for 2 months without further training. In Gashaj et al. (2021) study exergames, electronic puzzle games, and board games significantly correlated with inhibition, switching and visual updating for a period of two years.

To date, empirical evidence of long-term impact has been obtained only for role play and games with rules (Rosas et al., 2019; Thibodeau-Nielsen et al., 2020). The data regarding the sustainability of digital games effects are contradictory. Furthermore, most previous studies only evaluated the short-term impact of various types of games on EF (Bukhalenkova et al., 2020; Veraksa et al., 2021). The sustainability of improvements after the interventions remains insufficiently studied. Therefore, the second aim of the current study was to reveal the potential of role play, play with rules and digital play in terms of the sustainability of developmental results.

Current Study

In this study, the sustainability of the results of EF training was investigated for different types of play activity, including traditional types of play (role play and play with rules) and digital play. The experiment with two post-tests was planned and conducted in such a way as to assess the long-term developmental effects. The following research question was put forward: whether the results of the development of EF obtained by means of role play, play with rules and digital play are sustainable and if so for which EF? Short-term developmental effects were discussed in our previous paper (blinded paper). In that paper it was shown that children in all three types of play performed significantly better in EF assessment immediately after the intervention (post-test) than before the play sessions (pre-test). Despite the assumption that role play would have the highest developing potential, digital play have shown the highest efficiency in the first post-test. Digital play, unlike other types of play, influenced all components of EF (blinded paper).

In this paper, we are focusing on long-term effects and analyze changes in EF development at post-test carried out immediately after the intervention and at follow-up post-test carried out 4 months later. Based on the results of the evaluation right after the intervention, and according to the cultural-historical theory (Elkonin, 1999; Veresov et al., 2021; Vygotsky, 1984), and, finally, guided by the principle of sustainable developmental results (Veresov, 2014, 2015), three hypotheses were formulated. The first hypothesis of the study was that the developmental effect of role play on EF will be seen in the delayed assessment. According to the second hypothesis, it was expected that play with rules would also show sustainable results in terms of the EF development. Although play with rules is similar to digital play in terms of play mechanics, from the point of view of the cultural-historical approach, play with rules belongs to one of the latest developmental stages in terms of the evolution of play in preschool age (Elkonin, 1999). Finally, the third hypothesis of the study was that, in the long-term, digital play would have less impact compared to other types of play despite its good short-term effect.

Methods

Participants

The study was carried out in 2020–2021. The overall sample comprised 196 children (90, 52% males) aged 5 to 6 years (mean age 60,71 months) attending federally funded kindergartens in Moscow, Russia, at the time of the pre-test. Participants were excluded from the analysis due to the absence of delayed post-test results ($N=24$), ceiling effect ($N=20$), transition to another kindergarten ($N=3$), absence during the intervention ($N=5$) or attendance of less than seven sessions ($N=8$). The number of children in the final sample under the analysis was 136, of whom 71 (52%) were male and 65 female (48%).

The parents of each participant gave their written consent for their child to participate in the study, the children were asked for their intension and assent to participate in play sessions. The sample size was determined by the number of kindergartens and teachers who allowed the intervention. Not all children from the classes participated in the intervention, some just followed the usual curriculum. This allowed the formation of six groups equal in sex, age, and initial level of EF which were randomly divided between experimental and control conditions. The study was approved by the Ethics Committee of the Faculty of Psychology of Lomonosov Moscow State University.

Procedure

The study was conducted using a randomized experimental design with repeated measures. It had several stages. First, children's EF were assessed using the NEPSY-II subtests (2020b; Korkman et al., 2007; Veraksa et al., 2020a) (T1). After evaluating their EF, the children were divided into 6 groups: Free Play group ($N=30$), Adult-directed Play group ($N=29$), Child-directed Play group ($N=29$), Play with Rules group ($N=29$), Digital Play group ($N=30$), Control group ($N=30$). All groups were equalized based on the initial level of EF.

A 7-week long intervention was performed. For each group, 14 experimental play sessions lasting 20–30 min each were held for mini-groups of 4–6 children. Not all children from the kindergarten group were included in the experiment. The sessions took place twice a week at kindergartens in equipped rooms for extracurricular education (similar to regular kindergarten classrooms). Classroom teachers were not involved in them to avoid the influence of the child's previous experience of communication with the teacher. EF testing and intervention were conducted by experimenters with psychological education. Experimenters interacted with children through all the intervention, which made it possible to establish trusting contact with the children and to avoid stress of getting used to a new adult every time. The experimenter who organized the play sessions could not test children from his/her study group. The assessment of the EF development, similar to the baseline diagnostics, was conducted: post-tests immediately after the intervention (T2) and 4 months

after the end of the intervention (T3). Differences in the time and duration of the assessment were excluded: all groups completed training at the same time, testing was performed in standardized way during two meetings with each child. Thus, the groups differed only in type of intervention. All other procedures were identical.

EF Assessment

The "The Dimensional Change Card Sort" test was used to assess cognitive flexibility (Zelazo, 2006). This technique consists of three tasks for sorting cards. First, the child must sort the cards by color, then by shape, and eventually, to follow a complex rule: if a card has a frame, it must be sorted by color, and if there is no frame, by shape. The test took 7–10 min. To measure EF the NEPSY-II subtests were employed (2020b; Korkman et al., 2007; Veraksa et al., 2020a). The NEPSY-II "Sentence Repetition" subtest was applied to evaluate verbal working memory (2–3 min). This test consists of 17 sentences that gradually become more difficult to remember due to their length and grammatical structure. To assess the cognitive inhibitory control, the NEPSY-II "Naming and Inhibition" subtest was used (5–10 min). In particular, it evaluates the speed of information processing and inhibition of impulsive reactions. The first task is to identify the form (circle or square) as quick as possible. The second task is to do everything contrariwise: for example, if a square is demonstrated, he/she is supposed to say "circle" and so on. The NEPSY-II "Memory for Designs" subtest was employed to evaluate visual working memory (4–6 min). This test requires memorizing image details and their spatial location correctly. The Statue subtest was used to evaluate behavioral inhibitory control (2–3 min). In this test, the child needs to maintain a stationary body position with his/her eyes closed for 75 s, restraining impulsive reactions in response to distracting sounds. Diagnostics of EF were performed individually during two meetings with each child. The tests were conducted in a quiet secluded place.

Intervention

Role Play Intervention

Three types of role play intervention were developed—1) Free play, 2) Adult-Directed Play and 3) Child-directed play. They only differed in the level and function of an adult's involvement, as well as in the way the sessions were organized. The conditions did not differ in any other way including the play context or attributes. Three play contexts were designed with their specific sets of characters and attributes: the Magic Kingdom, the Lion King, and Space. At each session, the children switched characters.

In the *Free Play intervention,* the adult only helped children to start playing (for example, suggest explore attributes and space) and did not intervene anymore. Thus, Free Play intervention involved all the EF components: working memory (the child had to remember the plot line and keep in mind other characters), inhibition (the

child had to stay within the character and follow its logic), and cognitive flexibility (the child had to simultaneously follow the logic of the assigned character and the logic of the plot).

Adult-directed Play intervention suggested that the adult controlled the distribution of characters and the plot development of the game. He or she told the designated story to the children and they tried to follow it in a pretend play. All interactions, actions and replicas were spontaneous but performed following the theme and the logic of plot and characters. In this case, the load on working memory was significantly reduced as the adult controlled play context, children's performance, and compliance to the character, if necessary. In other words, the adult took on the functions of inhibition and cognitive flexibility. She or he also basically set an example of "mature" role play and taught children how to play. For this intervention, a new scenario was prepared every session.

In *the Child-Directed Play intervention,* the role of the adult–"the director"–was transferred to one of the children. An adult helped this child to distribute characters, create a game plot and act it out with other children. It should be noted that the load on the directors' EF increased significantly, since he or she had to control the plot and the performance of other participants. Meanwhile, for the other children, the level of engagement and, thus, the development of EF remained the same as in the Adult-Directed Play group. Each play session consisted of two stories with two children performing the director's functions. All participants assumed this position in turns, so each child had to do it 4 times on average.

Play with Rules Intervention

Three board games (in Russian edition) were chosen for this experimental group: "Sleeping Queens" (Gamewright™), "Barabashka" ("Geistesblitz", Zoch Verlag™), and "Outfoxed"(Gamewright™) (see Appendix 1). Each game involves 3 to 5 participants and a gradual increase in the complexity of the rules. The time required for each game was 15–30 min. During one session the children played one type of board games. After the completion of the first round participants could start another round if there were more than 10 min left before the end of the play session. "Sleeping Queens" is a game with cards where one has to get rid of the cards and wake up the princesses. Each card (character) suggests an action, changes the plot line, or the rules. This game activates switching (one should quickly switch between cards with different characters and keep in mind the constantly changing external context) and working memory (the child should remember the story and all the plot twists). "Barabashka" engages behavioral inhibition, visual working memory and cognitive flexibility. The aim of the game is to grab the totem located in the center of the table, but under certain conditions. That is, the child has to grab the right figure faster than the others (reaction speed) and not touch the wrong one (inhibition). In order to do that, the child has to memorize the right object from the cards (visual working memory). At the same time, the conditions determining whether it is a right moment to grab the totem change regularly, so it also requires switching. "Outfoxed" is a detective game. Players move around a playing field in search of clues or open cards

with information on suspects scattered all over the field. The goal is to find the Fox who stole the pie. This game involves visual and verbal working memory more than any other EF skill, since children must remember all the facts gathered throughout the game. Such a set of games allowed each EF component to be involved equally. During each session, the experimenter played one game with the children. His or her task was to observe, help the children, and remind them of the rules, if necessary.

Digital Play Intervention

Three games targeting different components of EF were selected for this study group: "Fruit Ninja" (Halfbrick Studios™), "Focuz—sort the cards fast!" (Eng Tat Lim™), and "Dots" (Aristide flandrin™) (see Appendix 1). All games gradually increased in task complexity as the child was mastering the skill and provided feedback on the successful or failed steps. 'Fruit Ninja' activates behavioral inhibition due to the significant emotional engagement it creates. In this game, the player has to randomly cut flying fruits while avoiding bombs. The increase in difficulty occurs through changing speed, the number of objects appearing on the screen and the intervals between their appearance. In other words, "Fruit Ninja" is aimed at the development of behavioral inhibition. "Focuz" involves sorting cards. First, by two colors (blue and red), and then by three (blue, red and yellow). At the same time, sorting places in different tasks change, which requires children to switch to a new condition. This game mostly engages cognitive flexibility. In the "Dots", the child needs to identify new dots appearing on the screen among the ones that are already there. The dots are added one after another, but differ in color and location. It is assumed that this game boosts visual working memory, as the player must remember the colors and the location of already existing dots, while spotting the new ones. This intervention by means of digital play took place in groups, but the children did not interact with each other. Each child had an individual iPad. At the first play session, the experimenter told the children about the Spy Academy, where the students were taught to be fast and focused. This imaginative element was used to increase motivation. During each play session the children played all three games in the same order, 5 to 7 min for each *game.*

Control Group

Control group participants attended classes of identical duration (20 min). During the sessions, the experimenter read a story, after which the children were asked to draw what they wanted. The children from the Control group were read the same stories as the children from other study groups. This procedure was used to control the mere presence of narrative and characters, without group interaction or action. In this case, drawing did not directly involve EF but implied some use of verbal working memory and planning skills. Therefore, reading to children could develop these components of EF.

Table 1 Descriptive Statistics for every EF skill measure before (T1), right after (T2) and 4 months after the intervention (T3) in different study groups with the Kruskal–Wallis test for group differences

EF measures in each study group	T1 M ± SD	T2 M ± SD	T3 M ± SD
Cognitive flexibility			
Free play group	17.7 ± 1.4	19.2 ± 2.51	19.9 ± 3.18
Adult-directed play group	17.8 ± 1.94	19.1 ± 2.15	20.6 ± 2.58
Child-directed play group	18.3 ± 1.99	18.3 ± 2.93	18.9 ± 2.39
Play with rules group	17.5 ± 2.13	19.1 ± 2.72	19.9 ± 2.77
Digital play group	18.4 ± 2.17	19.3 ± 2.22	18.7 ± 3.22
Control group	19 ± 2.44	18.9 ± 2.95	20.1 ± 2.55
Kruskal–Wallis test, *p*	$p = 0.111$	$p = 0.847$	$p = 0.454$
Verbal working memory			
Free play group	17.8 ± 2.01	18.1 ± 1.94	19.3 ± 2.67
Adult-directed play group	16.8 ± 3.95	16.8 ± 3.99	18.3 ± 3.58
Child-directed play group	16.9 ± 3.58	18.3 ± 3.88	18.8 ± 3.97
Play with rules group	16.5 ± 3.11	18.1 ± 3.45	19.1 ± 3.94
Digital play group	18.1 ± 3.63	19.2 ± 2.9	18.3 ± 3.61
Control group	16.8 ± 3.43	18.1 ± 3.56	20.2 ± 5.77
Kruskal–Wallis test, *p*	$p = 0.325$	$P = 0.745$	$p = 0.682$
Cognitive inhibition			
Free play group	8 ± 3.17	11.9 ± 3.55	11.8 ± 2.76
Adult-directed play group	9.9 ± 2.61	10.9 ± 3.82	12.8 ± 3.24
Child-directed play group	8.26 ± 3.22	9,95 ± 3.31	12.6 ± 3.82
Play with rules group	8.82 ± 3.27	12 ± 3.02	12 ± 2.67
Digital play group	9 ± 2.03	11.7 ± 2.79	12.1 ± 2.95
Control group	10 ± 2.45	11.9 ± 3.07	13.1 ± 2.53
Kruskal–Wallis test, *p*	$p = 0.085$	$p = 0.172$	$p = 0.733$
Visual working memory			
Free play group	63.2 ± 9.83	68.2 ± 17.4	73.6 ± 18.1
Adult-directed play group	62.7 ± 15.2	75.8 ± 20.3	83.1 ± 21.2
Child-directed play group	61 ± 14.7	72.9 ± 22.8	77 ± 20.6
Play with rules group	66.9 ± 15.2	78.3 ± 21.2	88 ± 22.7
Digital play group	58.7 ± 10.3	76.3 ± 17.8	73.3 ± 25.5
Control group	71.3 ± 16.2	73.8 ± 20.5	82.5 ± 18.6
Kruskal–Wallis test, *p*	$p = 0.086$	$p = 0.694$	$p = 0.153$
Behavioral inhibition			
Free play group	26.6 ± 3.42	28 ± 2.58[a]	28.8 ± 1.71[b]
Adult-directed play group	21.8 ± 6.07	26.8 ± 5.82	26.5 ± 7.31
Child-directed play group	26.2 ± 3.21	25.1 ± 5.3	26.3 ± 4.89
Play with rules group	24.7 ± 4.48	26.4 ± 3.68	25.6 ± 4.3
Digital play group	23.3 ± 7.09	24.2 ± 5.85[a]	25.8 ± 5.19[b]
Control group	24.2 ± 4.15	24.7 ± 4.57	26.9 ± 3.22
Kruskal–Wallis test, *p*	$p = 0.183$	$p = 0.02$[a]	$p = 0.016$[b]

Table 1 (continued)

[a]There was a significant difference between groups at T2 for behavioral inhibition; the post-hoc t_{Tukey}-test revealed that in the Free Play group, the participants performed better than in the Digital Play group ($p < 0.05$)

[b]There was a significant difference between groups at T3 for behavioral inhibition; the post-hoc t_{Tukey}-test revealed that in the Free Play group the participants scored higher than in the Digital Play group ($p < 0.05$). Also, other results showed no significant group differences ($p > 0.05$)

Data Analysis

One-way analyses of variance (ANOVA) were conducted on the groups to test whether there were any differences between study groups at pre-test; and on sex to control for possible sex-dependent differences in EF development. Change over time (T1–T3) was calculated for EF measures by repeated-measures ANOVA using data from the participants who completed the tests in all time points. Intervention was

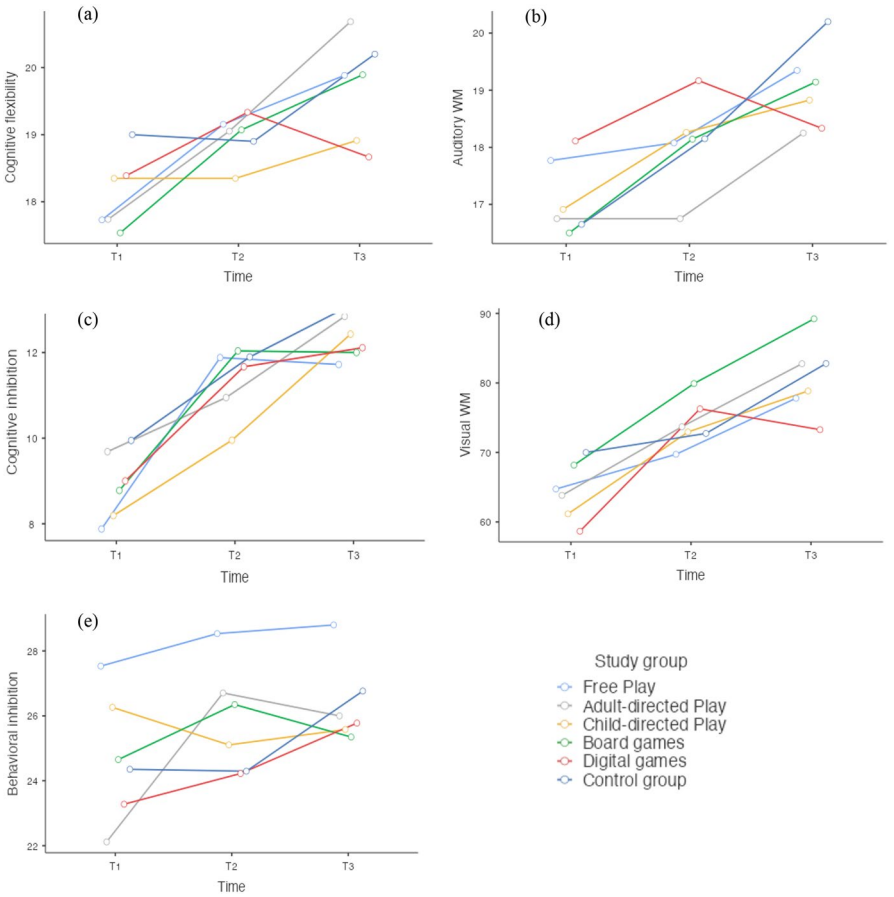

Fig. 1 Group marginal means for each of the EF at pre-test (T1), post-test (T2) and follow-up test (T3)

used as the between-subjects factor to explore the main effect of this factor on the EF development. There were 6 levels of the intervention as the between-subjects factor: Free Play group, Adult-directed Play group, Child-directed Play group, Play with Rules group, Digital Play group, Control group. Regression analysis was performed to check the second study hypothesis that progress in EF at T3 for the Digital Play group would be lower compared to other interventions. The significance was established at a p value of 0.05 throughout the analysis.

Results

Preliminary Analysis and Descriptive Statistics

One-way ANOVA on ranks did not reveal any significant differences between study groups at pre-test for any of the EF components (the Kruskal–Wallis test, $p > 0.05$ for each component of the EF). Table 1 provides an overview of descriptive statistics, including the mean scores, standard deviation for each of the EF measures at T1, T2 and T3 for each of the six study groups and the results of the Kruskal–Wallis test for group differences. There were also no significant differences in the preliminary EF assessment between boys and girls (the Kruskal–Wallis test, $p > 0.05$ for each component of the EF). Therefore, a further analysis of group differences was carried out without limitations.

The Dynamic of EF Measures Across the Study Groups

Repeated-measures ANOVA examined main and interaction effects of the intervention factor on the dynamics of EF development and its change over time (T1-T3). Time, one of the within-subjects factors, included 3 levels: EF scores at T1, T2 and T3. Intervention as the between-subjects factor included 6 levels: Free Play group, Adult-directed Play group, Child-directed Play group, Play with Rules group, Digital Play group, and Control group.

A significant time effect (T1–T3) was evident in the cognitive flexibility results ($F(5,2) = 21.63$, $p < 0.001$, $\eta^2_p = 0.061$). A significant interaction effect of time and intervention ($F(5,10) = 2.07$, $p < 0.027$, $\eta^2_p = 0.029$) has been recorded. As seen from Fig. 1a, the participants from the Digital Play group have shown a decrease in cognitive flexibility scores at the T2-T3 period, while in other study groups the indicators have improved.

For verbal working memory, children have shown a significant growth over time ($F(5,2) = 25.22$, $p < 0.001$, $\eta^2_p = 0.045$). The interaction effect of time and intervention ($F(5,10) = 1.92$, $p < 0.043$, $\eta^2_p = 0.017$) has been found. Also, there was a decrease in scores in the Digital Play group at T3 (see Fig. 1b). Meanwhile, participants under other experimental conditions have shown progress in verbal working memory development at T3.

Table 2 Results for the model predicting performance on EF at T3

Stability regression pathways	*b*	SE	*p*
Cognitive flexibility T1 → cognitive flexibility T3	0.255	0.128	0.001*
Cognitive flexibility T2 → cognitive flexibility T3	0.413	0.08	< 0.000*
Auditory working memory T1→ Auditory working memory T3	0.393	0.121	< 0.001*
Auditory working memory T2→ Auditory working memory T3	0.303	0.119	0.003*
Cognitive inhibition T1→ Cognitive inhibition T3	0.372	0.09	< 0.001*
Cognitive inhibition T2→ Cognitive inhibition T3	0.198	0.08	0.026*
Visual working memory T1 → Visual working memory T3	0.467	0.153	0.041*
Visual working memory T2 → Visual working memory T3	0.082	0.107	0.420
Behavioral inhibition T1 → Behavioral inhibition T3	0.0949	0.123	0.430
Behavioral inhibition T2 → Behavioral inhibition T3	0.1834	0.121	0.123

Significant predictive models are marked with *

Analyses for cognitive inhibition have revealed only a significant main effect of time ($F(5,2)=71.68$, $p<0.001$, $\eta^2_p=0.183$). Inhibitory control improved significantly from T1 to T3 among all children as shown in Fig. 1c.

For visual working memory, the results indicated a significant change over time ($F(5,2)=7.911$, $p<0.001$, $\eta^2_p=0.112$). As seen in Fig. 1d, participants in the Digital Play group have shown a decline in scores at T3, while other groups have shown an increase.

There was a significant main effect of time ($F(5,2)=4.99$, $p=0.008$, $\eta^2_p=0.02$) and intervention ($F(5,2)=2.29$, $p=0.05$, $\eta^2_p=0.054$) for behavioral inhibition. Specifically, the Digital Play group participants showed significantly lower score at T2 and T3 compared to the children from the Free Play group (Post Hoc, $t(103)=3.105$, $p_{\text{Tukey}}=0.029$, $\eta^2_p=0.03$).

Comparative Analysis of EF Score Gains at T3 in Different Study Groups

Regression analyses were performed to assess if the Digital Play intervention was less effective than other interventions for training EF in the long-term. The predictors of performance at T3 were the results at T1 and T2 tests. The Digital Play group was chosen as the reference level based on the second study hypothesis that the gain in the EF at T3 in the Digital Play group would be smaller compared to the gain in the other groups. The results indicated that the model was significant for cognitive flexibility ($R^2=0.347$, $F(7,126)=8.3$, $p<0.001$), verbal working memory ($R^2=0.431$, $F(7,127)=11.9$, $p<0.001$), cognitive inhibition ($R^2=0.257$, $F(7,121)=5.18$, $p<0.001$) and visual working memory ($R^2=0.323$, $F(7,103)=6.08$, $p<0.001$) but not for behavioral inhibition ($R^2=0.107$, $F(7,101)=1.3$, $p=0.0110$). In the Table 2 and below is more detailed information about the predictors for each EF component at T3.

Therefore, cognitive flexibility at T3 was significantly predicted by cognitive flexibility performance at T1 ($\beta=0.255$, $p=0.001$) and T2 ($\beta=0.413$, $p<0.00$). Results at

T2 were the strongest predictor. Moreover, cognitive flexibility at T3 was lower among children who were playing digital games compared to children from the Free Play group ($\beta=0.541$, $p=0.036$), the Adult-directed Play group ($\beta=0.839$, $p=0.003$), the Play with Rules group ($\beta=0.581$, $p=0.023$) and the Control group ($\beta=0.413$, $p=0.051$). Verbal working memory at T1 ($\beta=0.393$, $p<0.001$) and T2 ($\beta=0.303$, $p<0.003$) predicted the performance on this skill at T3. Improvements in verbal working memory at T3 were significantly lower in the Digital Play group than in the Play with Rules group ($\beta=0.489$, $p=0.041$) and the Control group ($\beta=0.736$, $p=0.004$). Scores at T1 and T2 were also significant predictors ($\beta=0.372$, $p<0.001$ for T1 and $\beta=0.198$, $p=0.026$ for T2) for cognitive inhibition results at T3. Intervention turned out to be an insignificant predictor. Participants from all study groups showed the same progress. For visual working memory at T3 only the performance at T2 ($\beta=0.467$, $p<0.041$) was found to be a strong predictor. Results at T1 were insignificant predictors. It was found that the Play with Rules participants demonstrated better results at T3 for visual working memory than the children from the Digital Play group. No significant predictors for behavioral inhibition at T3 were revealed. Inhibition performance at T1 and T2, intervention did not predict children's scores in behavioral inhibition at T3. Study groups did not significantly differ from each other.

To sum up, cognitive flexibility at T3 was lower in the Digital Play group compared to four other study groups: Free Play, Adult-directed Play, Play with Rules and Control group. Verbal working memory performance at T3 in Digital Play was worse than in Play with Rules and Control group. The Play with Rules group has also shown better results at T3 for visual working memory than the Digital Play group. Meanwhile, neither cognitive nor behavioral inhibition was significantly predicted by the intervention (Table 2).

Discussion

The main goal of this research was to find out 1) which types of play activity (role play, play with rules, digital play) provide lasting, sustainable results in terms of the EF development in preschoolers and whether the positive effect of role play, play with rules and digital play on the EF development can last beyond the intervention. The analysis has shown a significant increase in indicators for all EF four months after the end of the intervention. At the same time, the scores in the first and second tests had predicted the results of the third test for all EF except behavioral inhibition. Based on the resulting models of the EF developmental dynamics throughout three assessments, it can be seen that children who participated in Free Play group, Adult-directed Play group, Child-directed Play group and Play with Rules group retained their EF level formed during the intervention at least for four months after it ended. Although the children from the Digital Play group showed solid progress immediately after the intervention, their positive shift proved less stable than the results in other groups in the delayed testing. The analysis results indicate a decrease in scores in the Digital Play group for cognitive flexibility, verbal, and visual working memory in the delayed post-test. In terms of cognitive flexibility, the Digital Play group showed significantly lower scores than the Free Play group, Adult-Directed Play group, Play with Rules group, and Control groups. On verbal working memory, the

Digital Play group showed a smaller increase than Play with Rules group and Control group. On visual working memory, the Digital Play group performed significantly worse than the Play with Rules group. However, children in all groups, including Digital Play, demonstrated stable results in cognitive and behavioral inhibition.

The results obtained, firstly, indicate that EF are susceptible to targeted training and correction. Secondly, they confirm the assumption that play activity significantly contributes to the development of EF in preschoolers. These results are consistent with other EF development studies (2012b; Bukhalenkova et al., 2020; Diamond, 2012a; Fleer et al., 2020; Moore & Russ, 2008; Thibodeau et al., 2016; Veraksa et.al, 2022). At the same time, they are clarifying existing data. In particular, the developing effect of EF training at preschool age can be long-term, but only if it is based on role play and play with rules.

Role play (Free Play group, Adult-directed Play group and Child-directed Play group) has indeed shown sustainable impact even 4 months after the end of intervention. That confirms the first hypothesis of the study. Play with rules group has also been shown to have a long-term positive effect on EF, which is fully consistent with the second hypothesis of the study. The level and sustainability of the developmental results obtained through these two types of play point to the similarity of some of the developmental mechanisms inherent to both types. For example, aspects such as interaction with peers, flexible system of roles and rules, an imaginary situation, intense engagement, and excitement are common traits to role play and play with rules. These features largely determine their developmental potential (Bierman et al., 2016; Thibodeau et al., 2016; Veresov & Veraksa, 2022) and provide advantages over digital play. These data are consistent with other studies with delayed assessment (Moore&Russ, 2008; Rosas et al., 2019; Thibodeau-Nielsen et al., 2020). However, in the current work, more sophisticated diagnostic tools were used, which allowed not only for general assessment, but also for measurement of separate EF. The influence of different types of play on the EF development was considered and compared. In addition, the period for the long-term assessment has been extended.

Based on these results, indicating the sustainable impact of EF training, it can be assumed that role play and play with rules can contribute not only to the improvement of individual EF, but also to the restructuring of interfunctional connections (Veresov, 2014, 2015; Vygotsky, 1984). Firstly, that gives reason to believe that role play and play with rules provide a qualitative shift in the children's mental development. This underlines the importance and relevance of designing effective developmental tools based on role play and play with rules and integrating them into the system of modern preschool education. Secondly, that may confirm that the EF could be considered not just as a set of behavioral and cognitive self-regulation, but as a system indicator of HMF. Putting the EF in this broader perspective opens up prospects for further research in the field of child development. Digital play has proven to be less effective tools for the long-term development of cognitive flexibility, verbal, and visual working memory than role play and playwith rules. However, all the analyzed types of play including digital play have shown a stable training effect for cognitive and behavioral inhibition. Probably, the sustainable developmental effect on the inhibitory control in all groups is due to the fundamental role of rules in the play activities designed for the current research (Dickinson et al., 2019; Elkonin, 1999; Goldstein & Lerner, 2018; Veraksa et al., 2020a, 2020b; Vygotsky, 1984). All the

formative interventions during the study required a fairly consistent and strict rule following: whether it be the rules of behavior, the adherence to the character (in case of Free Play group, Adult-Directed Play group and Child-Directed Play group), or instructions to board games or digital games. At the same time, the adherence to the rules involves planning and controlling emotional and impulsive reactions, which is directly related to both cognitive and behavioral inhibition. It should be clarified that the digital games selected for the study were aimed at training only visual, but not verbal working memory. And yet, probably due to the transfer effect, the children showed improvements in verbal working memory right after the intervention (Rueda et al., 2012; Veraksa et al., 2022). But this effect turned out to be unstable. For inhibitory control, digital play has shown a sustainable developmental impact. Thus, the third hypothesis of the study was partially confirmed.

Based on these results, it can be assumed that digital play does not lead to lasting improvement in cognitive flexibility and working memory, but can provide sustainable development of inhibitory control. However, it cannot be said with certainty that digital play contributes to systemic changes in children's development. Apparently, they rather train separate mental processes without qualitative reorganization of the mental structures. Despite the fact that digital play was aimed at training EF, its unsustainable effects may be due to the absence of such important developmental aspects of play as: creation and development of an imaginary situation, interaction with peers, introduction of rules through a cultural normative situation (Veresov & Veraksa, 2022). In common digital play includes virtual but not imaginative situations, pre-determined rules and no peer-cooperation. This reduces child's opportunities to master cultural psychological tools. Meanwhile, mastering psychological tools is the basis for mastering one's behavior and developing self-regulation (Veresov & Veraksa, 2022; Vygotsky, 2004). The increase in the digital play's developing potential may be associated with the strengthening of the mentioned play aspects.

Unexpected results were obtained regarding the development of behavioral inhibition. On the one hand, we failed to build a valid predictive model to describe the results for this EF component in the delayed post-test. Also, the regression analysis has not shown any differences between the Digital Play group and the other groups in the delayed testing. However, according to the analysis of means, children from the Free Play group scored significantly higher in behavioral inhibition in the second and third assessments than children from the Digital Play group. In other words, the groups differ from each other in absolute scores, but the actual progress between the post-test and the delayed post-test was the same for these groups, as can be seen in the graphs. This result may be due to the possible initial differences between the groups, which were not statistically detected when comparing the 6 interventions, as well as the ceiling effect of the technique. Despite the fact that the children who got the maximum score were excluded from the analysis, a large number of participants showed high results in the pre-test (for example, 28–29 points out of 30).

Further research vectors may be aimed at designing and implementing developmental tools based on role play and play with rules for preschool institutions. With their help, it would be possible to achieve a significant impact on the children's

development and increase their school readiness. In addition, further analysis of the factors and conditions that contribute to the less sustainable effect of digital gaming on the EF development in preschoolers will allow to identify the key limitations of this type of play activity and, probably, find ways to overcome them.

Limitations

The limitation of this study is primarily due to the lack of additional qualitative tools which would allow investigating what type of changes occurred during the intervention, and to make sure that these changes depicts qualitative reorganization of psychological processes (Veresov, 2015). Additionally, the study groups were formed within existing kindergarten groups, which implies well-established relationships between the children. This factor can be a hidden variable in the analysis of formative influences, because social interaction is crucial in play (Bierman et al., 2016). Information was also collected on the socioeconomic status of participants, as it can affect EF development (Noble et al., 2007). Finally, at each stage of the EF assessment, some children dropped out of the experiment, which is a common problem in this type of study.

Conclusion

A sustainable positive impact on all components of EF in preschoolers has been proven for training by means of role play and play with rules. Role play and play with rules not only contribute to the improvement of individual EF but also may lead to the restructuring of interfunctional connections and systematic, qualitative changes in a child's development. Meanwhile, digital play, despite its good short-term effect, have only shown sustainable results for inhibition. Digital play trains separate mental processes without qualitative reorganization of the mental structures. This data point to the developmental potential of play, in particular, role play and play with rules. They also open up prospects for applying these tools while working with preschoolers.

Appendix 1

See Table 3.

Table 3 Links to original editions of board and digital games

Title of the game	Link
Sleeping queens	Sleeping queens	GameWright. (n.d.). Gamewright. Retrieved August 29, 2023 https://gamewright.com/product/Sleeping-Queens
Geistesblitz (Barabashka in Russ.)	Geistesblitz	Zoch Verlag. (n.d.). Retrieved August 29, 2023 https://www.zoch-verlag.com/zoch_en/categories/card-games/geistesblitz-5-vor-12-601105054-en.html
Outfoxed!	Outfoxed!	Gamewright. (n.d.). Gamewright. Retrieved August 29, 2023 https://gamewright.com/product/Outfoxed
Fruit Ninja	Fruit Ninja®| App Store. (n.d.)..Halfbrick Studios. Retrieved August 29, 2023 https://apps.apple.com/ru/app/fruit-ninja/id403858572
Focuz—sort the cards fast!	Focuz—sort the cards fast! ® App Store. (n.d.). Eng Tat Lim. Retrieved August 29, 2023 https://apps.apple.com/by/app/focuz-sort-the-cards-fast/id1150864951?l=ru
Dots	Dots ® App Store. (n.d.). Aristide flandrin. Retrieved August 29, 2023 https://apps.apple.com/us/app/dots-memory-game/id1120100453?ign-mpt=uo%3D4

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical Approval The study was approved by the Ethics Committee of the Faculty of Psychology of Lomonosov Moscow State University.

Research Involves Human Participants The parents of each participant gave their written consent for their child to participate in the study.

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