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DEVELOPMENTAL RESEARCH AND PRACTICE IN CULTURAL-HISTORICAL PSYCHOLOGY

On the 125th anniversary of Lev Vygotsky

Controversy and Growth Points in the Activity Theory in Psychology

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Background. Activity theory is the most powerful and influential current of Russian psychology in the world today. It considers the psyche to be a special form or function of object-oriented activity. The level of psychical development of a living being is directly proportional to the variety and freedom of its activities.

Objective. The aim of this article is to explore the key growth points in activity psychology through the analysis of arguments among its creators — S.L. Rubinstein, L.S. Vygotsky, A.N. Leontiev, and P.Ja. Galperin. Vygotsky dreamed of building a scientific psychology on the model of Marx's *Das Kapital*; his project is resumed in this article.

Results. The author traces how, due to Walter Cannon's experimental research, Vygotsky came to the activity concept of affect, in which he finds the primary "cell" of the psyche. The problem of the relationship between concept and affect became the central problem of his "acmeistic psychology." While Vygotsky focused on the affective reflection of activity in the subject, Leontiev focused on its cognitive side, directed toward the object. In the objective world, the psyche serves a person's material life-activity, performing a search-and-orientation function. Leontiev considered consciousness a structural projection of that activity, but Galperin argued that Leontiev never managed to overcome the dualism of consciousness and activity.

Conclusion. A new path to the realization of Vygotsky's dream is outlined. The proposed solution is based on Spinoza's concept of affect and the idea of freedom, interpreted as "the affect in the concept." (Vygotsky)

Keywords:

Activity;
action; affect;
perezhivanie;
freedom

Introduction

Marxism has always claimed to be a theory of action. Its cornerstone is the concept of labor, practice, or activity, understood as the process of transforming both the external world and human beings themselves. Naturally, Marxist psychology, since its birth, has also declared that the psyche¹ is derived from activity, *i.e.*, that it is a special form or function of object-oriented activity.

Already at the beginning of 1926, L.S. Vygotsky formulated the key postulate of the psychological theory of activity: “Mind (*psikhika*) is the formation of something stable amidst the streaming. It is a selection organ, a sieve, which changes the world so that we can act.” (2018, p. 92)

Vygotsky then criticized the widespread materialistic notion of psyche as a mere reflection of objective reality. A thermometer also reflects something real; it is important to understand *what and how* the psyche reflects. It is a selective reflection: only what is *valuable to the activity* is fixed as a psychical phenomenon. If everything were reflected in the psyche indiscriminately, as in a mirror, then it would be impossible to orient oneself in the limitless and chaotic sensory stream, and to find what is required for life. Activity would be blind. “If we would see (be conscious of) everything, we would see nothing.” (Stern) The psyche discerns and singles out the stable, the self-identical, “distorting reality to the advantage of the organism,” and each sense organ reflects the world with its “coefficient of specification.” (Vygotsky, 2018, p. 92)

At first, Soviet psychologists, feeling sympathy for American behaviorism, tended to blend the concepts of activity and behavior. Thus, the first edition of the *Great Soviet Encyclopedia* had no entry for “Activity,” but a huge article on “Behaviorism” was commissioned from John B. Watson “in view of the novelty of the topic and the great interest he aroused among modern scientists, including Marxists.” (Watson, 1927, p. 434)

There was also no entry for “Activity” in B.E. Varshava and L.S. Vygotsky’s *Psychological Dictionary* (1931). At the same time, however, Vygotsky and other Soviet psychologists were beginning to develop their variants of activity theory. Vygotsky dreamed of “creating our *own Das Kapital*” for psychology (1997b, p. 330; 2018, p. 87). No more, no less. Let us see how far he and his school succeeded in this task.

The aim of this article, though, is not so much to tell the story of the past as to define the weak spots inside activity theory; they are, at the same time, its *growth points*. These promising flaws are best seen as forks in the road of thought, occurring in the course of polemics and mutually critical attacks undertaken by the creators of activity psychology. We should listen to their dialogue and try to participate in it. The archives that have been opened in recent years can help us here. In them, we see that the disputes were conducted frankly and without undue politesse. Many discrepancies and arguments between the parties have not previously appeared in print. For example, the recently published volume of Vygotsky’s notebooks contains previously unknown materials about his polemics with Aleksei Leontiev. Formerly, we only knew about that “schism,” which decided the future of activity psychology, from Leontiev himself.

¹ I use the term “psyche” for Russian *psikhika*, and “mind, mental” for the *human* psyche or the higher (cultural) psychological functions, in Vygotsky’s sense.

**S.L. Rubinstein versus A.N. Leontiev:
the Internal and the External in Activity**

Sergei Rubinstein started to develop the concept of activity back in 1922, asserting that activity creates its own subject. He proposed to place this principle of “creative self-activity” at the foundation of pedagogical practice (Rubinstein, 1989).

In his *Fundamentals of General Psychology* (1940), Rubinstein described a scheme of activity in which a certain “internal change” is located between stimulus and response. This “internal change” includes all the processes of life-activity and bodily states that affect particular actions. It is just this factor that makes the active reaction of a living being different from mechanical reactions in inanimate nature. Even the simplest organism can react differently to the same external stimuli, depending on its internal state at the time. “The higher the level of development, the greater the role played by internal conditions.” (Rubinstein, 2003, p. 126)

Spinoza called the internal state of a living body which influences its ability to act, “affect.” But Spinoza, unlike Rubinstein, understood that any internal change is an *effect, a reflection of the external activity* of this body. In the absence of external activities, there are no internal changes. That is why God-substance, acting only on itself, does not change and has no affect.

In 1959, a year before his death, Rubinstein criticized the cultural-historical theory of interiorization developed by Leontiev and Galperin for not taking into account how cultural schemes of activity are refracted through the prism of “initial internal preconditions in the individual.” These are “organic, natural, in particular physiological, conditions,” *i.e.*, genetically inherited bodily structures and innate automatic reactions. In the historical development of mankind, they “play an invariable, that is *constant, role*.” (Rubinstein, 1973, p. 223)

Since man stands at the top of the evolutionary ladder, his activity should depend on these natural factors as much as possible, given that “the higher the level of development, the greater the role played by internal conditions.” At the same time, Rubinstein declared *social, cultural* schemes and norms of activity to be *external* conditions of human development. The process of their interiorization was interpreted by Rubinstein as the “determination of abilities from the outside.”

A.N. Leontiev, for his part, argued that the subject’s body itself is formed by object-oriented activity, both its morphology and brain structure, and how they react to external stimuli. The empirically observed dependence of activity on the structure of the body is, in fact, the dependence of the *current* act of activity on its own *previous* acts which formed this or that bodily structure. The “internal” and the “external,” subject and object, are not preconditions of activity, but *its extreme poles*. In the process of activity, the “external” and “objective” are transformed into the subjective, and vice versa. The very person, the “particular subject,” is presented here as “the *inner moment of activity*.” The category of activity now comes to light in its actual fullness, as embracing both poles — both the pole of object and the pole of subject.” (Leontiev, 2004, p. 122)

Leontiev embraced the activity principle far more profoundly and more consistently than Rubinstein. It is wrong to consider interiorization of cultural forms of

activity as a determination of the psyche from *outside*, he said. After all, culture is created by activity and constitutes the objectively tangible form of its own being. The process of interiorization simply means a *change of activity form*, the re-appropriation and de-objectification of what was previously “posited” by the activity itself as an artifact of culture.

Higher, specifically human activity is joint, collective activity. It always occurs in society as an internal, immanent condition of human life. Among the external, “prehistoric” conditions of *human* activity and mind are body morphology, innate reactions, and everything that was formed in the processes of *animal* activity, all that was not created by human labor.

Rubinstein mistakenly took natural factors for “the internal” and, vice versa, regarded the real internal (cultural, specifically human) as something external to the human mind. Hence his reproach of the “mechanistic nature of this [cultural-historical] interpretation of personality and the development of its abilities, since the very activity of the subject is thought to be determined *only* by the object, *only* from the outside.” (Rubinstein, 1973, p. 227)

Here Rubinstein understands the “subject” as an *individual*, and the “object” as any thing *outside* this individual, regardless of whether it is a natural thing or an artifact. For cultural-historical theory, this difference is extremely significant. The world of artifacts belongs to the subject and forms the “inorganic body” of the human mind. The true subject is not an individual organism with its genes and reflexes, but a human community, *i.e.*, a circle of people sharing a common body of culture. Every single “higher psychological function,” in Vygotsky’s terms — *i.e.*, every specifically human mode of mental activity — is of social origin. The individual acquires such functions only by way of cultural communication with other humans.

The alternative to the cultural-historical stance is the individualistic stance: a particular body and psyche vs. the outside world. Marx called the view of the world from the standpoint of abstract individual a “Robinsonade.” In psychology, such a Robinsonade is an illusion as natural as believing in the rotation of the Sun around the Earth. In the course of their polemics, A.N. Leontiev bypassed this foundational feature of Rubinstein’s criticism of the concept of the interiorization of higher psychological functions and corresponding human “abilities.”

Both Rubinstein and Leontiev knew very well that any activity is always *reflected* in its subject in its current state. It remained to realize that the psyche is nothing but this reverse reflection of activity, or its “reflection into itself,” as Hegel would say.

All activities end in a double result: on the one hand, the form of the external object changes, and on the other, there is a change in the state of the acting subject. The change that subjects themselves undergo in the process of object-oriented activity Spinoza called “affect,” with the caveat that the class of affects includes only those changes which influence the individual’s activity potential, or “the affections of the body by which the body’s power of acting (*agendi potentia*) is increased or diminished, aided or restrained.” (*Ethics*, III, def. 3)

At this point Vygotsky took the baton from Spinoza. “Affect is the alpha and omega, the first and last link, the prologue and epilogue of all mental development.” (1998, p. 227)

From then onward, the psychology of activity forked into two branches. Vygotsky focused on the affective reflection of activity in the subject, while Leontiev focused on the cognitive side, directed towards the object; specifically, he concentrated on the search and orienting function that the psyche fulfills in the objective world.

L.S. Vygotsky: Affect in the Structure of Activity

Marx wrote that the history of industry was “the exposure to the senses of human psychology.” In Vygotsky’s eyes, another open book of human psychology is *art*, especially theater.

In his early manuscript *The Psychology of Art*, the principle of object-oriented activity is not formulated and plays no significant role. The whole study revolves around the concepts of emotion and affect. The activity of imagination is defined as the “discharge of affect,” art as the work of “very special emotional thinking.” And the collision of affects, or “affective contradiction,” forms the “true psychological basis for our aesthetic response.” (Vygotsky, 1987b, pp. 48-49, 138) At the same time, the *activity nature* of affect, and of the psyche in general, remains on the far side of the Moon.

However, even earlier, and already in his first major work *Educational Psychology*, Vygotsky declared that “an emotional reaction is a powerful guide of behavior. It is in an emotional reaction that the activity of our organism manifests itself. ... At every turn, the emotions act as the ruler of behavior.” (Vygotsky, 1997a, p. 102) “The transition to a psychical type of behavior undoubtedly occurred on the basis of the emotions,” he adds. The natural cycle of psychical activity begins with the affect of desire and ends with the affects of pleasure and displeasure. These emotional reactions, “which arise earlier than all the other reactions, are the primary forms of a child’s purely mental behavior.” (*Ibid.*, p. 103)²

In August 1930, the journal *I Want to Know Everything* published a small article entitled “The biological basis of affect,” written by Vygotsky in response to the question from a “group of readers.” The major portion of it was a popular retelling of Walter Cannon’s *Physiology of Emotions*.³ Its central thesis ran as follows: in animals, affect serves “basic life instincts,” preparing the organism for activity. The major emotions have an “energizing effect” upon the organism, releasing its inner “reservoir of power.” (*cf.*, *agendi potentia*)

Vygotsky could not help but recognize in this thesis Spinoza’s definition of affect as a state of the body that increases and aids (as in Cannon’s experiments), or diminishes and restrains, (as in Luria’s “combined motor method” experiments or in Freud’s clinical practice with neurotics) the body’s power to act.

But Vygotsky sought to distinguish between animal and human affects. The “progressive development of emotions” consists in replacing innate reactions by *ideas*. “What Cannon demonstrated was that it is not the emotions themselves that die away, but only their instinctive component. The role of the emotions in the human mind is different [than in animals]. They are isolated from the instinctive domain and

² In the English edition of Vygotsky’s *Educational Psychology*, “*aktivnost*” is rendered as “purposefulness,” *psikhicheskiy* as “passive,” etc. I corrected the terms in quotations.

³ The title of the Russian edition (1927) of Cannon, 1920.

transferred to an entirely new plane” (Vygotsky, 1987a, p. 332). This is the ideal, the cultural plane.

With this, an entirely new problem arises — the issue of the relationship between idea and affect. In the course of trying to solve this problem, Vygotsky years later, in 1932, turned again to the art of theater. The actor is a professional creator of affect, trying to bring the viewer to the point of the “highest emotional shock,” he argued. In doing so, what happens in the actor’s own soul?, Diderot asked. Vygotsky’s answer: it depends entirely on his *culture*, the world of ideas in which the actor’s soul is immersed. Theatrical affects are *ideal*; they don’t reflect and represent organic processes in the actor’s body, but in people’s social life.

“These are idealized passions and movements of the soul; they are not natural, live feelings of one actor or another; they are artificial; they are created by the creative force of man and to that extent must be considered as artificial creations, like a novel, a sonata, or a statue.” (Vygotsky, 1999, p. 239)

Vygotsky called the idealized cultural emotion *perezhivanie*, effectively equating these two terms: “The experience (*perezhivaniya*) of the actor, his emotions...” (*Ibid.*, p. 244) The tower of human consciousness is built of “bricks” of *perezhivaniya*. But, unlike bricks, *perezhivaniya* are fluid and changeable; these “soul movements” are able to change their meaning during life, including under the influence of theatrical acting, or reading a novel or poem.

Emotional *perezhivaniya* get their meanings from *ideas*. The culture of feelings is to *idealize passions*, that is, to subordinate natural affects to the highest goals of social life, and to teach people to 1) induce the required affect, and 2) change the “order and connection” of their emotions. Emotion is embedded as a dynamic element into a certain (historical) system of ideas. This is “the path to mastery of emotions, and, consequently, the path of voluntary arousal and artificial creation of new emotions. [...] Only indirectly, creating a complex system of ideas, concepts, and images of which emotion is a part, can we arouse the required feelings.” (Vygotsky, 1999, p. 243)

In recent years, the notion of *perezhivanie* has come to the forefront in Vygotsky studies. In his lectures on child psychology, *perezhivanie* was defined as a “dynamic unit of consciousness.” It is the internal relationship of a person to things and events of the external world, which includes attention, thinking, and emotions, and contains “all the basic properties of consciousness.” (Vygotsky, 2001, p. 213.)

A.N. Leontiev regarded the turn to the study of consciousness and *perezhivanie* as a departure from activity theory. But in fact, Vygotsky’s notion of *perezhivanie* was a further development of the activity concept of affect. Vygotsky vindicated “the understanding of affect as an integral psychophysiological reaction that *includes in itself experience [perezhivanie] and behavior* of a certain type and represents a unity of the phenomenal and objective sides.” (Vygotsky, 1999, p. 159; *emphasis added*) Commenting on Gregorio Maranon’s experiments, Vygotsky wrote of an “internal interweaving of experience [*perezhivanie*] and the organic reaction in the composition of affect.” (*Ibid.*, p. 93)

Thus, *perezhivanie* is a social affect, observed from its internal, or “phenomenal” side. And human consciousness is a system of *perezhivaniya* as the “idealized passions and movements of the soul.”

L.S. Vygotsky: the Psychology of Freedom

Already in January 1924, in his paper at the Congress on Psychoneurology, which opened up his pathway into Big Science, Vygotsky posed the problem of “liberation from the most terrible slavery, the slavery to oneself, and from the most bitter dependence, the dependence on one’s own nerves and psyche.”⁴ This is how he translated Spinoza’s statement about freeing a person from slavery to his affects into a language familiar to psychoneurologists.

To the extent that a man subdues and controls his own affects, he becomes master of his behavior and mental life. An infant, like an animal, is a slave to its natural desires. The adoption of cultural norms of behavior, ideas, always involves “moderating and restraining affects” (Spinoza). From the material of natural affects, people create artificial emotions, *perezhivaniya*. Natural affects are moderated and restrained by cultural ones. How this happens is seen clearly already in children’s games. Every rule of a game is an idea. Games give the child the first experience of the self-reliant regulation of his or her affects through ideas.

While natural affects serve the body’s vital activity, cultural affects serve the activities of society. These are the states of the collective “quasi-body” (Spinoza) or “inorganic body” (Marx) of mankind. Being “grown” into the psyche of an individual, they allow him to emotionally experience (*perezhivat*) things that are useless, if not harmful, in a biological respect, but valuable to society.

Behind every cultural emotion there stands an *idea* — a norm or scheme of social activity. Ideas are assimilated (interiorized) through affects, together and simultaneously with affects. If an idea did not get the slightest emotional response, it simply would not be grasped. The soul would remain deaf to it.

Ideal emotions rebuild the biological system of affects, establishing a cultural order and connection between them. “Like all other mental functions, emotions do not remain in the connection in which they are given initially by virtue of the biological organization of the mind. In the process of social life, feelings develop, and former connections disintegrate; emotions appear in new relations with other elements of mental life, new systems develop, new alloys of mental functions and unities of a higher order appear within which special patterns, interdependencies, special forms of connection and movement are dominant. To study the order and connection of affects is the principal task of scientific psychology.” (Vygotsky, 1999, p. 244)

Science should help a person tame the “wild” affects by organizing them intelligently, *i.e.*, in accordance with the order and connection of ideas. This is exactly the same thing that art does, only by other means. Both scientific psychology and art solve the problem of rational management of the stream of *perezhivaniya*; they both aspire to liberate the soul from the natural slavery to affect.

Vygotsky saw the key to the solution in the *concept*. Brought to the light of consciousness, *conceptualized* affect ceases to be a slave, or passive bodily state. “The affect in the concept becomes active” (Vygotsky, 2018, p. 410). “To understand the affect is an active condition and is *freedom*. *Freedom*: the affect in the concept.” (Vygotsky, 2018, p. 209)

⁴ The paper has not yet been published; it is quoted in Zavershneva, 2009, p. 130.

Hence, art is an *exercise in freedom*. Art puts affect at the service of concept. Here, the human mind learns to command passions and to direct its feelings towards higher, ideal goals. This process of the psychological liberation of the personality is the subject matter of practical training for the artist, and the subject of theoretical research for the psychologist.

Art and scientific psychology have the same subject matter and solve the same problem. Vygotsky came close to this idea but did not formulate it directly. In *The Psychology of Art*, art was seen as a kind of affective vaccination, allowing us to develop immunity to the passions of real life and, thus, to acquire psychological “superhealth.”

The “acmeistic psychology,” or “height psychology,”⁵ that Vygotsky intended to create, can be defined as the *psychology of freedom*. This is a theory of forming a “self-active free person” (*samodejatel'naja svobodnaja lichnost*). That is what Spinoza taught us. “He all the time investigates the question as to how the *motion* toward freedom *really* takes place: toward *a life guided by reason* — and this is freedom. His central idea is the power of reason.” (Vygotsky, 2018, p. 209)

“Spinoza’s theory *implicite* contains the whole acmeistic psychology, the whole theory of concepts, affects and volition, the semantic and systemic structure of consciousness, which we *explicite* developed. Spinoza has the *idea* of man, which can serve as a model for human nature: This makes his theory of the passions the prolegomena for a psychology of man.” (Vygotsky, 2018, p. 375)

Both Spinoza and Vygotsky sought to teach man to think and live freely; both saw the purpose of their science as increasing man’s activity potential and degrees of freedom.

In outlines written during the last years of his life, Vygotsky drew a plan of a three-storied building of human psychology:

- 1) “the direct movement from life to consciousness”;
- 2) “the inner reality,” the realm of consciousness, inhabited by *perezhivaniya*, *znacheniya* (meanings), and *smysly* (purposes), where “communication with oneself” goes on; and
- 3) “the reverse movement from consciousness to life (consciousness changes life).” (Vygotsky, 2018, pp. 354–355)

The first floor was the fiefdom of instrumental psychology. Here, the “external in-growing (of the *sign*)” takes place; Vygotsky and his team had been investigating this process since the mid-20s.

Next came the “internal ingrowing (of *meaning*)”; this was the topic of his book *Thinking and Speech*.

Construction of the third floor was just begun in *The Teaching about Emotions*. The process of a person’s transition to free, rational conscious life can be called the *exteriorization of consciousness*.

⁵ In Russian, *vershinnaja psikhologia*. The interpreters have not yet agreed on how best to translate it. Literally, *vershina* means a peak of a tree or a mountain. In his notebooks, Vygotsky uses the synonymous expression “acmeistic psychology.” Acmeism was a realistic trend in Russian poetry that was sharply opposed to symbolism; Mandelshtam defined acmeism as the “longing for world culture.” And Vygotsky contrasts *vershinnaja psikhologia* with *Tiefenpsychologie* (depth psychology), which explains human behavior and culture by unconscious processes.

A.N. Leontiev and P.Ja. Galperin: Looking for the Nature of Psyche

Leontiev departed from Vygotsky's concept early on, before reaching his "second floor." Moving into the "inner reality" of consciousness seemed to him a betrayal of the activity approach. He wished to continue studying consciousness as a form of human objective-practical activity. "Seek the consciousness of man here, in the objective world!" (Leontiev, 1994, p. 39)

For Vygotsky, that approach defined only the initial stage of research, which had already passed. Yes, *in the beginning* was the Act, but then the Act *became the Word* and gave rise to consciousness. "The meaningful word is a microcosm of human consciousness." (Vygotsky, 1987c, p. 285) Now he starts to analyze of how purposes (*smysly*) are formed in consciousness.

Meanwhile, Leontiev drew cultural psychology back to external activity, in the bosom of which consciousness was born. Vygotsky commented that: "Development is ignored. Everything is moved to the beginning. But then everything [is to be moved] to the conception. The most important thing does not take place in the beginning, but in the end, for the end contains the beginning. The height (*vershinnaja*) viewpoint. [We] should not work near the lower boundaries all the time." (2018, p. 247)

The transition from life practice to consciousness was only the first floor of scientific psychology. Research should not remain stuck at this early stage, "near the lower boundaries." Furthermore, consciousness should be investigated as such, in its inner reality, and then in its outer, practical implementation. The "height/acmeistic" subject matter of psychology is *conscious life*, or what is the same, *human freedom*.

"The direct movement (from life to consciousness) is only important to the extent that it allows us to understand the *reverse movement* from consciousness to life (consciousness changes life), the dependency of life on consciousness." (Vygotsky, 2018, p. 355)

Leontiev could not help but respond to his teacher's challenge. In the 1930s, he went back to the subject of emotions.⁶ One of the sections of his doctoral thesis was devoted to this topic. The work was conceived as the first volume of his monograph *Development of the Psyche*; it has not been published, but some key statements are known from Piotr Galperin's letter of October 1940 to Leontiev (Galperin, 1997). Leontiev explained the problem of linking affect and intellect, bequeathed by Vygotsky, through the relationship of activity and action. Here, affect was quite rightly defined as "the internal representation of activity." Galperin called this definition "deep and important" and approved the concept of psyche as the "internal form of activity" derived from the external activities that take place in the physical world.

However, he continued, "precisely the understanding of psyche as activity remains undeveloped [in Leontiev's book]. It is more likely postulated and applied in a broad genetic construction than it is revealed and substantiated as such. And this leads to the replacement of psyche as activity by psyche within activity, psyche stand-

⁶ Leontyev's first address to this topic took place back in his student years, at the suggestion of his supervisor Georgi Chelpanov. Then, along with Aleksander Luria, they studied "objective symptoms of affective reactions" with the apparatus for recording disorders in fine motor movements.

ing behind activity and remaining a set of phenomena and *perezhivaniya* of consciousness as before.” (Galperin, 1997, p. 4)

In other words, Leontiev failed to *derive* the inner world of consciousness from the external, object-oriented activity. But this was the main point of his theoretical program, as opposed to Vygotsky’s program. Leontiev’s closest associate insisted that the problem remained unsolved.

“In fact, in the scheme you sketched, there stands out clearly a parallelism of consciousness and behavior. In behavior — activity, action, operation; in consciousness — affect, purpose, meaning. [...] Consciousness represents and reproduces, in its own language, the plot of actions and things. It is true that activity is mediated by ‘reflection’ and is one with it. But what kind of activity? External, non-psychological activity! *And when we are asked what **psychical** activity itself is*, it turns out to be affect, purpose, meaning, *perezhivaniye*, etc.” (Galperin, 1997, p. 4)

Thus, the psyche is declared to be activity and considered through the prism of external activity. “That is good, but that is not quite what we set out after,” Galperin concluded, referring to the time they began moving away from Vygotsky about eight years before. As a solution, he proposed to regard the phenomena of consciousness, *perezhivaniya* as “*subjective visions*.” All such are “*not the actual, but only a former psyche*,” they are, in a sense, the Platonic shadows of real orienting activity. This is how to overcome the dualism of the external and the internal (actions and *perezhivaniya*) within human activity.

Obviously, Leontiev did not approve such a radical massacre of the inner world of consciousness. His book offered a more complex and cautious solution to the problem, namely, to depict consciousness as a structural projection of activity. On the internal mental plane, the triad *activity — action — operation* takes the form of *affect — purpose — meaning*. “In general, man’s activity is internally linked to affect, action to purpose, and operation to meaning.” (Galperin, 1997, p. 4)⁷

There are two things worth noting in this formulation:

- 1) On the plane of consciousness, affect is activity’s double. Hence, consciousness is nothing but the *affective form* of activity.

Vygotsky would scarcely object to that; but he could add that this is the definition of the psyche in general, not only human consciousness.

- 2) Meaning is correlated with *operation*; by that Leontiev removed semantics from the scope of psychology. Meaning, as operation, becomes a psychological phenomenon only when transformed into a component of the living activity of the individual.

This objection to Vygotsky was then developed and substantiated in Leontiev’s book *Activity. Consciousness. Personality*,⁸ but here, again, without mentioning the name of his opponent, Vygotsky.

⁷ This passage from Leontiev’s *Development of the Psyche* is cited verbatim in Galperin’s letter.

⁸ “Meanings and the operations, contained within them, *in themselves*, that is, in their abstraction from internal relations of the system of activity and consciousness, are not at all the subject of psychology.” (Leontyev, 2004, p. 111)

In *The Basic Processes of Mental Life* (1940), Leontiev proposed a new understanding of affect as an experience (*perezhivaniye*) of the difference between the motive and the result of activity (Leontiev, 1994, p. 49). The activity concept of *perezhivaniye* is elaborated in the first of his four “philosophical notebooks.” On the same pages, we find the assertion that sensation, forming the “germ cell” of psyche, is nothing but affect. “Sensation emerges as a feeling, as a vague sensation — affect.” (*Ibid.*, p. 164)

The thesis of the affective nature of the psyche was not covered in Leontiev’s published works, let alone systematically developed. Leontiev commented on it in his later lectures on general psychology, but without using the term “affect.” He asserted that the first, most ancient forms of sensitivity are diffuse; there is not yet a boundary between the states of a feeling body and the states of the external bodies it perceives. Differentiation between the “gnostic” and emotional functions of sensitivity “occurs slowly throughout biological evolution.” (Leontiev, 2001, p. 51)

Thus, first, Leontiev actually agreed with Vygotsky that the psyche begins with affect. But in subsequent years, the term “affect” became a rare guest in his work, and the meaning of this term was narrowed to “strong, sudden emotional phenomenon.” (*Ibid.*, p. 462)

Realizing the Kapital Dream

“When we want to see an oak with all its vigor of trunk, its spreading branches, and mass of foliage, we are not satisfied to be shown an acorn instead” (Hegel, 2005, p. 75-76). Soviet psychologists did not get too far in realizing Vygotsky’s *Kapital* dream. The Spinozist Vygotsky came to the conclusion that the “cell” of psyche is affect. Later, Leontiev talked about “a vague sensation — affect,” in which the feeling of the object of activity with the feeling of the active body are merged.⁹ But Leontiev does not distinguish between passive and active affects, and does not admit that they determine activity. Only by reflecting itself in the affective “mirror” does the objective motive becomes the *internal, psychological* determinant of activity.

Criticizing Vygotsky’s views, Leontiev argued that “affect is not a *driving force*” (1994, p. 40). One can answer with the words from the Foreword of Cannon’s book: “Fear, rage and pain, and the pangs of hunger are all primitive experiences which [...] are properly classed as among the most powerful that determine the action of men and beasts. A knowledge of the conditions which attend these experiences, therefore, is of general and fundamental importance in the interpretation of behavior.” (1922, p. vii)

Vygotsky cited these words with approval, and he undoubtedly intended to build the science of behavior on the basis of the concept of affect. Of course, we must not forget that affect is the attribute of activity. Behind affect, there stand needs on the one hand, and objective motives on the other. Affect is the effect of their interaction. As such, this interaction is studied in the sciences of material life and represents an

⁹ Vygotsky called this kind of vague sensation “affective perception,” in which “emotions and perceptions are not yet differentiated between them.” This psychological function is formed in the early childhood first and occupies “the dominant place in relation to all the others” (2001, p. 98–99).

“antediluvian” condition for the emergence of the psyche, along with the body’s morphophysiology, biochemical reactions, and so on.

Affects are the “perturbations” in the state of the body that determine its ability and readiness to act. This is also the definition of psyche in general, with the reservation that the “body” of *higher* mental forms is *objective culture*, which includes the organic body of the person, developed by human labor. Cultural, ideal affects are as different from natural affects as an orchard is from a wild wood.

The activity process consists of two opposite phases merged in each specific action: a *direct* effect upon the object and a *reflected* effect generating affects. An analysis of the phases of activity allows us to define the specificity of *psychical reflection* (see Maidansky, 2021).

What is the place and role of the psyche in the activity process? Leontiev and Galperin, for all their differences, saw this role in *orienting to the object*. This shifts the focus to the first phase of activity. However, here the psyche serves material life activity as one of its internal moments, along with simple irritability and metabolic processes. Only in the second, affective phase of activity does the psyche find its special content, different from the “physical” one. Here it forms its own “cells,” its specific domain. “The grandiose signalistics of speech” (Ivan Pavlov) are formed from the matter of emotional-expressive reactions.

As the wealth of bourgeois society consists of commodities, so the wealth of the psyche consists of affects; they are its living tissue, its flesh and blood. Affect represents, on the one hand, the wants and needs of a living being, and on the other, a sensual image or idea of an external thing (Marx liked to compare commodities with mirrors). This is, so to speak, the use-value and the exchange-value of affect.

Like commodities, affects live their own lives in processes of mutual exchange, in the element of *communication*. Here, the psyche is opposed not to the “mute” object, but to *another* psyche with its personal affects. It is necessary to deduce logically the universal forms of this interaction of “souls,” just as Marx deduced the value forms of commodity exchange in the first chapter of *Kapital*.

Empirically, it is not difficult to detect three forms of affect exchange: 1) a simple or immediate form of communication; 2) a signaling form; and 3) a language or symbolic form. The last is created by human labor and is a universal form of *cultural* activity. Vygotsky understood language in the same vein. In the language “market,” not only affect, but also thoughts and ideas are exchanged. The word succeeds in combining communication (speech) and thinking.

As early as Wolfgang Köhler, it was acknowledged that in the animal world, communication and affective life have almost no overlap with intellect and rational behaviors. Similarly, in early human childhood, speech communication develops independently of thinking. Even in adults, reason and passions are often at odds. But one fine day they conclude an alliance: thinking is poured into a word, and affect is cast into the form of a concept, becoming a cultural emotion. This is a man’s first step towards freedom.

According to Vygotsky, the evolution of mind is a process of its liberation from slavery to the passions, just as for Marx, human history is the path to the “realm of freedom” (*Reich der Freiheit*) through the Golgotha of alienated labor.

"Freedom is not given; it is taken. It is not primordial but achieved in a difficult inner struggle. Man can become free, but this is as excellent as it is rare. The path to freedom leads through steep summits. Freedom does not lie in the plain; it is not accessible and within easy reach for everyone. It lies not at the beginning but at the end of a person's path. It is inaccessible to the child. It is not located in the depths but in the summits of the mind." (Vygotsky, 2018, p. 374) This is why Vygotsky called his unfinished project "height" or "acmeist" psychology.

Following the author of *Theses on Feuerbach*, Vygotsky might say: the psychologists have only *interpreted* human life in various ways, but the point is to *change* it. Or, as he wrote down on a scrap of paper: "To preserve life is the main function of the passions. To change life is the main function of consciousness." (Vygotsky, 2018, p. 221)

Das Kapital showed us how an entire economic formation grows out of a commodity "cell." Marxist-oriented psychology should show how the "oak" of *psychological* formation grows from the "acorn" of affect, that is, to demonstrate a series of evolutionary stages that differ from one another "by the order and connection of affects." In this way, I believe, Vygotsky's dream would come true, were we to take it seriously.

In Soviet psychology, formational theories were developed by Aleksei Leontiev (sensory psyche, perceptive psyche, intellect, and consciousness) and Pavel Blonsky (memory in its motor, affective, imaginary, and verbal forms). But they were empirical constructions, having no sign even of formal-geometric deduction, as in Spinoza's *Ethica*, let alone the sophisticated dialectics of *Das Kapital*.

Conclusion

Since the second half of the last century, the theory of activity in psychology has been developed extensively. As a "big narrative," however, it has stagnated. "This system of notions turned out to be frozen, without any movement," Leontiev ascertained in 1969 (1994, p. 247). The perfect way to unfreeze it and set it in motion is to refer to Vygotsky's unfulfilled plans, which his *Notebooks* have recently told us about. In his hands, activity psychology developed in a highly dynamic way.

"Orientation by the stars is most primitive. But contemporary psychology, which has no compass or map, must rely on the stars: on Spinoza." (Vygotsky, 2018, p. 221) This testament has remained the voice of one crying in the wilderness. The problem of freedom, understood as "moderating and restraining affects," is hardly discussed in cultural-historical psychology, and the very concept of affect has been degraded.

A.N. Leontiev expressed concern about the transformation of the notion of activity into an empty abstraction. And already at the beginning of our century, his student and assistant Nina Talyzina, having condemned the fashion of renaming mental functions "activities," summed up the disappointing result: "The activity approach has not yet been implemented. [...] We don't have activity psychology; it should still be built. There should be an analysis in the language of actions, not in the language of functions." (2003, p. 15)

But why has it not been built? Outstanding minds worked on the development of activity psychology for a good 50 years but could not turn it into a full-fledged

scientific system. I have no concrete answer. Perhaps its methodology, the “language of action,” appeared not powerful enough, especially in the higher spheres of mental life, such as literature and theater. The achievements of activity psychology, in its Leontiev version, became more and more modest as it moved away from the “lower boundaries.” No psychologists dream any longer of a *Das Kapital* of their own, but it may be worth a try.

Ethics Statement

This is an original paper, not previously published in any venue.

Author Contribution

The author is the sole contributor to this article.

Conflict of Interest

The author declares no conflict of interest.

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Elaboration of Neuropsychological Evaluation of Children: Structural Analysis of Test Results

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Background. Modern neuropsychology is discussing the possibility of combining qualitative and quantitative approaches in the evaluation of cognitive functions. In Russia a battery of tests called “Methods of neuropsychological assessment for children 6–9 years old” (Akhutina et al., 2016) has been proposed; it is based on the Lurian approach to diagnosis and combines qualitative and quantitative approaches to testing. The present paper describes the development of this combined qualitative and quantitative assessment of various groups of cognitive functions in preschool and primary school children. Structural modeling enables us to analyze a possible combination of integral indices of functions that includes the results of both a face-to-face neuropsychological assessment and computerized testing.

Objective. To develop a combined qualitative and quantitative neuropsychological assessment of children, in order to 1) check the structural reliability of integral indicators of various cognitive functions; and 2) confirm the correctness of combining the results of face-to-face and computerized tests.

Design. A sample of 299 children between the ages of 6 and 9 years old (111 preschoolers, 82 first graders, and 106 second graders) underwent a Lurian face-to-face neuropsychological examination adapted for 6-to-9 year-old children, and five tests from the Computerized Neuropsychological Assessment for 6–9 Year-old Children. The five were the “Dots” test, the Schulte Tables, the Cancellation test, the Corsi Tapping Block test, and the Understanding of Similar Sounding Words test. In each of the tests (face-to-face and computerized), key parameters were identified to evaluate various cognitive functions.

Results. A confirmatory factor analysis verified the composition of the neuropsychological indices that were based on the results of the face-to-face neuropsychological assessment. At the same time, when the computer test data were added to the model, the fit indices of the model considerably improved.

Keywords:
Neuropsychological assessment;
development of higher mental functions;
primary school students;
cognitive functions;
face-to-face testing;
computer testing

Conclusion. The confirmatory factor analysis confirmed the validity of the identification of eight neuropsychological indices that indicate the component processes underlying complex cognitive functions in children: 1) programming and control of voluntary actions (executive functions); 2) serial organization of movements and speech; 3) the processing of kinesthetic information; 4) the processing of auditory information; 5) the processing of visual information; 6) the processing of visual-spatial information; 7) hyperactivity/impulsivity; and 8) fatigue/slowness.

Introduction

Neuropsychological methods that examine and assess the state of cognitive functions in children are under development all over the world. Earlier stages of the development of such methods were characterized by two different approaches: a psychometric quantitative one, and a qualitative one based on the theory of functional systems. The first approach is based on expert-independent objective testing and quantification of results. The second is devoted to a detailed analysis of the quality of the subjects' test performance. However, the present stage of child neuropsychology research is characterized by the convergence of these approaches for determining a diagnosis (Akhutina, Ignateva, Maksimenko, Polonskaya, Pylaeva, & Yablokova, 1996; Akhutina, 2016; Baron, 2004; Golden, 1987; Korkman, 1998; Korkman, Kirk, & Kemp, 2007; Reitan, 1959; Reitan & Wolfson, 1985; Tramontana & Hooper, 1988; Weiler, Willis, & Kennedy, 2019).

How were the qualitative and quantitative approaches combined in the research by T.V. Akhutina and her colleagues? If, as in making a qualitative diagnosis of adults, one can proceed from a general idea of the normative performance of tasks and take it as 0, then when working with children, it is necessary to quantitatively assess the qualitative characteristics of task performance by typically developing children of different ages. To capture the qualitative specificity of the test performance and be able to assess it quantitatively, it has been necessary to standardize the presentation and analysis of the tests, and to develop parameters for evaluating not only the productivity of test execution but also specific errors which reflect both primary and secondary difficulties in completing the tasks. The division of errors into primary and secondary types is a distinctive feature of neuropsychological analysis in the Vygotsky-Luria approach. Combining the productivity parameter for a certain test with the primary errors during its performance, and then summing them up with the parameters of other tests aimed at detecting the same primary defect, has led to the development of integral estimates, or indices (Korneev & Akhutina, 2016).

The method of adding the parameters of several tests has also been proposed within the quantitative approach; it is known as latent process analysis (Miyake, Emerson, & Friedman, 2000). To solve the problem of analyzing the component comprising executive functions, Miyake and his colleagues concentrated on "the task impurity problem." Due to the complexity of any human activity, there are no tasks that are unambiguously associated with only one cognitive function without involving others. Latent process analysis makes it possible to reduce the impurity of tests. In discussing executive func-

tions, the authors write: “A latent variable is essentially a hypothetical construct created by statistically ‘extracting’ what is common among the multiple tasks chosen to tap that construct. In the case of our study, we created three latent variables that corresponded to the Shifting, Updating, and Inhibition factors, respectively. It is important to point out that these latent variables were ‘purer’ measures of the target executive functions because each latent variable contained only what was shared among all three tasks and not what was specific to each task.” (Miyake et al., 2000, p. 178)

A similar method of adding unidirectional parameters to aggregate a set of results which would give a “purer” objective estimation has also been developed in child neuropsychology based on the Vygotsky-Luria theory. It is applied to assess not only executive functions but information-processing functions and functions of activation. This approach has evolved from the principles and methods of diagnosing local brain lesions in adults described by Vygotsky and Luria (Luria, 1965, 1976, 1980). It has turned out to be efficient even in solving such difficult issues in child neuropsychology as the analysis of cognitive functions for the selection of effective methods to overcome learning difficulties (Akhutina & Pylaeva, 2012).

In the context of the assessment of typical and deviant development, a further elaboration of optimal methods for evaluating cognitive functions in terms of efficiency, conciseness, and ecological validity turns out to be an important issue. In particular, we should examine a set of quantitative parameters of the quality of test performance, which we can use when calculating integral estimates or indicators of various cognitive functions. The need for such verification grows out of the problem of the “insufficient purity” of any test or task. To check the correctness of distributing the parameters into indices, we use the method of confirmatory factor analysis.

Within our work, a comprehensive neuropsychological examination for 6-to-9 year-old children was employed to diagnose the children’s state of higher mental functions (Akhutina, 2016). This battery consisted of 20 tests; their performance was assessed according to numerous parameters that are used to determine a neuropsychological conclusion about the state of a subject’s cognitive functions. The system for calculating integral indices has also been developed to determine generalized quantitative indicators of the state of different cognitive processes (Korneev & Akhutina, 2016). Each of those indices consists of a set of performance indicators for different tests within the examination.

At present, our approach applies a set of indices that allows for evaluating the following processes: programming and control of voluntary actions (executive functions); serial organization of movements and speech; processing of kinesthetic information; processing of auditory information; processing of visual information; processing of visual-spatial information; hyperactivity/impulsivity; and fatigue/slow tempo. When diagnosing the state of cognitive functions in preschool and primary school children, that set of indices is quite complete and makes it possible to assess all of the most important cognitive components that intensively develop at that age, and are important for the child’s success in learning (Ardila & Rosselli, 1994; Klenberg, Korkman, & Lahti-Nuuttila, 2001; Korkman, Kemp, & Kirk, 2001; Stiles, Akshoomoff, & Haist, 2013; Vanvooren, Poelmans, De Vos, Ghesquière, & Wouters, 2017). It is important that the indices not indicate global multifactorial constructs

like memory or language but rather the component processes that underlie complex cognitive functions in the children.

In recent years, computerized batteries for neuropsychological examinations have been developing rapidly. The most famous of them is CANTAB (Luciana & Nelson, 2002), but there are also several others, including MINDS (Brand, & Houx, 1992; Brand, von Borries, & Bulten, 2010), ANAM, ImPACT, CogState, and CNS-VS (see Parsons, 2016 for a review). We also have developed and used a battery of tests aimed at evaluating executive functions, functions of activation (arousal), and functions for processing visual-spatial and auditory information (Korneev et al., 2018). Our computer battery is based on ideas of the Lurian assessment and provides a more objective and standardized way to estimate cognitive functions in children. It can be used as a method for screening children with a risk of learning or other disabilities. In this battery we apply the same approach when certain cognitive functions are evaluated by integral indices that consist of a set of indicators derived from the performance of several tests. A separate task may be the creation of such integral indicators that combine the performance parameters of both face-to-face and computer-based neuropsychological tests.

The techniques for calculating the indices are described in our previous works (Korneev, & Akhutina, 2016; Akhutina, Korneev, Matveeva, Gusev, & Kremlev, 2019). A detailed description of the procedure is beyond the scope of this paper, but in brief, the main idea is to standardize the parameters (productivities and specific mistakes in various tests) and to sum up the *z*-values into integral estimations.

Since the elaboration of the indices is based on theoretical analysis and the experience of neuropsychological examinations, suggestions about the composition of the indices should be verified in targeted studies. This current work attempts to verify the structural validity of a set of indices of different cognitive functions that we developed specifically for preschool and primary school children. Confirmatory factor analysis is one of the methods of that assessment. This method is quite common in the study of the structure of cognitive functions. Thus, there are studies of the factor structure of executive functions that allow for identifying and assessing their different components: inhibition, updating, and shifting (Miyake, 2000; Friedman & Miyake, 2017). This approach is also employed in the analysis of the structure of intelligence based on the results of the Wechsler Intelligence Scale for Children, which distinguishes four factors: verbal, perceptual, processing speed, and working memory abilities (Bodin, Pardini, Burns, & Stevens, 2009). Using confirmatory factor analysis, we intend to assess the structural validity of the indices that characterize the state of different cognitive functions in children, while including various indicators of task performance in both paper and pencil and computerized neuropsychological examinations. Our research questions may be formulated in the following way:

1. To what extent can the composition of neuropsychological indices, which were developed earlier and based on the theory and practice of child neuropsychology, be verified on a large sample of typically developing children ages 6 to 9 years old?
2. Is it possible to combine the results of a face-to-face examination and computer tests for a more accurate and reliable assessment of the state of cognitive functions?

Method

Participants

This study involved 299 children ages 5.1 to 9.5 years. Of these, 111 were preschoolers (56 boys and 55 girls; average age 6.45 years); 82 were first graders (31 boys, 51 girls; average age 7.67 years); and 106 were second graders (62 boys, 44 girls; average age 8.58 years). The participants were from regular Moscow kindergartens and primary schools; their families had middle socioeconomic status. None of the participants had any diagnosed neurological or developmental disorders. The parents of all children gave informed consent for them to participate in the study.

Measures

Face-to-face neuropsychological examination

The neuropsychological examination adapted for children ages 6 to 9 years old was used to determine the state of their cognitive functions (Akhutina, 2016). Although a comprehensive examination includes 20 behavioral tests, in this study we analyzed data from only some of them. The list of the tests with a short description of the procedure is presented in *Table 1*.

Table 1

Test battery for the neuropsychological assessment of children 6-to-9 year-olds (partial)

Test	Description
<i>Executive functions and Serial organization of movements and speech</i>	
Go/No Go Task, Reciprocal Motor Program Test	The test consists of two series: 1. One knock should be responded to with two knocks, and two knocks with one knock; 2. One knock should be responded to with two knocks, and two knocks with no knock.
Verbal Fluency Tests	The test consists of three series. The participant must name as many words as he can in one minute: 1. any words; 2. names of actions; 3. names of plants.
Odd one out	Five series of five words are presented aurally. The child has to find the odd one and explain the choice.
Counting	The participant must count from 1 to 10; from 10 to 1; from 3 to 7; from 8 to 4; or count from 20 subtracting 3 at a time.
3 Positions Test, or "Fist-Edge-Palm"	The participant must remember and automate a series of hand-movements: Fist-Edge-Palm
Oseretskii-Luria Test of Reciprocal Coordination (RecC.)	The participant is asked to reverse the configurations of his or her hands repeatedly and simultaneously from palm to fist, so that when the fist is opened in one hand, it is closed in the other.
<i>Kinesthetic information processing</i>	
Finger Position Test	The test consists of three series: 1. imitation of finger positions (five positions for each hand); 2. reproduction of finger poses using proprioceptive memory (three positions for each hand); 3. transferring finger poses from one hand to the other (three positions for each hand).
Oral Praxis	The participant must perform movements and poses using the orofacial muscles on verbal command (ten tasks).

Auditory information processing

Verbal Memory Test	The participant must remember two groups of three words each. Three attempts are given, and delayed replay is also evaluated.
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Visual information processing

Visuo-perceptual Tests	The participant must identify superimposed, crossed out, and unfinished images (22 pictures).
Design Fluency Tests (DFluency)	The participant must draw any eight objects and any eight plants.

Visual-spatial information processing

Visual-Spatial Memory	Four nonverbal figures are presented for eight seconds. The participant must remember and draw them. Three attempts are given, and delayed replay is also evaluated.
Three-Dimensional Drawings	The child must copy a three-dimensional picture of a house.

Test performance was evaluated by an expert neuropsychologist according to several parameters that indicate the child's ability to understand the task, the accuracy and efficiency of performance, and specific mistakes revealing any weakness of the tested function (primary mistakes) and other functions (secondary mistakes). We calculated productivity as the number of correct answers, marks of accuracy in ordinal scales (from 0 to 3), and numbers of specific or unspecific mistakes. For instance, when analyzing the Finger Position test, kinesthetic difficulties (specifically the prolonged search for a pose) were assessed as primary errors and impulsive performance as a secondary error.

According to the results of the examination, the neuropsychologist could evaluate the state of the functions of activation: symptoms of fatigue, sluggishness, a tendency to perseveration, impulsivity, and hyperactivity (on an ordinal scale from 0 to 3).

Computerized neuropsychological tests

In this study, we used tests from the battery of the Computerized Neuropsychological Assessment in 6-9 Year-old Children (Korneev, Akhutina, Gusev, Kremlev, & Matveeva, 2018). The battery consists of 10 tests; five of them were used in the present work:

1. The Dots test (Davidson, Amso, Anderson, & Diamond, 2006). The test consists of three subtests; each of them involves 20 stimuli. In the first subtest, the stimuli (hearts) are presented on the computer screen, in a quasi-random order, to the left or to the right of the screen center. The child's task is to press the button on the side where the stimulus appears as quickly as possible. The subtest assesses the ability of the participant to follow instructions and the speed of a simple motor reaction. The second subtest evaluates the child's ability to inhibit the "natural" response that is irrelevant to the task: another stimulus (a flower) appears on the screen; the task is to press the button as quickly as possible on the side opposite to the one where the stimulus appears. The third subtest evaluates the child's ability to switch between the two parallel programs: two types of stimuli (hearts and flowers) are presented

alternately on the screen; the task is to press the key on the same side where the heart appears, and on the opposite side where the flower appears. This test is assessed according to the average response time and productivity (the number of correct responses).

2. A computer version of the “Schulte Tables” (Korneev et al., 2018). The test consists of five subtests; each presents a table consisting of 20 cells on a touch screen. In those cells, there are two series of numbers from 1 to 10 arranged in quasi-random order; one series consists of black numbers, while the second set of numbers is red. The participant must search for and indicate the numbers in a certain order by touching the screen with a finger. The first subtest calls for pointing to the black numbers from 1 to 10, followed by the red numbers from 1 to 10 in the second subtest; then in the third subtest, the black numbers from 10 to 1; in the fourth subtest, there should be two parallel series showing red and black numbers in ascending order (1 black, 1 red, 2 black, 2 red, etc.), and in the fifth, the participant must indicate red numbers from 10 to 1. Such a set of tasks makes it possible to assess the children’s ability to master a simple action program (the first and second subtests), a more complicated reverse program (the third and fifth subtests), and the most difficult, a “parallel” action program (the fourth subtest). They have to switch their attention from one program to another and must inhibit inadequate responses. Based on the results, we calculated the average time of searching for a number as well as the error count, both for the whole test and in the five subtests separately.

3. The Cancellation test for preschoolers and primary school children (Korneev et al., 2018). The test consists of three subtests. The touch screen displays a table consisting of six similar elements (geometric figures in the version for preschoolers, letters in the version for young students). In the first subtest, the child’s task is to find and mark one of the stimuli, in the second one they find and mark the other one, and in the third subtest the target is both of those stimuli. Thus, during the first two trials, we assess the child’s ability to keep their attention on a simple task for quite a long time, and in the third trial, the ability to switch to a more complicated instruction is assessed. The evaluated parameters are tempo (the number of correct answers per minute) and accuracy (the percentage of correct answers).

4. The Corsi Tapping Block test (Milner, 1971; a computerized version for children by Korneev et al., 2018). Nine cubes presented on the touch screen light up one by one. The task is to remember their positions on the screen, and after their presentation, the participant must reproduce the sequence of the highlighted cubes. The trial starts with a row of two cubes; with every right answer, the length of the row increases. The indicators in this trial are the maximum length of a correctly reproduced sequence, the average time of the first response, and the average time of pauses within the sequence.

5. The Understanding of Similar Sounding Words test (USSW; Korneev et al., 2018). The child is presented with a set of 10 pictures of distinct objects whose names differ in one sound; for instance, “bochka-pochka” (barrel-bud). Then a sequence of words is presented aurally (a total of eight sequences, each two to five words in length). The child must indicate the corresponding pictures in the same order. We

evaluate the percentage of correctly reproduced words (relative to the total number of responses) and the numbers of different mistakes (substitutions of similar and dissimilar sounding words and omissions).

Analysis

Confirmatory factor analysis was used to test our hypothesis about the possibility of identifying the parameters that characterize different groups of cognitive functions. The parameters of the tests' performance (productivity, specific errors, and reaction time) were used as the exogenous variables (indicators) in the model, and the cognitive functions were included as endogenous variables (factors). Since some of the performance indices of the neuropsychological examination were estimated on ordinal scales, we used the method of weighted least squares with the means and variation adjusted (WLSMV; Muthén & Muthén, 2012). This method is applied in the case of ordinal scales and is resistant to a non-normal distribution of data. The analysis was conducted in R version 3.6.0 with the Lavaan package (ver. 0.6-9, Rosseel, 2012). To assess the quality of the models, we used the following rules: for CFI and TLI, values higher than .90 reflect a good model fit; for RMSEA, less than .08 indicates close fit (Schumacker, & Lomax, 2010).

Results

Models with parameters of face-to-face assessment

Several models were constructed and tested. The first model corresponded to the composition of indices used in practice (Korneev & Akhutina, 2016). It included eight factors:

- 1) Executive functions (hereafter EF): the total number of mistakes, performance speed, and understanding the instruction in the second part of the Go/No go test; performance in the first two parts of the verbal fluency tests (VFT) and number of inadequate responses in the third part of the VFT; number of errors in the Counting test; mastering the program in the 3 Positions test; and productivity, number of inadequate responses, and overall score on the Odd One Out test;
- 2) Serial organization of movements (SerOrg): mastering the program, quality of execution, and number of errors in the 3 Positions test; performance on the Reciprocal Coordination test;
- 3) Kinesthetic information processing (Kinst): performance on the Finger Positions test, efficiency of reproduction by the left hand according to the proprioceptive pattern, efficiency of the pattern transfer, number of kinesthetic errors, and productivity in the Oral Praxis test;
- 4) Auditory information processing (Aud): productivity of repetition and reproduction after the third presentation in the Verbal Memory test, substitutions of one consonant or a vowel sound when reproducing words, efficiency of the second part of the Verbal Fluency test, number of verbal mistakes in the Visual Perception test;

- 5) Visual information processing (Vis): productivity, number of visual errors in the Visual Perception test, number of well-recognized pictures in the Design Fluency tests, and the tree drawing score in 3-Dimensional Drawing;
- 6) Visual-spatial information processing (VSp): productivity of the first and third reproduction of stimuli in the Visual-Spatial Memory test, number of transformations of stimuli into a sign, severity of weakness of the right-hemisphere or left-hemisphere strategy in 3-Dimensional Drawing, and number of spatial mistakes in the Finger Positions test;
- 7) Sluggish tempo (ST): indices of fatigue, a lower tempo of task performance, and severity of the tendency to perseveration; and
- 8) Hyperactivity/Impulsivity (HImp): indices of hyperactivity and impulsivity.

The model also allowed for correlations between all those factors. The estimates of this model turned out to be acceptable but not too high ($\chi^2(915) = 2295.921$, CFI = 0.907, TLI = 0.899, RMSEA = 0.071); the full data on the coefficients of the model are given in the Appendix, *Table 1A*. However, since some variables in this model had very small factor loads, we modified the model to exclude such cases. On the EF factor index, the index of mastering in the 3 Positions test was excluded. On the Kinest factor, performance in the Oral Praxis test was excluded (this index displays the ceiling effect). On the Aud factor, we excluded the vowel change in the Verbal Memory test (this is a rare error) and verbal errors in the Visual Perception test. On the Visual-spatial factor, the number of transformations into a sign in the Visual-spatial Memory test and spatial errors in the Finger Positions test were excluded.

Meanwhile, the productivity of the first repetition and the number of distortions during the reproduction of words in the Verbal Memory test were added to the factor of processing the auditory information. The estimates of this modification improved ($\chi^2(750) = 1692.926$, CFI = 0.918, TLI = 0.910, RMSEA = 0.065; the full data about the coefficients of the model are given in the Appendix, *Table 2A*), and all of the factor loads were significantly different from zero at the level of $p < 0.05$.

Model with parameters of both face-to-face and computerized assessment

The addition of the indices of computer test performance into the model was the next step. The following were added:

- 1) to factor EF: productivity of the third subtest of Dots, number of mistakes in the fourth Schulte Table, and the total accuracy of the Cancellation test;
- 2) to factor Aud: productivity and similar replacements in the USSW;
- 3) to factor VSp: productivity in the Corsi Test and response time (search) in the fourth Schulte Table;
- 4) to the factors of sluggishness and hyperactivity: response times in the first subtests of Dots and Schulte Table, the average interval between responses in the Corsi Test, and the average tempo in the Cancellation test.

The estimates of that model improved ($\chi^2(1241)=2579.507$, CFI=0.935, TLI=0.930, RMSEA=0.060); the full data on the model coefficients are given in Table 2.

Table 2

Structural model coefficients

Factor	Test	Variable	Est.	Std. error	Z-value	Sig.
EF	Go/ No go	understanding the instructions for the second trial	0.550	0.062	8.825	<0.001
		number of errors	0.669	0.025	27.241	<0.001
		speed	0.339	0.039	8.592	<0.001
	Verb. Fluency	VF 1 — productivity	-0.555	0.040	-14.003	<0.001
		VF 2 — productivity	-0.313	0.068	-4.577	<0.001
		VF 3 — inadequate responses	0.177	0.057	3.121	0.002
	Coun- ting	availability	0.466	0.030	15.544	<0.001
		number of errors	0.302	0.053	5.740	<0.001
	Odd One Out	productivity	-0.584	0.037	-15.918	<0.001
		total score	-0.537	0.044	-12.086	<0.001
		inadequate responses	0.431	0.035	12.172	<0.001
	Dots	productivity in Dots 3	-0.480	0.045	-10.723	<0.001
	Schulte	errors in Schulte 4	0.195	0.053	3.656	<0.001
	Cancel.	accuracy in the Cancellation test	-0.296	0.052	-5.702	<0.001
SerOrg	3 Posi- tions test	mastering program	0.586	0.047	12.356	<0.001
		productivity	0.849	0.047	18.087	<0.001
		errors in serial organization	0.572	0.053	10.900	<0.001
	Rec. c.	productivity	0.638	0.048	13.157	<0.001
Kinest	Finger position test	productivity acc. to the proprioceptive pattern	-0.700	0.061	-11.519	<0.001
		productivity in the transfer	-0.704	0.049	-14.418	<0.001
		kinesthetic errors in total	0.956	0.046	20.564	<0.001
		performance rate	0.483	0.065	7.396	<0.001
Aud	VFluen.	VF 2 — productivity	-0.339	0.080	-4.256	<0.001
	Verbal Memory	productivity in repetition 1	-0.534	0.049	-10.851	<0.001
		productivity in repetition 3	-0.591	0.052	-11.381	<0.001
		productivity in reproduction 3	-0.685	0.047	-14.593	<0.001
		substitution of the first consonant	0.240	0.065	3.676	<0.001
		distortions	0.282	0.060	4.673	<0.001
	Underst. sim.s.w.	productivity	-0.596	0.064	-9.263	<0.001
		similar errors	0.354	0.133	2.662	0.008

Factor	Test	Variable	Est.	Std. error	Z-value	Sig.
Vis	Visual perception	productivity of the recognition of superimposed pictures	-0.596	0.041	-14.563	<0.001
		productivity of the recognition of unfinished pictures	-0.688	0.036	-19.008	<0.001
		perceptually similar mistakes	0.311	0.054	5.807	<0.001
		rough errors	0.535	0.045	11.952	<0.001
		fragmentary errors	0.278	0.060	4.634	<0.001
		errors in shape/background	0.310	0.049	6.286	<0.001
	DFluency	well-recognized pictures	-0.556	0.052	-10.685	<0.001
VSp	3 dim. dr.	picture of a tree	0.766	0.028	27.544	<0.001
	Visual-spatial memory	productivity in reproduction 1	-0.442	0.043	-10.340	<0.001
		productivity in reproduction 3	-0.523	0.043	-12.266	<0.001
	3 dim. drawing	holistic strategy	0.687	0.035	19.428	<0.001
		analytic strategy	0.674	0.023	29.419	<0.001
	Corsi	productivity	-0.443	0.047	-9.509	<0.001
	Schulte	errors in Schulte 4	0.705	0.021	33.772	<0.001
ST	Observations	fatigue	0.623	0.055	11.427	<0.001
		slow tempo	0.281	0.048	5.818	<0.001
		tendency to perseveration	0.457	0.057	8.032	<0.001
	Schulte	time in Schulte 1	0.851	0.088	9.642	<0.001
	Dots	time in Dots 1	0.495	0.092	5.389	<0.001
	Corsi	time in Corsi	0.330	0.069	4.765	<0.001
	Cancel.	tempo in the Cancellation test	-0.292	0.073	-3.994	<0.001
HImp	Observations	impulsivity	0.720	0.063	11.341	<0.001
		hyperactivity	0.992	0.085	11.652	<0.001
	Schulte	time in Schulte 1	-0.720	0.111	-6.470	<0.001
	Dots	time in Dots 1	-0.468	0.102	-4.594	<0.001
	Corsi	time in Corsi	-0.446	0.080	-5.556	<0.001
	Cancel.	tempo in the Cancellation test	0.280	0.078	3.608	<0.001

Note. Est. = estimated coefficients, std. err. = standard errors, sig. = significance of *t*-test.

The correlations between the factors are shown in *Table 3*.

Table 3

Correlations between the factors in the model

	SerOrg	Kinest	Aud	Vis	VSp	ST	HImp
EF	0.725*	0.302*	0.566*	0.787*	0.919*	0.793*	0.119
SerOrg		0.288*	0.341*	0.579*	0.658*	0.510*	0.192*
Kinest			0.161*	0.312*	0.395*	0.307*	0.128
Aud				0.505*	0.570*	0.251*	-0.162*
Vis					0.886*	0.637*	0.136
VSp						0.718*	0.014
ST							0.613*

Note. * = significant at level $p < 0.05$

Discussion

A confirmatory factor analysis of the performance parameters of the various tests from the batteries of face-to-face and computer neuropsychological examination made it possible to identify the factor structure that corresponded to the proposed structure of integral estimates of different groups of cognitive functions.

We detected and confirmed two factors associated with the functions of activation at the level of empirical data. These were the hyperactivity/impulsivity factor, which correlated with disturbances in the form of ADHD (Barkley, 1998), and the factor of sluggishness, which manifested in the syndrome of a sluggish cognitive tempo (Becker, Marshall, & McBurnett, 2014; Becker & Willcutt, 2019). These results correspond to the data obtained in fMRI research (Fassbender, Krafft, & Schweitzer, 2015). It is worth emphasizing that, in our model, the same indices of performance times for the computer tests had significant loads in both factors but with an opposite sign. This also justifies separating the neurodynamic functions in that way.

As to the functions associated with information processing, we received confirmation at the level of the structural model for the validity of the division of individual factors for the processing of kinesthetic, auditory, visual, and visual-spatial information. The possibility of identifying modally specific mechanisms of information processing in solving different tasks is under discussion in the literature. There are arguments both in favor of (Barsalou, Simmons, Barbey, & Wilson, 2003) and against (Anderson, Qin, Jung, & Carter, 2007) that division. Within the framework of our approach, the results obtained on a sample of typically developing children pointed toward such a division, at least at the level of behavioral indicators of neuropsychological task performance.

As to the distinction of factors connected with voluntary activity, following A.R. Luria (1976, 1980) in this case, our model distinguished the factor of the programming and control of activity (\approx executive functions) and the factor of the serial

organization of actions. The results of the confirmatory analysis also reaffirmed that division. Executive functions are important for the performance of almost any voluntary activity; some studies show that they have a heterogeneous structure and can be divided into separate groups of functions (inhibiting, updating, and shifting; see Miyake et al., 2000; Friedman & Miyake, 2017). Such detailing was not carried out in our research; it may require a separate study based on neuropsychological examination.

It is noteworthy that the identified factors highly correlate with each other. This is not surprising, as it is difficult to expect them to be independent of each other. Solving even a simple task inevitably engages several groups of functions. This corresponds to ideas about the relationships between functions in neuropsychological theory. We attempted to identify the indices of the states of certain specific functions, and we managed to do that to some extent, although at the same time we detected quite a close relationship between functions. Whether it is possible to identify more “pure” indicators of certain functions within the framework of ecologically valid tasks in the examination is a topic for further discussion. Such a “targeted” assessment is possible through more specific laboratory studies held in the framework of experimental psychology.

Another significant result obtained in our study was the preservation of, and even some improvement in, the quality of the model by including the results of the computer tests. This indicates that the combined usage of face-to-face and computerized neuropsychological examinations can improve the reliability and accuracy of the assessment of the states of different functions. There are data about a weak correlation between the results from the computer tests and the traditional neuropsychological examination (Smith, Need, Cirulli, Chiba-Falek, & Attix, 2013). Our model detected that the same indices (reaction time) may be associated with different factors with an opposite sign. This is explainable and meaningful, but it can also be the reason for the weakening of simple linear relationships between the results of different methods. Constructing and testing models like the one described in our paper can be an efficient way to investigate the consistency of the tests.

Thus, the results of our confirmatory analysis support the structural validity of identifying our hypothesized groups of functions and the validity of evaluating them by indices that include indicators of the performance of different tasks within the neuropsychological examination. This approach makes it possible to carry out a detailed and comprehensive analysis of the cognitive states of children at preschool and primary-school ages, with typical development and with different disorders. In the typical samples, this approach makes it possible to distinguish children with a relative weakness (deficiency) of certain abilities associated with the uneven development of some functions and, if necessary, to arrange a preventive remedial intervention. With more pronounced behavioral problems classified as disorders, such an assessment provides an opportunity to analyze the structure of the defect and to suggest the most efficient ways to correct it.

Conclusions

The present study proposed and evaluated several models describing the possible composition of indices of different cognitive functions, made up of indicators of performance on neuropsychological examinations by preschool and primary school children. They include the following groups of cognitive functions: programming and control of voluntary actions (executive functions), serial organization of movements and speech; the processing of kinesthetic information; the processing of auditory information; the processing of visual information; the processing of visual-spatial information; hyperactivity/impulsivity; and fatigue/slow tempo. The final model showed good consistency with the data. This confirmed the structural validity of the proposed scheme for quantifying the state of the cognitive sphere in children.

Including the performance indices from two methods (face-to-face and computerized tests) had the important result of improving the quality of the model. Furthermore, this model may be useful in the research of the patterns of cognitive capacities in children with typical and deviant developments. Secondly, our findings make it possible to construct more detailed models that clarify the structure of cognitive functions, especially executive functions, in children. In general, our work shows that the qualitative approach to neuropsychological diagnostics, developed by A.R. Luria (Luria, 1980), can be effectively combined with quantitative analysis of neuropsychological data.

Limitations

Our study had some limitations. We did not analyze the influence of socioeconomic factors, although they may be important. We selected schools with approximately the same average socioeconomic level of children, but more detailed and precise analysis may be needed in future studies. Our sample included only children of the metropolis, so it would be important to test our findings on samples from other regions.

Computer methods allow us to see the quantitative characteristics of some cognitive functions, but they still do not replace expert qualitative assessments. Computer tests can be used as a screening method: to identify children with risk for learning disabilities. The quantitative estimates obtained with their help can complement the qualitative assessment of the expert.

We have developed and discussed the integrative indices that can be useful in the situation of screening or for the generalization of results of the assessment in large samples. But this approach is less sensitive than a neuropsychological conclusion made by an expert. We have to remember that both the qualitative and quantitative approaches have both strengths and weaknesses.

Ethics Statement

Parents of all subjects gave their informed consent for participation of their children in the study. The study received ethical approval from the Ethical Committee of the Faculty of Psychology, Lomonosov Moscow State University (Moscow, Russia).

Informed Consent from the Participants' Legal

Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author Contributions

Tatiana Akhutina and Aleksei Korneev developed the concept of the study and performed the theoretical analysis. Ekaterina Matveeva collected the data and prepared it for analysis. Aleksei Korneev performed the computations. All authors prepared the original draft, carried out the review and editing of the manuscript, and contributed to the final version.

Conflict of Interest

The authors declare no conflict of interest.

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Appendix

Table 1A

The structural model coefficients for Model 1

Factor	Test	Variable	Est.	Std. error	Z-value	Sig.
EF	Go - no go	understanding the instruction for the second trial	0.529	0.061	8.681	<0.001
		number of errors	0.530	0.019	27.292	<0.001
		speed	0.410	0.046	8.830	<0.001
	Verb. Fluency	VF 1 — productivity	-0.502	0.048	-10.561	<0.001
		VF 2 — productivity	-0.121	0.073	-1.658	0.097
		VF 3 — inadequate responses	0.169	0.058	2.910	0.004
	Counting	availability	0.514	0.041	12.586	<0.001
		number of errors	0.358	0.056	6.429	<0.001
	Odd one out	productivity	-0.668	0.030	-22.351	<0.001
		total score	-0.930	0.025	-37.787	<0.001
		inadequate responses	0.801	0.021	37.677	<0.001
	3 positions test	Mastering program	0.056	0.069	0.814	0.416
SerOrd	3 positions test	Mastering program	0.563	0.090	6.262	<0.001
		productivity	0.807	0.047	17.018	<0.001
		errors in the serial organization	0.589	0.052	11.338	<0.001
	Rec. c.	productivity	0.658	0.050	13.199	<0.001
Kinest	Finger position test	productivity acc. to the proprio- ceptive pattern	-0.634	0.061	-10.432	<0.001
		productivity in the transfer	-0.720	0.048	-14.925	<0.001
		kinesthetic errors in total	0.942	0.047	20.111	<0.001
		performance rate	0.555	0.065	8.514	<0.001
	Oral Praxis	Productivity	-0.015	0.081	-0.187	0.851
Aud	VFluen	VF 2 — productivity	-0.556	0.083	-6.738	<0.001
	Visual percep- tion	Verbal errors in the recognition of the superimposed pictures	0.030	0.077	0.398	0.691
		Verbal errors in the recognition of the unfinished pictures	0.095	0.071	1.338	0.181
		productivity in repetition 3	-0.616	0.049	-12.666	<0.001
		productivity in reproduction 3	-0.583	0.056	-10.404	<0.001
		substitution of the 1st consonant	0.180	0.069	2.600	0.009
		substitution of the 1st vowel	0.083	0.081	1.019	0.308

Vis	Visual perception	productivity of the recognition of the superimposed pictures	-0.585	0.045	-13.123	<0.001
		productivity of the recognition of the unfinished pictures	-0.654	0.041	-15.821	<0.001
		perceptually similar mistakes	0.273	0.059	4.635	<0.001
		rough errors	0.508	0.046	11.120	<0.001
		fragmentary errors	0.292	0.059	4.976	<0.001
		errors in the shape/background	0.320	0.054	5.878	<0.001
	DFluency	well-recognized pictures	-0.546	0.053	-10.360	<0.001
VSp	3 dim. dr.	picture of a tree	0.822	0.032	25.556	<0.001
	Visual-spatial memory	productivity in reproduction 1	-0.452	0.051	-8.833	<0.001
		productivity in reproduction 3	-0.537	0.046	-11.692	<0.001
		Transformation to a sign	0.039	0.051	0.772	0.440
	3 dim. drawing	holistic strategy	0.714	0.035	20.459	<0.001
		analytic strategy	0.789	0.037	21.099	<0.001
	Finger position test	Spatial errors	0.074	0.058	1.280	0.201
ST	Observations	fatigability	0.891	0.076	11.740	<0.001
		slow tempo	0.434	0.065	6.702	<0.001
		tendency to perseveration	0.597	0.071	8.449	<0.001
HImp	Observations	impulsivity	0.759	0.101	7.500	<0.001
		hyperactivity	0.981	0.129	7.607	<0.001

Note. Est. = estimated coefficients; std. err. = standard errors; sig. = significance of *t*-test.

Table 2A

The structural model coefficients for Model 2

Factor	Test	Variable	Est.	Std. error	Z-value	Sig.
EF	Go - no go	understanding the instruction for the second trial	0.553	0.065	8.459	<0.001
		number of errors	0.680	0.032	21.123	<0.001
		speed	0.361	0.040	8.961	<0.001
	Verb. Fluency	VF 1 — productivity	-0.522	0.049	-10.736	<0.001
		VF 2 — productivity	-0.315	0.076	-4.134	0.097
		VF 3 — inadequate responses	0.188	0.057	3.297	0.004
	Counting	availability	0.472	0.037	12.925	<0.001
		number of errors	0.338	0.054	6.262	<0.001
	Odd one out	productivity	-0.592	0.039	-15.175	<0.001
		total score	-0.518	0.048	-10.772	<0.001
		inadequate responses	0.448	0.047	9.456	<0.001

SerOrd	3 positions test	Mastering program	0.595	0.048	12.397	<0.001
		productivity	0.824	0.047	17.487	<0.001
		errors in the serial organization	0.588	0.051	11.500	<0.001
	Rec. c.	productivity	0.646	0.047	13.834	<0.001
Kinest	Finger position test	productivity acc. to the proprioceptive pattern	-0.641	0.061	-10.450	<0.001
		productivity in the transfer	-0.721	0.049	-14.754	<0.001
		kinesthetic errors in total	0.939	0.047	19.847	<0.001
		performance rate	0.552	0.067	8.277	<0.001
Aud	VFluen.	VF 2 — productivity	-0.298	0.081	-3.660	<0.001
	Visual perception	productivity in repetition 1	-0.626	0.048	-13.046	0.691
		productivity in repetition 3	-0.685	0.048	-14.214	<0.001
		productivity in reproduction 3	-0.708	0.047	-14.951	<0.001
		substitution of the 1st consonant	0.274	0.060	4.598	0.009
		Distortions	0.306	0.054	5.616	0.308
Vis	Visual perception	productivity of the recognition of the superimposed pictures	-0.581	0.045	-12.797	<0.001
		productivity of the recognition of the unfinished pictures	-0.652	0.042	-15.604	<0.001
		perceptually similar mistakes	0.281	0.060	4.669	<0.001
		rough errors	0.506	0.046	11.081	<0.001
		fragmentary errors	0.291	0.059	4.962	<0.001
		errors in the shape/background	0.333	0.054	6.176	<0.001
	DFluency	well-recognized pictures	-0.550	0.053	-10.400	<0.001
	3 dim. dr.	picture of a tree	0.818	0.032	25.592	<0.001
VSp	Visual-spatial memory	productivity in reproduction 1	-0.457	0.051	-9.017	<0.001
		productivity in reproduction 3	-0.551	0.046	-12.031	<0.001
	3 dim. drawing	holistic strategy	0.720	0.035	20.326	<0.001
		analytic strategy	0.770	0.037	20.897	<0.001
ST	Observations	fatigability	0.905	0.076	11.843	<0.001
		slow tempo	0.400	0.061	6.585	<0.001
		tendency to perseveration	0.602	0.071	8.418	<0.001
HImp	Observations	impulsivity	0.698	0.083	8.376	<0.001
		hyperactivity	1.067	0.127	8.397	<0.001

Note. Est. = estimated coefficients; std. err. = standard errors; sig. = significance of t-test.

Learning Disabilities in Primary School. How to Diagnose and Remediate the Difficulties with a Team Approach: The First Results

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Background. An important problem of our day is the significant increase in the number of learning-disabled pupils all over the world. This has led to the emergence of a new branch of neuropsychology — “school neuropsychology” or the “Neuropsychology of learning.”

Objective. This paper analyzes the role and functions of a neuropsychologist in primary schools and the possibilities of his/her collaboration with other specialists in diagnosing children’s problems and organizing remediation for problematic kids.

Design. We established four steps for launching neuropsychological work at primary schools: 1) setting up a screening group for neuropsychological assessment of all children entering the first year of school; 2) a comprehensive neuropsychological assessment of the children who showed poor results in the first step of the study; 3) a team remediation program; and 4) evaluation of the remediation results by a new neuropsychological assessment at the end of the remediation program.

Results. The results of the first step of our study showed a very high percentage of children with cognitive problems — 37% of 202 6–8 year-old schoolchildren entering the first year of school. They formed a group at risk for future learning disabilities and maladjustment at school. Age and gender differences, and the structure of cognitive underdevelopment, were discussed in the second step of our study. In the third step, a team of school specialists, including a neuropsychologist, a teacher, a school psychologist, and a school social worker, implemented a remediation program which was created and supervised by a neuropsychologist.

Conclusion. A comprehensive neuropsychological assessment of the pupils revealed a complex structure of cognitive disturbances which interfere with pupils’ learning abilities in primary school. The team approach can efficiently prevent learning disabilities and help children with cognitive underdevelopment and risks of future unsucces at school, when this collaboration of school specialists has a common theoretical approach and is based upon comprehensive neuropsychological assessment.

Keywords:

Learning disabilities; primary school; neuropsychological assessment; remediation; team approach.

Introduction

A pre-eminent contemporary problem in international psychology and pedagogics today is the significant increase in the number of “practically healthy” children who have problems in learning and adjustment to primary school. Once accepted in elementary school, these children manifest a lack of readiness for schoolwork, and cognitive, emotional, and behavioral disturbances. Different authors have proposed various causes for these learning problems: psychophysiological problems (Bezrukih & Kreshenko, 2004); social maladjustment (Andreeva & Danilova, 2020); giftedness (Pylayeva, 2015); and limited health (Nikolskaya, 1995). Without special psychological and pedagogical assistance, such children become maladjusted to school by the end of the first year. School maladjustment means functioning in a way that does not correspond to the child’s psycho-physiological capacities and needs, nor to the requirements of his/her micro-social environment. It manifests itself in difficulties following school programs, the child failing to perform up to his abilities, and in frequent refusals to attend school and/or to follow its rules (Glozman, 2011, 2017; Prieler et al., 2018; Schwarz & Gawrilow, 2019).

According to various estimates, the number of “problematic” children exceeds 30% of students and ranges from 15% to 40% in primary school (Mikadze, 1998; Sapir & Nitzburg, 1973). Some authors relate it to the socioeconomic situation of single-parent families (Mencarini, Pasqua, & Romiti, 2019).

Problems of self-regulation, up to the level of attention deficit/hyperactivity disorder (ADHD), are a frequent cause of learning disability and of maladjustment to school, because self-regulation has cognitive, behavioral, and emotional influence on a person’s well-being and achievement (Kanfer, Reinecker, & Schmelzer, 2006). “Self-regulation assists the achievement of goals by helping to bridge the gap between intention and behavior.” (Schwarz & Gawrilow, 2019, p. 10)

ADHD has severe social and educational consequences. This syndrome manifests itself mostly in modified characteristics of cognitive processes and attention. The main manifestations of the syndrome are *disturbances of attention concentration*, resulting in instability, low selectivity, distractibility with frequent switches of attention (that is, a lack of a selective, sustained, executive, and orienting attention, strategy generation and use, etc.), and *increased unstructured activity*. The latter is expressed via agitation, fussiness, numerous movements not appropriate for the situation (*i.e.*, without purpose and functional significance), the inability to sit still, and talkativeness. In class, a child with ADHD often interrupts teachers; cannot sit still at the desk for a long time, so often drops belongings to move under the desk; can suddenly get up and get out of the class, etc.

According to many Russian and Western researchers, the manifestation of attention-deficit and hyperactivity disorder in pediatric populations has grown exponentially in recent years. While the average number of children diagnosed with ADHD is 7–8% of the entire population, our studies show that the symptoms of ADHD have been observed in the vast majority (81%) of children needing remediation for learning difficulties at school (Glozman, 2013, 2017).

The presence of learning problems is also a risk factor for disturbances in child-parent relations and communication with peers, which in turn aggravates a learning disability. The secondary symptoms of learning disability include *emotional instabil-*

ity, leading to rapid changes of mood, sometimes from aggression to affection. Disapproval and rejection by others often lead to poor self-esteem and communication difficulties. Especially dangerous for a child's personal and emotional well-being is the situation where the parents' negative attitude toward him coincides with the others' negative and accusatory opinions.

Emotional problems have a profound impact on children's development, behavioral functioning, and physical health. Yet, there remains controversy as to whether or not emotional instability is a part or a consequence of the disorder.

A new and interesting approach to learning disability is to explain and overcome it by inducing the child to form a responsible attitude, which is understood to be the capacity to vouch for their actions appropriately and in a way that fits social norms, including: obedience in family settings, accepting their own mistakes, trusting their parents, taking responsibility in the school setting, being friendly and willing to help, and caring for the environment. (Martín-Antón, Carbonero, Valdivieso, & Monsalvo, 2020). It has been shown that such activity has a direct effect on academic performance and commitment (Carbonero, Martín-Antón, Otero, & Monsalvo, 2017). Positive effects were obtained in the children's motivation and prosocial behavior, including reduction of violent behaviors, and/or improvements in the classroom climate (Manzano-Sánchez & Valero-Valenzuela, 2019).

Many authors consider it essential to involve the family in the learning process, thus incorporating the process into the child's everyday life (Belando, Ferriz-Morell, & Moreno, 2012; Camacho, Jiménez-Iglesias, Rivera, Moreno, & Gaspar de Matos, 2020; Dinisman, Andresen, Montserrat, Strózik, & Strózik, 2017; Olhaberry & Santelices, 2013).

Although there are many different approaches, it should be noted that traditional methods of education and psychological assistance for learning-disabled children are not efficient. The work of a school psychologist or speech therapist, as a rule, lacks the general foundation and training for a school program, and fails to increase the child's level of adaptation and learning abilities. "Various psychological interventions are grounded in tradition and one's own beliefs or in subjective theories; a psychologist does not always get clear feedback on the effects of an intervention." (Jurišević, Lazarová, & Gajdošová, 2019)

Therefore, the need for a theoretical foundation of remedial education for learning-disabled pupils inside elementary schools is evident. A necessary condition for it is precise knowledge about the level of cognitive development and zone of proximal development for each student (Akhtutyna & Pylaeva, 2003). The best possibility for obtaining it is a neuropsychological assessment (Akhtutyna & Pylaeva, 2003; Gaddes, 1981; Glozman, 2013, 2017; Hynd & Obrzut, 1981). This is assured by including school neuropsychologists on the staff of primary schools and the emergence of a new branch of neuropsychology — "school neuropsychology" (Hynd & Obrzut, 1981) or the "Neuropsychology of learning" (Gaddes, 1981).

The neuropsychological approach helps a pupil to adjust to school through identifying his/her partial underdevelopment of some mental functions, mechanisms of learning, and behavioral problems, in such a way as to orient the pedagogical and psychological impact, and to work out an individual program of remediation using the strongest aspects of each child's development (Mikadze & Korsakova, 1994).

A school neuropsychologist alone cannot realize all the potentials of the neuropsychological approach in the context of the actual organization of education in elementary public schools. After the reorganization and unification of public schools, a great number of pupils (up to 200–250 children) were accepted for the same grade. This complicated the primary diagnostics and put an end to an individualistic approach from the start of schooling. Children with low learning abilities became mal-adjusted to school from the very beginning and manifested related problems such as abnormal behavior, low self-esteem, poor motivation for learning, and psychosomatic symptoms. The number of learning-disabled children permanently increased, and each school group could count 30–70% of such pupils. This interferes with the teacher's work and emotional state, makes him/her change their approach to education, and/or creates a syndrome of "professional burnout." As a result, the quality of the teacher's work and his/her professional identity suffer.

The best way to solve this problem is the team method of dealing with learning-disabled children's education and remediation inside the primary school. The *team method means the collaboration of all those responsible for the child's adjustment at school (the teacher, school psychologist, school neuropsychologist, and social worker), unified by common approach, and oriented to diagnosing the mechanisms of the child's difficulties, the zone of his/her proximal development, and the possibilities for working out an individual program of remediation and development.* It is also important to assure the participation of parents in the remediation program. This means getting parents to adopt an attentive attitude to their child, follow all advice, participate in developing exercises together with the child, attend lectures for parents on how to understand better the specific features of their child, and participate actively in search of ways to help him or her.

The neuropsychological approach needs detailed knowledge about each child's level of development, which is provided by a comprehensive neuropsychological assessment (Lebedinsky, 1998). It is also specific to a contemporary public school. First, the neuropsychological methods should permit a face-to-face assessment, and must be easily scored and analyzed. On the other hand, these methods must be individual and sensitive. This task can be achieved in a public school by using a *multistep procedure of assessment* — a principle of "sieves" with a diminution of cells at each step.

The aim of this paper is to determine this multistep procedure of assessment and to analyze the possibilities for using a team method based upon the neuropsychological approach in public elementary schools.

Methods

Procedure

We established four steps for the neuropsychological work at primary school. This paper analyzes the first three steps in detail. The fourth one (the follow-up after rehabilitation) will be the subject of a new paper.

In the *first step* of our study, we used screening methods that permitted us to determine children who needed further assessment and supervision. The selection methods can be used in public schools and identify a risk group in each school group. A general psychologist without neuropsychological specialization can apply these methods.

In the *second step*, the neuropsychologist assessed the children from the *group of those with risks of learning disabilities* (whose scores in the first step were below normal) using Luria's battery, which was adapted for children with qualitative and quantitative analysis of the data (Glozman, 2012, 2013; Glozman & Soboleva, 2018). The assessment data helped us to create an individual program of remediation for each child, taking account of the child's specific problems and his/her zone of proximal development. The second aim of the individual neuropsychological assessment was to differentiate pupils who could receive help at school from those who needed to be sent to special remediation institutions.

In the *third step*, all participants of the team worked out an individual program of remediation for each pupil. The program includes not only methods of neuropsychological remediation but also fairy-tale therapy, game-therapy, family therapy, and special methods of pedagogical and social impact. It was also necessary to provide consultations and help the teacher who works with the children most of the time. A part of the remediation program took place at school; for another part we sent the child to special centers for neuropsychological remediation, because the public school did not have sufficient resources to effect the full remediation program.

In the *fourth step (follow-up)*, the neuropsychologist repeated the individual neuropsychological assessment to evaluate the results of the effectuated remediation program. The detailed analysis of these data will be the subject of our next paper.

Participants

Two hundred and two first grade pupils 6-8 years old from five elementary school groups participated in the group screen for neuropsychological assessment in the first step of our study. In the second step, 75 of them formed the group at risk for learning disabilities and had comprehensive individual neuropsychological assessments done by Luria's methods, together with structured interviews aimed to determine each child's personality, motivation for learning, and emotional stability. Followed the remediation program at school, 28 children had individual neuropsychological follow-up during the third and fourth step of our study. The remaining 47 pupils with learning disabilities were recommended to visit special centers for neuropsychological remediation.

Let us describe in more details the **methods** used in the first step of the study. We selected the methods that had been successfully used in previous applied neuropsychological assessments of learning-disabled children, since they were accessible for group testing, sensitive enough to reveal the structure of cognitive problems in children of this age, and significant for learning at school.

1. A *modified "correction" (visual search) test* (Glozman & Soboleva, 2018) to reveal difficulties in concentration and sustaining attention. Within one minute, a child had to find and cross out as many letters identical to the indicated example as possible. After one minute, the instruction changed: the child had to cross out one letter and underline another letter during the second minute.

Diagnostic criteria:

- Mastering and following the new instruction;
- Concentration of attention after instruction change.

Difficulties in mastering and following the new instruction manifested in:

- Following the old instruction (crossing out the indicated letter);
- Mixing the old and new instructions;
- Failure to carry out one of the instructions (unrelated actions);
- Making errors in following the instruction (the child underlines wrong letters).

Low concentration of attention manifested in the following statistical criteria:

- Increase in number of mistakes by more than 30% after the instruction change;
- Wrong letters comprised more than 60% of all crossed-out or underlined letters;
- The number of underlined letters (even without mistakes) during the second minute of the test was more than twice lower than during the first minute.

2. *Neuropsychological assessment by a screening group of all children entering the first year of school* (7 school groups) using Luria's battery, adapted for children with qualitative and quantitative (scoring) analysis of the data (Glozman, 2012, 2013; Glozman & Soboleva, 2018). The assessment aimed to evaluate kinetic, spatial, mnestic, and intellectual functions and included the following tests:
 - Graphic test for dynamic praxis;
 - Copying a drawing of a table;
 - Visual memory test;
 - Reasoning tests: a generalization test (which one of four pictures does not belong with the others) and an analogies test.
3. *Bender gestalt test* (Belopolsky, 2003) for evaluation of visual-motor coordination and spatial functions. Each child had to copy as precisely as possible the drawings presented in *Figure 1*. The time was not limited.

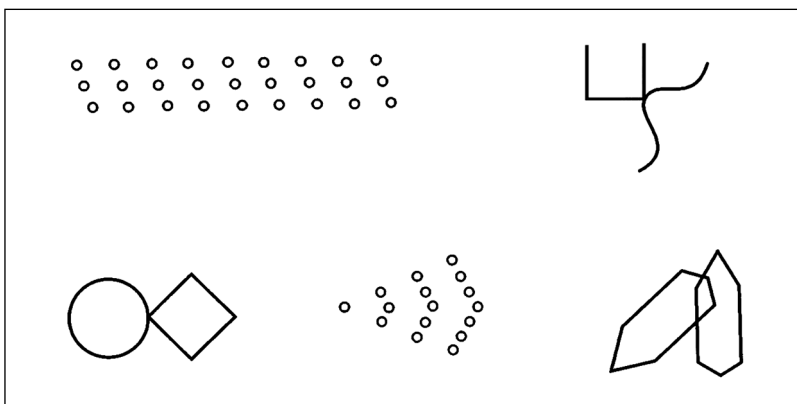


Figure 1. Samples of drawings in the Bender gestalt test

Each drawing was evaluated with three scores:

- Right angles;
- Orientation of elements;
- Mutual coincidence of elements.

For each parameter the score varied from 0 to 10, where 0 meant the most precise copying of the example, while the scores 8–10 were given for rotated images; perseverations of the drawings' elements; gaps exceeding 1 mm between elements of the figure; incomplete figures; inversed angles; and disconnected elements of the figure. The summarized score for all five examples was compared with the table values, differentiated by age (Belopolsky, 2003).

Results

Results of the first step of the study

The first important result from analysis of all three parts of the screening group's neuropsychological assessment of the 202 children entering the first year of school showed that *37% of them (75 pupils) had scores below the normative data* ($p < 0.001$). We qualified these children as a group at risk for future learning disabilities. Note that their number corresponds to above-mentioned literature data on the frequency of learning problems in primary school.

The *distribution* of the “at-risk children” among different school groups was not equal (Table 1). We explain that fact by difficulties in the primary assessment of the children during their admission process for school. Such a distribution can interfere with the efficient organization of education for children with learning problems and successful pedagogical work.

Table 1

Distribution of “at-risk children” in different school groups

School group	A	B	C	D	E	F	G
Number/ (%) of “risk children”	10 pupils/ 36%	8 pupils/ 27%	7 pupils/ 23 %	9 pupils/ 31%	13 pupils/ 46%	13 pupils/ 37%	15 pupils/ 50%

Let us now analyze the *gender and age differences*.

Among the 75 pupils from the at-risk group, there were 47 boys and 28 girls. The significant ($p < 0.005$) predominance of boys correlates with the literature's data about the greater frequency of abnormal development in boys compared to girls (see details: Mikadze, 1998; Glozman, 2013, 2017).

The age distribution of the group of pupils at risk of learning disabilities was the following: 17 six year-old children, 22 eight year-olds, and 36 seven year-old pupils. An early start to schooling indicated once more the need for early (in preschool age) diagnosis and remediation of delayed development, in order to ensure future successful learning (Shevchenko & Glozman, 2015).

Results of the second step of the study

The most important points for the program of remediation were the data about *the structure of cognitive disturbances* in the first grade pupils at risk of future learning disabilities (Figure 2).

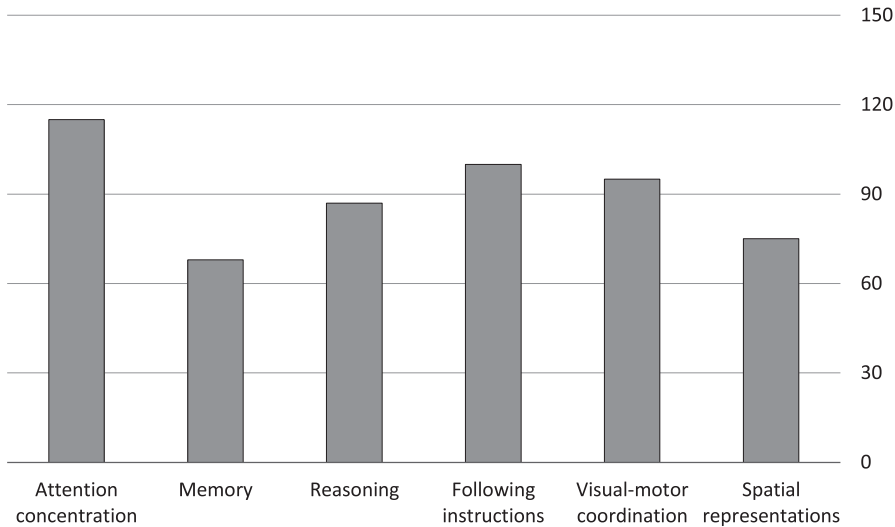


Figure 2. Structure of cognitive disturbances in the first grade pupils (% of children from 75 pupils in the at-risk group)

We first see a complex structure of cognitive disturbances interfering with pupils' learning abilities in elementary school. The most pronounced (but not achieving the level of significance) defects were in attention concentration and the ability to follow instructions (neurodynamic and executive functions). These functions assure self-regulation in learning activity, concentration, and the sustaining and distribution of attention necessary for successful learning at school and adequate motivation for learning. They correlate with the data from other studies (see Introduction) on ADHD's role in learning disabilities in primary school.

Results of the third step of the study

The program of remediation for the children from this group at risk of future learning disabilities took account of the data, as well as of the results of the comprehensive neuropsychological assessment, which revealed the weak and strong components of mental functioning of each child and his/her zone of proximal development. The program included¹:

1. *Individual neuropsychological remediation.*
 - A course of 20 sessions of neuropsychological remediation carried out by the *school neuropsychologist*. The exercises had to meet each child's needs

¹ This paper does not describe the concrete methods of work, as our main task was to determine the roles of the different specialists in the remediating team

- and possibilities for realizing the programs inside the public school. The program was carried out in mini-groups of 3–5 pupils.
- A course of game and fairy-tale therapy, carried out by the *school psychologist*, aimed at stabilizing the child's emotional state and increasing his/her adjustment abilities.
 - A course of social and pedagogical remediation, carried out by the *school social worker*, aimed at improving the child's social adjustment, and self-assurance by creating "situations of success." The number of sessions depended upon each child's needs.
2. *Preventive intervention in school groups* with a large number of learning-disabled children. The school neuropsychologist worked out this program and effected it together with the school psychologist, working with the group as a whole during gymnastic breaks, walks, pauses between classes, and after class. The program included 30 preventative sessions of neuropsychological and psychological remediation, aimed at developing executive functions, motor functions, and interhemispheric interaction.
 3. *The program for teacher support* included:
 - The school neuropsychologist working out a training course for teachers in fundamental principles of the neuropsychological approach to education and some practical methods that the teacher could apply during classes.
 - The school psychologist working out some exercises in art-therapy, relaxation, and elements of psychotherapy in order to help the teacher solve problems of communication with maladjusted children, namely with learning-disabled children.
 4. *Lectures by neuropsychologists and psychologists for parents*, which aimed to help them better understand the specific features of their child and to participate actively in his/her remediation.

A collaboration among all specialists included in the child's education at primary school is mandatory for success of each of these programs. The results of the *fourth step (neuropsychological follow-up)* and the description of the efficiency of this collaboration will be discussed in the continuation of this study.

Discussion

Our study found a very high percentage of children with cognitive problems and at risk for future learning disabilities and maladjustment at school: 37% of schoolchildren entering the first year of school. This rate correlated with data from many specialists (Akhutina, & Pylayeva, 2003; Glozman, 2017; Mikadze, 1998; Sapir, & Nitzburg, 1973; Schwarz, & Gawrilow, 2019). In this situation, starting school early, at 6 years old, increases the risk of future learning problems. Parents of these children, especially those with pre- and perinatal disorders, should be strongly urged to have a neuropsychological assessment of their child done before his entering school, to

confirm that his mental functions (primary neurodynamic and executive) are ready for schooling. If any underdevelopment is revealed, a timely course of neuropsychological remediation could prevent future failure at school.

How to help children already accepted for the first year of school?

1. Delayed cognitive development and its structure must be diagnosed as soon as possible, while learning problems still have not provoked emotional and behavioral consequences. This is now possible due to the inclusion of neuropsychologists on the staff of many big primary schools.
2. Nevertheless, the number of pupils in these big primary schools makes it impossible for one neuropsychologist to assess all of them. Therefore, a two-step assessment procedure is described in detail in this paper:
 - A screening group's neuropsychological assessment of all children entering the first year of school. A general psychologist without neuropsychological specialization can apply the proposed methods;
 - A comprehensive neuropsychological assessment by the school neuropsychologist of all children who showed poor results in the first step of the study.
2. Such an assessment permits the school neuropsychologist to:
 - Diagnose the structure of cognitive and emotional disturbances interfering with learning abilities for each assessed child;
 - Work out an individualized program of remediation for each pupil;
 - Assure a team approach (participation of the general psychologist, social worker, teacher, and neuropsychologist) in the realization of the remediation program. The paper determines the tasks of each specialist;
 - Reveal in a timely fashion the children who need the help of a specialized remediation institution, because the contemporary public schools all over the world lack the necessary resources to realize neuropsychological remediation in full.

The follow-up of the children who participated in this study can show the efficiency of the proposed team approach for prevention and remediation of learning disabilities

Conclusion

Neuropsychological assessment revealed the complex structure of cognitive disturbances which interfere with pupils' learning abilities in primary school. The most pronounced defects were in attention concentration and the ability to follow instructions (neurodynamic and executive functions).

A team approach in public schools can efficiently prevent learning disabilities and help children with cognitive underdevelopment and at risk of future failure at school, when this collaboration among school specialists has a common theoretical approach based upon comprehensive neuropsychological assessment.

The team approach helped realize both diagnostic and remediating tasks, and assured efficient supervision of children with special needs and learning disabilities. A special emphasis should be put on preliminary group assessment of first year school-children to reveal the pupils at risk of future learning problems.

Contemporary public schools lack the necessary resources to realize neuropsychological remediation in full. The main task of the school neuropsychologist is to coordinate the work of other specialists at the school, to work out necessary programs of collaboration, to make a comprehensive individual neuropsychological assessment of each child with learning and behavioral problems, and to make timely decisions revealing which children need the help of a specialized remediation institution.

Limitations

The findings relate only to the first three steps of our study; they can inform future studies.

Ethics Statement

The study received ethical approval from the Ethical Committee of the Faculty of Psychology, Lomonosov Moscow State University (Moscow, Russia).

Informed Consent from the Participants' Legal Guardians

Written informed consent to participate in this study was provided by the participants' legal guardians.

Author Contributions

Janna Glozman developed the concept of the study and performed the theoretical analysis. Anna Plotnikova collected the data, performed statistical analysis and computations, and described the results. The two authors discussed the results of the study and prepared the text.

Conflicts of Interest

The authors declare no conflicts of interest.

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Neuropsychological Assessment of Difficulties in Reading Spanish: A Cultural-Historical Approach

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Background. This paper argues that Cultural-Historical neuropsychology provides a solid theoretical framework for the assessment of reading difficulties.

Objective. The objective of the paper is to discuss how reading process and reading difficulties are perceived through the prism of Cultural-Historical neuropsychology.

Design. This paper is of a theoretical and methodological nature, directed to practice and research in the field of neuropsychology.

Results. This paper provides an outline of the fundamental concepts and principles of Cultural-Historical theory that are relevant to the assessment of reading difficulties. It provides a blueprint for the assessment of difficulties in reading Spanish via a presentation of data on common mistakes and their relationship to neuropsychological factors.

Conclusion. The crucial role of in-school teaching in facilitating students to avoid developing reading difficulties, or to overcome them, is highlighted.

Keywords:

Cultural-Historical;
neuropsychology;
assessment;
reading
difficulties;
Spanish language

Introduction: Reading from the perspective of Cultural-Historical theory

Cultural-Historical theory understands reading as a kind of intellectual activity directed to the cognitive goal of understanding the meaning of text. Reading is never considered in isolation from the process of writing; the two are examined together as they form written speech (Luria, 2002). The complex understanding of the meaning of text includes transformation and modification of the meaning according to ideas previously assimilated by a subject, or his or her will to be open and receptive to new ideas. Reading and writing cannot be reduced to motor articulation or visual perception processes; instead, they are complex intellectual activities, which include different processes that can be examined through different levels of analysis (Luria, 2002). Complex verbal communication cannot be limited to the understanding of isolated sentences. In Luria's words, *"the process of understanding a text as a whole is much more complex and has a variable psychological structure"* (Luria, 2002, p. 259). Variability of the psychological structure of reading depends on the reader's motives, goals, methods, and the level of acquisition of reading and linguistic structures of each language.

On the level of the brain, the process of reading is represented as a complex functional brain system. Such a system may not be reduced to only visual, tactile, or auditory zones, but includes complex and flexible combinations of joint work among different cortical and subcortical levels with a hierarchic organization. Such organization depends on the level of reading mastery and the structural peculiarities of each cultural language. Reading also includes intention, which is expressed in a concrete motive for the whole action of reading as directed to the specific reading objective. Intention is culturally introduced in infancy through meaningful cooperation with adults and directed to understanding written texts (Vygotsky, 1962).

On a psychological level, reading can be understood as a psychological process or activity. For instance, the reading process may be understood as syllabic, oral, semi-oral, or completely visual (Luria, 1976; Elkonin, 1989; Solovieva & Quintanar, 2020). Reading may be understood as the recognition of signs and symbols. Reading may be realized in different languages, and each cultural language has its own complex structure at several levels (phonetic, lexical, grammar, and text production). In reality, reading is all of these complex processes at the same time. Reading is the reconstruction of the oral word according to a written model of these words (Elkonin, 1989). Reading is a transformation of the profound sense of written text according to the reader's personality, which is different from superficial ordinary word meaning (Luria, 1976). Reading is also a part of the formation of the child's personality, since the sense of the texts may modify the child's image of the world (Leontiev, 1983). Therefore, the ultimate conscious goal of the action, from a psychological point of view, might be to read the text and understand its meaning.

The objective of this paper is to discuss how the reading process and reading difficulties are perceived through the prism of Cultural-Historical neuropsychology. This prism includes the concepts of functional system, neuropsychological factor, and neuropsychological syndrome. These concepts allow us to analyze and anticipate specific mistakes related to particular brain mechanisms. The mistakes are also

specific for each language, so in this article they are analyzed for the case of Spanish language. Establishing a clear relationship between the understanding of reading as a complex psychological process, its representation on the brain functional level, and analyses of mistakes made during the assessment of reading in Spanish-speaking subjects, is what we have attempted in this article.

Fundamental concepts of Cultural-Historical neuropsychology applied to the examination of reading

Functional systems

As a psychological action, reading includes different operations which take part in the content of this action, and normally, as automatized processes, are not reflected on the conscious voluntary level. These operations are:

1. Visual recognition of each letter in written words or integral words (combinations of graphemes).
2. De-codification of the written word into oral or silent words (articulation).
3. De-codification of written sentences into meaningful ideas.
4. Recognition or modification of the lexical meaning of words.
5. Recognition of grammatical structures and combinations.
6. Reflection on and verification of the meaning according to the goal.

All these operations do not develop automatically and do not appear spontaneously at a given chronological age. They are subject to instruction and should be introduced as voluntary and conscientious intellectual actions, first as a joint action between school teachers and children. In line with Galperin (1998), we argue that not only is phonological consciousness necessary for appropriate learning of reading, but also lexical, grammar, and syntactic consciousness (Solovieva & Quintanar, 2019; Solovieva, Rosas, & Quintanar, 2019; Solovieva & Quintanar, 2020).

The consideration of the content of operations which take part in the process of reading allows for the establishment of a relationship with the brain's action of reading via the application of the concept of a functional system. Luria (1980) argued that each mental function is based on the integrated functioning of different regions of the brain that unite into functional brain systems. Luria (1980) recognized that the localization of higher mental functions in the human cortex is always dynamic. The concept of dynamic localization originally developed by Luria (1970a, 1980) has been reformulated by the authors into a *systemic*, *dynamic*, and *hierarchical* representation of psychological actions as functional systems (Solovieva et al., 2019). The brain's representation of the reading action is *systemic* because a series of specific psychophysiological factors take part in the action. It is *dynamic* because it is dependent on different conditions, such as the stage of learning, type of usage, and age. It is also *hierarchic* because different brain cortical and subcortical mechanisms and relations are involved in this process in different ontogenetic periods. These elements, taken together, form the functional system of reading (either silent or oral).

According to Luria's proposal for the consideration of functional brain organization (Luria, 1973), the reasons for reading difficulties might be related to an insufficient level of functioning of one of three blocks of the brain: the block of general brain activation, the block of processing sensory information of different modalities (visual, auditory, tactile, and spatial), or the block of programming, regulation, and control. Functional difficulty with each functional brain block may be a "neuropsychological" reason for reading difficulties. The positive or negative role of each functional block in the reading process might be established, not according to the answers of the parents and teachers, but according to the results of clinical qualitative neuropsychological assessment (Solovieva & Quintanar, 2016, 2018).

Luria (1973) has stated that no voluntary processes, including movement, can be carried out by only one brain zone or level. Reading processes are a complex intellectual activity, which is also based on voluntary movements. These voluntary movements are explicit during oral reading and are implicit during reading in silence. Luria (1973) wrote:

... voluntary movement is the basis of the joint work of diverse brain sectors, and if the apparatus of the first block guarantees the necessary muscle tone, without which no kind of coordinated movement would be possible, the apparatus of the second brain block provides the possibility of afferent synthesis, on which systemic basis the movement takes place, so that the third functional brain block ensures that the whole process of the movement and the action according to the corresponding intentions, creates the programs and the motor realization, and guarantees regulation and control of the course of the movements in order to preserve an organized and conscious character" (p. 123).

A functional system may be stable if the subject accomplishes a high level of learning of the action, or unstable if the subject only happens to start the learning process or encounters any kind of obstacles or difficulties in the process for any reason (Leontiev & Zaporozhets, 2016). A functional system should not be understood as an elementary process which emerges from the brain. A functional system is rather the physiological basis of and for the execution of the actions that the child learns through interactions with others and within a culture in general. It follows that the formation of functional systems and brain factors is not merely biological, but is essentially a cultural and historical process as well (Luria, 1980). According to Luria (1973),

... each form of conscious activity is always represented as a complex functional system and is fulfilled with the help of joint work of three cerebral blocks, each of which accomplishes its own participation in the realization of the psychological process (p. 123).

The task of Cultural-Historical neuropsychology is not to provide a diagnostic label (e.g., dyslexia), but to study the origin of the difficulties from the perspective of functional brain organization, and to establish the precise reason for the child's functional difficulties.

Neuropsychological factor

A neuropsychological factor “is a structural-functional unit characterized by a definite principle of psychophysiological activity and functioning (*modus operandi*)” (Glozman, 2007, p. 73). The neuropsychological factor is a product of the functional role of a specific brain zone or level, which might be identified in the psychological actions of a subject. Difficulties with reading processes emerge due to the inadequate development or functional state of different types of neuropsychological factors (Torrado, Solovieva, & Quintanar, 2018). No psychological action can be fulfilled by a single neuropsychological factor. At the same time, these neuropsychological factors may contribute to a variety of psychological actions. Each brain factor is related to various brain cortical and subcortical zones, which take part in the realization of the operation (Luria, 1980). The reading process is carried out by the active participation of different neuropsychological factors.

Very frequently, children present the “symptoms” of difficulties for the codification of sounds into letters of the language they study at school. There is no one functional brain reason that explains these difficulties. Plenty of different reasons might underlie this symptom. These various reasons might include difficulties with the phonemic and phonematic analysis of sounds of oral speech, problems with the kinesthetic analysis and synthesis of the motor articulations of oral speech, complications with the visual and spatial analysis of graphic signs, and difficulties with the regulation and control of their own voluntary activity. All these kinds of functional deficits correlate with the child’s struggles in acquiring reading skills. In each case, the child would present specific typical mistakes in the reading process. At the same time, such errors in reading will appear together with similar types of mistakes in the other school activities, such as writing, oral speech, mathematics, drawing, etc. *Table 1* shows the participation of different neuropsychological factors in the process of reading in the Spanish language.

Table 1

The neuropsychological factors responsible for reading difficulties and their involvement in reading Spanish

Neuropsychological factors	Manifestation of deficit in reading
Phonematic discrimination	Confusion with sounds according to phonological oppositions; poor lexicon; confusing the meaning of concrete words; a preference for understanding sentences and texts instead of concrete words. A preference for silent reading but only in cases of previous premorbid automatized acquisition of reading. Never observed in school-age Spanish-speaking patients.
Kinesthetic analysis and synthesis	Confusion and substitution of consonant sounds close in mode and posture of motor production/articulation; omission of consonants; omission of consonants in cases of a complex combination of consonants; poor lexicon; misunderstanding of long, new, uncommon words; difficulties understanding sentences and texts; difficulties in all modalities of oral articulation. A preference for short words and sentences. A preference for silent reading and writing but only in cases of previous premorbid automatized acquisition of reading. One of the most common causes of reading difficulties in Spanish-speaking children in primary school. Very poor reading understanding.

Neuropsychological factors	Manifestation of deficit in reading
Audio-verbal retention	Difficulties understanding long sentences; problems understanding low-frequency words; problems understanding pairs of words similar in oral pronunciation; virtual absence of understanding long texts. Only observed in patients with brain damage, starting from 12 years old.
Spatial simultaneous analysis and synthesis	<p>Substitution and confusion of spatially close letters; difficulties with evoking entire words explicitly; difficulties understanding phrases and sentences with logical (temporal, spatial) prepositions and connectors; difficulties with understanding comparative, genitive, cause-effect with passive mode and subjunctive mode sentences. Severe difficulties understanding sentences with complex grammar structures and texts. A preference for understanding words and short sentences with a limited number of prepositions. No articulation difficulties. Very poor reading understanding.</p> <p>Very common, starting from 6 or 7 years old due to developmental or acquired functional deficit.</p>
Visual retention	<p>Confusion of similar graphic images such as letters and drawings. Inability to produce any concrete image or sign. Confused understanding and evoking similar words according to a concrete image.</p> <p>Never observed in Spanish-speaking school children with developmental difficulties.</p>
Sequential motor or kinetic motor organization	<p>Omissions, substitutions, confusions of consonants and entire syllables or short words, and perseveration of sounds, syllables, and words. Difficulties creating and understanding phrases and sentences. A total inability to understand texts or even sentences. Severe difficulties or even lack of ability to acquire reading and writing skills at school. Poor oral speech; reverting to simple words and common phrases.</p> <p>One of the most common reasons for reading difficulties in Spanish-speaking school children.</p>
Programming, regulation, and control	<p>General inability for flexible learning, including reading processes. Anticipation and substitutions of letters, words, phrases, or sentences close in meaning or pronunciation; inability to verify mistakes in reading; lack of interest in reading; absence of critical reflection on messages or instructions. Misunderstanding and inability to understand the meaning of rules and common patterns; lack of guessing or insight during reading. Notable difficulties applying orthography rules. Absence of proper expression and intonation, difficulties following signs of expressions and making pauses during reading aloud.</p> <p>One of the most common reasons for problems in the reading process.</p>
General brain activation, energetic tone of cortical functioning	<p>Difficulties following orthography rules; constant changes in all kinds of mistakes; commonly makes mistakes in the pronunciation of words when reading aloud; lack of interest in reading texts.</p> <p>One of the most common reasons for difficulties in school learning in general and not so evident for the reading process.</p>

According to the conception of a complex functional system, it is possible to identify specific mechanisms or components of reading as psychological processes related to the functioning of certain brain zones. It is important to stress that before identifying the brain mechanisms, it would be necessary to provide a psychological analysis of the content of the reading process. In other words, psychological analysis of the structure and content of the cognitive action might be carried out before

the neuropsychological analysis of the functional system and its brain mechanisms. Brain representation of reading actions is dynamic because it's changeable according to different conditions: stages of learning, type of usage, inner structure (language), age, etc. Brain representation of reading is systemic because a series of specific psychophysiological (cortical and subcortical) mechanisms take part.

The brain might be intact but the existence of the brain without cultural activity would mean the absence of functional systems. A functional system might be understood, not as a feature of the brain itself, but as the basis for executing actions, when the subject (a child) learns within cultural interactions with others, and with the culture in general. According to the belief of Cultural-Historical psychology about the formation of a functional system as active action (Leontiev, 1983; Solovieva & Quintanar, 2020), the absence of cultural interactions leads to a lack of psychological actions (reading) and, at the same time, to a lack of corresponding functional systems.

Neuropsychological syndrome

Following the principles of Luria (2002), the authors have proposed an understanding of the neuropsychological “syndrome” in child neuropsychology, including different levels of analysis, such as: a) the level of a material (anatomic or neurophysiological) cause of impairment; b) the level of functional brain mechanisms; c) the level of psychological actions, which will suffer as the consequence of the mechanism; and d) the level of speech or linguistic difficulties related to the functional brain mechanism (Solovieva & Quintanar, 2016, 2018). The level of neuropsychological factors may help to establish a relationship between the mentioned levels of analyses, which may be applied to diverse combinations of learning-difficulty symptoms, including reading difficulties. The determination of a specific neuropsychological syndrome may be made based on a qualitative neuropsychological assessment, taking into account specific elements of different functional systems and the psychological age of the child.

A neuropsychological syndrome is not a sum or a combination of different external behavioral symptoms (Solovieva & Quintanar, 2016). Considering that there is the same central factor or brain-function impairment causing such disturbances, the neuropsychological syndrome is always conserving some psychological functions with the disturbances of the other functions. A neuropsychological syndrome would never include only one disturbed function, for example, the reading process. There would always be several functions affected or disturbed by the same neuropsychological factor.

During learning at school, the child only learns psychological processes or acquires intellectual actions (Galperin, 2000; Talizina, 2018). The difficulties appear not only on the level of consolidated processes but in intellectual activities during development or during the teaching-learning processes. These problems might be understood better with the term “obstacles.” The objective of neuropsychology is to understand these obstacles better in order to propose and organize the method for overcoming such obstacles.

The neuropsychological syndrome, in these cases, should be understood as involving specific obstacles for learning some cultural activities (reading), always combined with difficulties for learning other cultural activities (writing, drawing, speech production), based on the same brain-function deficit or the same neuropsychological factor. The cultural actions which do not include this factor, present a positive level of development. The cultural actions which include this factor, present a deficient level of development. The child may or may not be conscious of their own difficulties.

The consequence of such neuropsychological syndromes would always include personal effects in the child's life, such as poor school learning, negative communication with peers and teachers, absence of broad cognitive interests, and so on. Each concrete case of reading difficulties should be analyzed from different levels or different points of view: 1) the neuropsychological factor, 2) affected and unaffected intellectual actions, and 3) negative consequences in the child's personality. In the case of reading difficulties, as in any other kind of verbal difficulties, one more level must be included during the analysis of difficulties: the linguistic level. This level comprises specific features or the structural organization of language: for example, phonologic, lexicon, grammar, or syntax at the level of general verbal expression as the sense of communicative expression (Bajtin, 2009).

Table 2 shows the levels for analysis of neuropsychological syndrome in cases of learning disabilities, according to our proposal. Each concrete case of learning difficulties should be analyzed according to these levels. The level of neuropsychological factors should unify and explain all the clinical manifestations of the rest of the levels.

Table 2

Levels for analysis of the neuropsychological syndrome for cases of learning disabilities

Levels of analysis of syndrome	Content
Neuropsychological	Brain functional mechanisms responsible for difficulties in learning
Psychological (intellectual actions)	School actions which show the proper level of gains and school actions, which suffer according to an established factor
Personality	Effect of learning difficulties on a child's social relations and interests
Linguistics	Concrete verbal difficulties related to any level of language structure: phonological, lexicon, grammar, syntax, etc.

As shown in *Table 2*, reading difficulties never appear as isolated problems. Brain mechanisms or factors which might be identified as the functional reason for reading difficulties, trigger problems at different levels: psychological, personal, and verbal. The student shows multiple learning difficulties. Even then, only reading difficulties are detected by the teacher. Reading challenges are accompanied by challenges in writing, problem-solving, productive tasks, and so on. The combinations and manifestations of these difficulties differ depending on each neuropsychological factor (*Table 1*). At the same time, the weak functional state of each factor causes typical mistakes by the child in the process of reading, which might be described in detail for each language system.

Common mistakes in reading Spanish and suggestions for their correction

From a Cultural-Historical neuropsychological point of view, the most crucial aspect of assessing reading difficulties involves the nature and explanation of errors (Ardila, 1992). Finding and identifying reading difficulties is a necessary but first step that simply provides a gross estimation. In the case of functional deficits of neuropsychological brain mechanisms, the effect of weak mechanisms would be necessarily reflected in all intellectual actions and operations of the child. The whole act of reading and understanding of written expression will suffer as a “complex verbal communicative” (Luria, 1998, p. 393). From the perspective of linguistics, the mistakes that appear in the reading process might be related to different levels, such as phonological, morphological, grammar, syntax, and the level of the sense of verbal communication (Bajtin, 2009).

As previously mentioned, the functional system of the reading process includes several functional brain mechanisms. The functional deficit of each brain mechanism provides specific difficulties. Such deficits are related to an unfavorable functional stage of neuropsychological factors, commonly detected as responsible for problems in the reading process in Spanish-speaking school children (Solovieva & Quintanar, 2020). These factors are 1) kinesthetic analysis and synthesis; 2) simultaneous spatial analysis and synthesis; 3) sequential motor organization; 4) programming, regulation, and control; and 5) general brain activation.

It is important to mention that, in the case of reading difficulties in Mexican children (Spanish language), no complications are related to phonematic integration, as was shown in a recent study (Solovieva, Akhutina, Pylaeva, & Quintanar, 2021). Difficulties pertaining to phonematic integration were reported in studies with reference to adult patients with brain injuries and a diagnosis of sensory aphasia (Pérez, 2000; Solovieva, Chávez, Pérez, & Quintanar, 2001; Benavides, 2015). The authors hypothesize that the phonematic content of Spanish is straightforward. There is no significant quantity of pairs of phonematic oppositions for consonants, as for instance, in Russian and Portuguese (Morais, 2010; Chastinet, et al., 2011, 2012; Morais, et al., 2012). These results contain considerable evidence of the role of the cultural specificity of each language in functional brain participation and in variants of difficulties, which arise during learning reading at school.

1. *Functional deficit in kinesthetic analysis and synthesis* might be observed in constant substitutions and omissions of sound, which are close to the point and mode of articulation production. These reading mistakes are related specifically to the phonological and morphological level of language. The most notable difficulties are related to consonant sounds. These mistakes occur in all kinds of productive oral speech, including repetition of words and sentences or proper individual expressions. For example, children confuse consonant sounds which are similar by mode and place of motor production (articulation), such as “l”, “r”, “ch”, “y”, “d”, “n,” and confuse all kinds of combinations of consonants in words. Similar difficulties appear during reading words, sentences, and texts aloud. Similar omissions also occur in writing by dictating and elaborating independent words, sentences, and texts. These mistakes might not be notable in repetition, especially in the repetition of unique words. Children will also present a very poor lexicon, which might be limited to very few com-

mon words, phrases, or sentences. At the same time, children try to articulate entire sentences with all syntactic components: subject, predicate, and direct or indirect object. This kind of difficulty is severe and persistent and reflects constant problems in all oral and written verbal processes. Correction in cases of such challenges is prolonged and requires patience from the therapist, the child, and the parents. Correction should be based on gradual training of precise hand and oral postures with the help of games and actions with objects. Drawings and perceptual table games are useful before the gradual introduction of reading and writing.

2. *Functional deficits in spatial simultaneous analysis and synthesis* are related to understanding and producing long sentences with complex grammar structures, and with severe difficulties with the production and understanding of spatial and temporal prepositions. For example, children do not understand sentences like "The dog runs behind (or in front of) the car." These reading mistakes are related specifically to grammar and the syntactic level of language. There are no errors in the repetition of words and direct simple sentences or proper short individual expressions, or the inability to produce or understand texts. Technically, reading is accessible but without a proper understanding of written information. Children are able to pronounce long words and sentences. In some cases, confusion between similar letters in a visual image or spatial orientation might be found. Systemic effects of these brain mechanisms seriously affect the learning of mathematics, writing, and sciences, which require orientation on the perceptual level, such as tables, graphics, schemes, maps, and systematic rules. Correction should include external orientation to objects and surroundings, with the help of games and external intellectual actions, and then proceed slowly to the level of orientation in perceptual space.

3. *Functional deficits in the sequential motor organization* will be related to severe difficulties in all reading modalities, and even total inability to read. These reading mistakes are related specifically to the phonological, morphological, and grammar-syntactic levels of language, and a very common inability to produce or understand sentences or phrases, with a clear preference for isolated word articulation and understanding. For example, children produce only isolated short nouns instead of long properly-organized sentences, such as "play" instead of "I like to play every day." There may be considerable difficulties in understanding and producing phrases or sentences with prepositions and with any kind of complex grammar structures, with frequent omission of complex consonants in words, and a total inability for producing or understanding texts. Technically, reading is not accessible at all. Systemic effects of the functional deficit of sequential motor organization affect all intellectual and practical actions based on organized movements. Correction in such cases is prolonged and difficult, and should include exercises for hand movements in established series, such as playing musical instruments, active games with physical actions, and ongoing drawing activity before passing to the level of written speech.

4. *Functional deficit in regulation and control* may be associated with the superficial articulation of common words and sentences, confusion and anticipation of sounds, words, and even sentences while reading texts. For example, children may read "go" instead of "going" or "play back" instead of "playing basketball." These reading mistakes are related to morphological and grammar-syntactic levels of language, but primarily to the level of sense reception and transmission of verbal communication as

the general meaningful expression, with an absence of the ability to critique their own mistakes. There is a total inability to produce or understand the profound meaning of texts and to replace complex sentences and phrases by direct and simple grammar structures in all tasks for reading and writing, with a poor interest in learning in general. Technically, understanding the reading of texts is not accessible at all. Systemic effects of a functional deficit of regulation and control are reflected in all intellectual tasks, which are new, require new understanding, or follow the goal and proper selection of the solution among two or more options. Correction of such difficulties should include detailed work with an orientation provided by steps, games with explicit rules, and external representation of each rule of strategy for each intellectual action.

5. *A functional deficit in general brain activation* may cause superficial articulation of common words and sentences. There is no specific level of linguistic organization of language observed concerning this factor, and more research should be conducted to determine the relationship between general brain activation and linguistic difficulties. It's possible to foresee potential problems with the general understanding of written texts due to a lack of stability in cognitive functioning. There are constant fluctuations and an absence of consistency in the execution of reading and all intellectual tasks. Children present an adequate reading of isolated words. There is an absence of consciousness of their own mistakes in situations of frustration or tiredness. Severe difficulties for producing or understanding the profound meaning of long texts might be detected with a much better understanding of short and funny stories. Children may show insufficient interest in learning in general, especially for long monotonous tasks. Technically, the understanding of texts is accessible in a good functional state with interest in the topic. Systemic effects of these difficulties also appear in all intellectual actions, which require a long period of concentration and execution of tasks, and repetition of exact information. Correction of such problems should include work with new and motivating tasks, changes in tasks, and the inclusion of rhythmic and active physical actions and games with a clear explanation of rules. *Table 3* summarizes the relationship between five neuropsychological factors as the reason for difficulties in reading, and the linguistic level of language organization for the Spanish language.

Table 3

Neuropsychological factor and linguistic levels

Neuropsychological factors	Linguistic level of language
Kinesthetic analysis and synthesis	Phonological and morphological level.
Simultaneous spatial analysis and synthesis	Grammar and syntax level
Sequential motor or kinetic motor organization	Phonologic, morphologic, grammar, and syntax levels
Programming, regulation, and control	Grammar, syntax, and the level of sensitivity of verbal expression and communication. Mistakes on the phonological and morphological levels may be observed.
General brain activation, energetic tone of cortical functioning	No relation between linguistic levels was determined. Probable difficulties for the formation of sense and intention of verbal expression.

Discussion

According to the principles presented, neuropsychological analyses might provide much more information and explain neuropsychological mechanisms in reading difficulties. The reading process may be hindered by multiple factors of brain functioning, such as kinesthetic integration, phonological integration, motor organization of sequential, flexible movements, regulation and control, and a general stage of activation. In each case, different kinds of mistakes would be typical in children with difficulties in the reading process. It is imperative to study and compare these typical mistakes in other languages. In Spanish-speaking school children, five functional brain mechanisms were observed as the main areas where difficulties arise during reading acquisition, according to the authors' clinical practice. These factors are: 1) kinesthetic integration; 2) simultaneous spatial analysis and synthesis; 3) motor organization of sequential, flexible movements; 4) regulation and control; and 5) a general activation stage.

Successful identification of such types of mistakes might help to find the proper ways to develop and correct children's reading. Modern neuropsychology should not be limited only to labeling students according to diagnostic categories, such as those presented in DSM-V (APA, 2013). Instead, it should be providing practical means for an objective understanding of difficulties in the reading process. Such knowledge may offer proper suggestions for teaching, organization of day-to-day activity, and correction. In this sense, reading-correction programs at school have to be directed not to the training and repetition of exercises for strengthening the reading process, but the gradual strengthening of absent, weak psychological operations with the inclusion of weak neuropsychological factors.

It is also essential to consider that difficulties in the acquisition of reading might develop due to inappropriate teaching methods at school, or the low level of a child's preparation for school learning. School psychologists, neuropsychologists, and teachers interested in analyzing the process of reading should pay special attention to the development of the symbolic function and general verbal communication at pre-school age, the pattern of conformation of voluntary activity, cognitive motivation, and emphatic reflection as essential features of the child's personality.

Several intervention programs that are rooted in Cultural-Historical neuropsychology have been used to help children overcome their difficulties in reading. Evidence has started accumulating for the effectiveness of such methods in Spanish and Russian (e.g., Akhutina & Pylaeva, 2012; Cadavid-Ruiz, Jiménez, Quijano, & Solovieva, 2019; Glozman, 2011; Torrado, Solovieva, & Quintanar, 2018; Solovieva, Torrado, & Quintanar, 2019). New studies in other languages and cultural situations are needed to elaborate a more precise panorama of problems in reading acquisition at school.

Conclusions

Luria (2002) has provided a neuropsychological analysis of the process of writing for the Russian language. His methodology was used by the authors of this article as a template to analyze the process of reading in the Spanish language. The present article might serve as an example of assessment and syndromic analysis of developmental and clinical difficulties in Spanish-speaking subjects. Detailed analyses of

mistakes related to brain functioning might facilitate a better understanding of the reading process, assessment, correction, and teaching for children of different ages. The limitations of this article are related to the absence of coordinated work between neuropsychologists who are specialists in the assessment and development of reading in different languages. The authors hope that the article might serve as a motive for such kind of novel collaboration.

Author Contributions

All authors conceived of the idea. Y.S. and L.Q. developed the theoretical background. Y.S. and A.K. wrote the article.

Conflict of Interest

The authors declare no conflict of interest.

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Executive Functions' Impact on Vocabulary and Verbal Fluency among Mono- and Bilingual Preschool-Aged Children

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Background. The phenomenon of multilingualism and its impact on child development are in the spotlight of latter-day psychology, and of utmost importance both for theory and practice. Language development is a strong predictor of psychological readiness for school and further academic success. At the same time, children's mastery of written and oral speech in school education in a multilingual environment has several distinctive features. This study was dedicated to examining the influence of executive functions on the development of the vocabulary aspects of speech (both active and passive vocabulary) of mono- and bilingual children growing up in a bilingual environment.

Objective. We aimed to analyze the relationship between bilingualism and language development (vocabulary and verbal fluency) and determine which executive functions may help overcome the resulting difficulties at preschool age.

Design. Both monolingual and bilingual children participated in the study ($n = 137$ and $n = 81$, respectively). The children's ages ranged from 6 to 7 years ($M = 78.7$ months, $SD = 5.87$). Two independent General Linear Models (GLM) were built to define which executive functions influenced the vocabulary and verbal fluency of the mono- and bilingual subjects (controlling for age, gender, and non-verbal intelligence as well).

Results. The results confirmed that bilingualism is negatively related to language development, but showed that verbal working memory significantly helps bilinguals compensate for difficulties in developing vocabulary and verbal fluency.

Conclusion. The study demonstrated that the ability to preserve and reproduce verbal information was of more significance for children's vocabulary and verbal fluency than their language group (mono- or bilingual).

Keywords: Preschool age; speech; vocabulary; executive functions; working memory; inhibitory control; cognitive flexibility.

Introduction

The phenomenon of multilingualism and its impact on child development are in the spotlight of latter-day psychology, and of utmost importance for both theory and practice. According to the definition given by the U.S. Department of Health and Human Services, 2008, a dual language learner is a person who acquires two or more languages simultaneously, *i.e.*, learning a second language while still developing the first. Bi- or multilingual education and parenting is gaining popularity internationally and becoming more and more common. In many countries, children learn and use two or more languages from their early childhood.

The experience of parallel mastery of two languages to a certain extent affects the process of language mastery itself, and is tightly connected to cognitive systems of language application, reflection on the world, and self-regulation. The current study is dedicated to examining the impact of executive functions on the development of vocabulary aspects of speech (active and passive vocabulary) of mono- and bilingual children growing up in a bilingual environment.

Language development

Language development is a complex phenomenon, defined by a whole number of mental processes related to children's mastering of written and oral speech. Speech not only executes its main function of communication; it also provides for the development and functioning of other mental functions. Language development at pre-school age has a significant impact on the development of cognitive skills (Diamond, Prevor, Callender, & Druin, 1997; Gooch, Thompson, Nash, Snowling, & Hulme, 2016; Pazeto, Seabra, & Dias, 2014; Rojas-Barahona et al., 2015) and emotional and personal development (Akhutina, Panikratova, Korneev, Matveeva, & Vlasova, 2019; Blair & Razza, 2007; Duff, Reen, Plunkett, & Nation, 2015; Slot, & von Suchodoletz, 2018; Weiland, Barata, & Yoshikawa, 2014). It also appears to be a strong predictor of psychological readiness for school learning (Pazeto et al., 2014; Rojas-Barahona et al., 2015; Japel, 2007).

A 2008 report by the U.S. National Institute for Literacy suggests distinguishing the following criteria when analyzing speech development: phonetic, vocabulary, syntactic, and symbolic. The phonetic criterion includes the perception of oral speech and independent sounds and words through the development of articulatory skills. The vocabulary aspect characterizes the success in the child's mastery of words' meanings (*i.e.*, lexical items) and is reflected in the richness of the child's vocabulary. Syntactic and grammar development is linked to the child's mastery of language rules, necessary for constructing sentences. And last but not least, the symbolic aspect of language development covers the child's mastery of graphic representations of sounds (letters) and the development of basic writing and reading skills.

The Relationship between executive functions and language

The concept of executive functions has been actively explored in studies dedicated to a person's self-regulation. We will be utilizing one of the most significant theoretical models of executive functions' development, the one created by A. Miyake,

Friedman, Emerson, Witzki, and Howerter (2000). Its advantage lies in its distinguishing several interconnected components of executive functions, which, if required by a corresponding research problem, can also be studied separately. According to this model, executive functions are a group of cognitive skills which provide for purposeful problem-solving and the ability to adapt to new situations. The authors suggest dividing executive functions into three main components: 1) working memory (visual and audial); 2) cognitive flexibility (allows the child to transition from one rule to another depending on the specifics of the situation); and 3) inhibitory control (allows the inhibition of impulsive reactions in favor of a voluntary and well-weighed answer).

At this moment, there are two main explanations of the nature of the relationship between language development and executive functions at preschool age. The first one derives from the idea of a gradual increase in the child's cognitive ability due to the development of his/her executive functions (Gooch et al., 2016; Rojas-Barahona et al., 2015; Bierman, Nix, Greenberg, Blair & Domitrovich, 2008; Cain, Oakhill, & Bryant, 2004; Goff, Pratt, & Ong, 2005; Nilsen & Graham, 2009; Shaigerova, Shilko, & Zinchenko, 2019; Verhagen & Leseman, 2016; Weiland, Barata, & Yoshikawa, 2014).

For example, the development of working memory first allows the child to distinguish independent phonemes in the flow of verbal interaction, and remember them. It contributes to the growth of the number of lexical items he/she can use in further communication. The development of executive functions is viewed as the impetus for speech, as well as the intellectual, emotional, and personal development of a child. A whole range of experimental research dedicated to the purposeful development of executive functions, has revealed its connection to significant progress in children's language development (Rojas-Barahona et al., 2015).

The second approach is based on the assumption that language development entails the development of executive functions (Botting et al., 2017; Bukhalenkova, Aslanova, Airapetyan, & Gavrilova, 2021; Henry, Messer, & Nash, 2012; Fuhs & Day, 2011; Lonigan, Wagner, Torgesen, & Rashotte, 2007). This explanation coheres with the principles of cultural-historical approach (Vygotsky, 2017), because the child's inner speech, as understood by Lev Vygotsky, acts as the means of self-regulation. This inner speech serves the functions of the child's goalsetting, planning, and performing of voluntary actions. This perspective has been supported by a number of research papers focused on the difficulties of attention and behavior control experienced by children with language development disorders (Henry, Messer, & Nash, 2012; Fuhs & Day, 2011; Petersen et al., 2013).

The relationship between executive functions and language was first registered in the lexical processing of the speech of monolingual subjects (Bohlmann et al., 2015; Fuhs & Day, 2011; Matthews et al., 2009). Moreover, Bierman and Weiland obtained evidence that the connection between those two domains didn't just exist in one point in time. In fact, their relationship was a prolonged one, and the level of executive functions acted as a predictor for the development of children's vocabulary (Bierman et al., 2008; Veraksa & Veraksa, 2021; Weiland et al., 2014).

For example, Weiland et al. discovered that the dynamic of vocabulary enrichment over one year in a kindergarten was determined by the child's level of development of executive functions at the moment of admission (Weiland et al., 2014). Many experts

point out that language skills evaluated at the beginning of preschool education, do not in fact influence either the means of development of executive functions or its pace. Equally, Bierman's research (Bierman et al., 2008) demonstrated that all the individual components of executive functions (working memory, inhibitory control, and cognitive flexibility) forecast in large measure the growth of a child's vocabulary.

Notwithstanding these results, two other major research papers revealed that there was indeed an association between lexical processing and executive functions, but a different one than was previously assumed (Oshchepkova, Bukhalenkova, & Almazova, 2021; Bohlmann et al., 2015; Vallotton & Ayoub, 2011). For example, Bohlmann's longitudinal study found a bi-directional connection between the two aforesaid domains. The bigger the child's vocabulary was at the beginning of the study, the better he/she solved the tasks that required additional skills, *i.e.*, the use of executive function throughout the research. Contrariwise, the better developed the child's executive functions were *ad initium*, the more noticeable the dynamic of vocabulary growth was (Bohlmann et al., 2015).

Nevertheless, the study by Vallotton and Ayoub demonstrated that the size of a child's vocabulary could be considered a reliable predictor of the development of his self-regulation, but not the other way around. The authors of the research emphasized that for children, language is a means of solving the self-regulation problem; it helps to focus their attention and thoughts (Vallotton & Ayoub, 2011). Research dedicated to the connection between vocabulary size and each separate component of executive functions, has led to the conclusion that it was the working memory which was related to the vocabulary size in the most consequent and powerful way (Cain et al., 2004; de Abreu et al., 2011; Morra & Camba, 2009; Verhagen & Leseman, 2016; Nilsen & Graham, 2009).

One should note that a similar positive connection was discovered on the morpho-syntactic level of processing; it was shown that children with poor working memory were facing more significant syntactic difficulties (Stanford & Delage, 2020; Delage & Frauenfelder, 2020). To conclude, our analysis of existing papers led us to assuming the presence of a bi-directional connection between the development of vocabulary and executive functions, where working memory plays a special role in the growth of vocabulary.

In the case of children who follow the typical developmental route, language and executive functions mutually impact and shape each other from the very first days of learning. Mastering a language creates a foundation for the development of a set of cognitive skills which support problem solving and adaptive behavior in new situations. Vygotsky's assumption that inner speech contributes to the development of the child's observation and regulation skills (including thinking and activity), was confirmed by research on children's atypical speech development. Vygotsky suggested considering inner speech "not as speech minus sound, but as a speech function completely special and peculiar in its structure and mode of functioning, which /.../ is in an inextricable dynamic unity of transitions from one plan to another" (Vygotsky, 2017, p. 275). What he meant by this transition was that the organization of the child's mental activity was in compliance with the situational context and assigned task. But then, various components of executive functions contribute to and support

language development because: a) they help the child concentrate his/her attention on the child-adult interaction; b) provide for retaining visual and audial information (what the adult pronounces, and how); c) facilitate the formation of concepts (by establishing the relationship of the word and its meaning); and d) factor into the child's control over his/her impulsive reactions and ability to act appropriately (finding the right words for a certain situation and making up his/her statements correctly).

It was to be expected that the development of bilingual children's executive and language functions would have some sort of unique and complex dynamic by contrast with monolingual subjects. That would be explained by the fact that a bilingual child has to master two language systems simultaneously (for all processing levels, such as phonetical, lexical, and symbolical). Yet, there are clearly insufficient studies on the relationship between bilingual children's language and executive functions, while there are quite a few for monolingual children (Bialystok et al., 2005). Therefore, the goal of the present study was to analyze the relationship between bilingualism and language development (vocabulary and verbal fluency) and determine which executive functions may help overcome these children's difficulties in language development at preschool age (considering also their age, gender and non-verbal intelligence level).

Methods

Participants

Two hundred and eighteen 6–7-year-old children participated in the current study ($M = 78.7$ months, $SD = 5.87$), 50.1% of them girls). All the subjects lived in the Republic of Sakha (Yakutia), and attended public kindergartens. The children were divided into groups (monolingual: $n = 137$, or bilingual: $n = 81$) in accordance with their preschool educators' answers to the following questions: a) which language does the child speak most of the time in the classroom? and b) which language is used for child-parents communication? The results of the t-test for independence allowed us to be sure that the mono- and bilingual groups did not differ age-wise ($p > 0.05$). Assessment of the children's executive functions was conducted individually by specially trained assistants. The assessment was performed in Russian in a separate quiet room provided by the kindergarten.

Materials

Measures of language development

The Peabody Picture Vocabulary Test 4th Edition (PPVTM-4) was used for the assessment of the subjects' passive vocabulary, *i.e.*, the volume of words that they could understand when perceived audibly (Dunn & Dunn, 2007). The latest edition of this test allows evaluation of a person's active vocabulary (the volume of words that the child knows and is capable of naming without the interviewer's assistance).

In order to evaluate the children's verbal fluency, we applied the *Verbal Fluency Test* (VFT) (Akhutina, 2016). This tool is designed to measure the process of word and verbal fluency. A subject is given a minute and asked to name as many words

as possible. The total score for Verbal Fluency is the number of productive associations, *i.e.*, all the words that were named without repetitions. The productivity score was calculated in the following way: every new word was assigned 1 point; the same applied to every combination of words; but if the child suggested combinations with a repeated word, each new one was assigned 0.5 point. If the subject produced a so-called “automatized sequence” (*i.e.*, a learned and well-established sequence of words, such as Monday, Tuesday, Wednesday, etc.), the interviewer assigned 1 point for the whole row.

Measures of executive functions

The Dimensional Change Card Sort (DCCS) (Zelazo, 2006) is an executive functions-related task designed for the assessment of cognitive flexibility. The DCCS requires that the child sort cards; there are three rounds, and the rules change for each new one. First, sorting must be performed based on the color of the picture (pre-switch trial); then based on the shape (switch trial); and the last round combines contradictory rules — sorting should be based on either the color or the shape, depending on the presence of a frame in the picture (post-switch trial). For further analysis, we used the total score of this technique (the range went from 0 to 24 points).

The subtest *Inhibition* (Korkman, Kirk, & Kemp, 2007) is another technique aimed at assessing executive functions, in particular, children’s ability to inhibit automatized cognitive reactions. It consists of two series of shapes (squares, circles, and arrows). In the first stage the child is asked to name the shape or the direction in which the arrow is pointing (naming trial). In the second stage, the subject is supposed to name the shapes in a reverse manner, which means, say “a circle” when presented with a square, and vice versa. The directions of the arrows are also to be named conversely (inhibition trial). The total score range, used later in the analysis, went from 0 to 19.

Verbal working memory was measured by means of the subtest *Sentences Repetition* (Korkman et al., 2007). This tool consists of 17 sentences to be remembered, with their complexity gradually increasing throughout the test (the sentences get longer and more complex syntactically). For instance, if the first sentence contains only two words and is of the most basic structure (“Good night.”), sentence number 12 consists of 14 words, and is quite complicated structurally (“The woman, who stands next to a man in a green jacket, is my aunt.”). Leaving out a word or substituting a different word was categorized as an error, as well as a modification of word order or another change in the sentence structure. Four consecutive sentences with errors (0 points) meant failure, and the test was ended. We used the total scores (which ranged from 0 to 30) for the final analysis.

We used the subtest *Memory for Designs* (Korkman et al., 2007) to measure visual working memory. There were two parameters to consider: memorization of “images” (the task was to select some pictures matching 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). Each successfully selected picture was assigned two points (“Content score”); one point was given for a correctly reproduced position (“Spatial score”). If the subject both correctly chose a picture and put it in the right place, he/she received two bonus points (“Bonus score”). Thus, there were

four measurements available to rank the children's visual working memory: a content score, a spatial score, a bonus score, and a total score (sum of all points obtained in all the tasks), in accordance with the NEPSY-II battery description.

Measure of non-verbal fluid intelligence

The Russian adaptation of Raven's Colored Progressive Matrices (CMPM) (Raven, Raven & Cort, 2002) was chosen for the assessment of non-verbal fluid intelligence. The respondents were asked to complete matrices of patterns and figures, choosing the right pattern among four options (only one could complete the matrix correctly). Points were accumulated until four consecutive mistakes were made. Then the trial was terminated. The total scores ranged from 0 to 36.

Statistical Analysis

Descriptive statistics and Pearson's r correlation were run for all the variables, to examine the data structure. For the main analysis, two independent General Linear Models (GLM) were built to define which executive functions influenced the vocabulary and verbal fluency of the mono- and bilingual subjects (controlling for age, gender, and non-verbal intelligence, as well). Jamovi software, version 1.0.7.0 (by The Jamovi Project) was used for the statistical analyses required for the current study.

Results

Descriptive statistics. See Table 1 for descriptive statistics and Pearson's r correlation for all study variables, including the subjects' vocabulary, verbal fluency, non-verbal intelligence, and four components of executive functions.

Table 1

Descriptive statistics and for all study variables

	M	SD	1	2	3	4	5	6	7
1. Language group	1.38	0.486	–						
2. Non-verbal intelligence	26.41	9.150	0.037	–					
3. Vocabulary	107.96	33.983	–0.262**	0.113	–				
4. Verbal fluency	8.69	4.53	–0.222**	0.020	0.151	–			
5. Cognitive flexibility	19.15	2.734	0.113	0.105	0.162	0.230*	–		
6. Visual working memory	91.22	20.641	0.006	0.214*	0.152*	0.046	0.015	–	
7. Verbal working memory	16.89	4.962	–0.281***	0.026	0.387***	0.376***	–0.026	0.065	–
8. Inhibitory control	11.31	3.299	0.135*	0.229**	0.134*	0.109	0.078	0.175***	0.162**

Note. * Significant correlation at $p < .05$ (2-tailed). ** Significant correlation at $p < .01$ (2-tailed). *** Significant correlation at $p < .001$ (2-tailed).

The outcome of Pearson's r correlation analyses confirmed that bilingualism had a significantly negative relationship with the subjects' vocabulary ($r(217) = -.262$, $p < .01$) and verbal fluency ($r(217) = -.222$, $p < .01$). It was positively related to their inhibitory control, though ($r(217) = .135$, $p < .05$). Apparently, respondents with a larger vocabulary performed better in all tasks focused on execution functions except cognitive flexibility ($p > .05$). Thus, they more often got higher scores on the visual working memory test ($r(217) = .152$, $p < .01$), the verbal working memory test ($r(217) = .387$, $p < .001$), and the inhibitory control test ($r(217) = .134$, $p < .01$). Children with well-developed verbal fluency often obtained higher scores for cognitive flexibility ($r(217) = .230$, $p < .01$), and verbal working memory ($r(217) = .376$, $p < .001$). Assessment results for executive functions and speech development are detailed in *Table 2* separately for mono- and bilingual children.

Table 2

Results of a complex study assessment separately for mono- and bilingual children

	Language Group	M	SD	Median	Min	Max
Non-verbal Intelligence	Bilingual	28.79	10.34	33	1	36
	Monolingual	28.66	7.20	31	6	36
Vocabulary	Bilingual	106.33	20.87	107	63	147
	Monolingual	121.39	33.21	118.00	10	228
Verbal Fluency	Bilingual	8.28	4.03	8.00	1	16
	Monolingual	10.14	4.77	10	1	26
Cognitive Flexibility	Bilingual	19.63	2.43	20	14	24
	Monolingual	19.05	2.56	19.00	11	24
Visual Working Memory	Bilingual	89.48	20.24	86	50	120
	Monolingual	89.21	19.97	91.00	53	120
Verbal Working Memory	Bilingual	16.11	4.15	17.00	1	23
	Monolingual	18.06	5.22	19	3	29
Inhibition Combined	Bilingual	11.94	3.00	12.00	6	19
	Monolingual	11.01	3.56	11	3	19

Vocabulary and verbal fluency

We built two independent General Linear Models (GLM) with the purpose of examining what levels of vocabulary and verbal fluency (dependent variable) were demonstrated by the subjects, depending upon their executive functions (independent variable). The following factors were controlled as well: language group (mono- and bilinguals), age (continuous in months), gender (categorical with two levels), and non-verbal intelligence (continuous).

Vocabulary

One GLM (Vocabulary (PPVT-4) $\sim 1 + \text{'Language group'} + \text{Gender} + \text{'Age'} + \text{'Non-verbal Intelligence'} + \text{'Cognitive Flexibility'} + \text{'Visual Working Memory'} + \text{'Inhibition Combined'} + \text{'Verbal Working Memory'}$) was built to find out which executive functions influenced the subjects' vocabulary (age, gender, and non-verbal intelligence controlled). [Model with Adj. R-squared = 0.506.] An ANOVA Omnibus test revealed that the model described the data correctly: $F(8) = 5.369$, $p < .001$, $\eta^2p = .506$. According to Fixed Effects Parameter Estimates, only verbal working memory had a significant effect on the children's vocabulary: $F(1) = 9.366$, $p = .004$, $\eta^2p = .182$. No significant effects of language group, gender, age, non-verbal intelligence, cognitive flexibility, visual working memory, and inhibition were registered. The vocabulary test score of the respondents from both language groups (mono- and bilinguals) was higher in correspondence with the development of their verbal working memory.

Verbal fluency

Then we built a GLM (Verbal Fluency $\sim 1 + \text{'Language group'} + \text{Gender} + \text{'Age'} + \text{'Non-verbal Intelligence'} + \text{'Cognitive Flexibility'} + \text{'Visual Working Memory'} + \text{'Inhibition Combined'} + \text{'Naming Combined'} + \text{'Verbal Working Memory'}$), to see which executive functions affected the subjects' verbal fluency. [Model with Adj. R-squared = 0.316.] An ANOVA Omnibus test indicated that the model described the data well: $F(9) = 1.59$, $p < .0161$, $\eta^2p = .316$. According to Fixed Effects Parameter Estimates, only verbal working memory had a significant effect on the children's verbal fluency: $F(1) = 5.975$, $p = .020$, $\eta^2p = .116$. Language group, age, gender, and non-verbal intelligence were controlled. No significant effects of language group, gender, age, non-verbal intelligence, cognitive flexibility, visual working memory, and inhibition were discovered.

Discussion

The key goal set for our study was to analyze the relationship between bilingualism and language development (vocabulary and verbal fluency) and determine which executive functions may help overcome difficulties in language development at pre-school age, while controlling for age, gender, and non-verbal intelligence. First, we explored the relationship among vocabulary, verbal fluency, executive functions, and bilingualism. It was revealed that bilingualism had a significant negative correlation with the subjects' inhibitory control, and a positive correlation with their inhibitory control. Vocabulary size turned out to be related positively to all executive functions except cognitive flexibility.

At the next stage, we studied the influence of executive functions on vocabulary and verbal fluency of bi- and monolingual children (age, gender, and non-verbal intelligence controlled). The outcome of that analysis proved that the size of vocabulary and the level of verbal fluency are determined to a major extent by verbal working

memory. As per our study results, other executive functions do not have any significant effect on the vocabulary and verbal fluency of bi- and monolingual children (language group, age, gender, and non-verbal intelligence controlled). Besides, the language group (mono-/bilingual) was of no significance in predicting vocabulary size and verbal fluency, if the models included verbal working memory.

The positive impact of verbal working memory on verbal fluency among bi- and monolingual children could possibly be understood as linked to the growth of the child's cognitive abilities due to the development of his or her capability to remember verbal information (Gooch et al., 2016; Rojas-Barahona et al., 2015; Weiland et al., 2014; Bierman, 2008; Cain, 2004; Goff, 2005; Nilsen, 2009; Verhagen, 2016). It has been previously demonstrated on a monolingual sample that working memory development allows the child to first distinguish independent phonemes in the flow of verbal interaction, and remember them. This contributes to the growth in the number of the child's lexical items. Our study results indicate that this pattern can be also observed when a child uses two languages simultaneously. Verbal working memory indeed can be considered one of the impetuses of a child's verbal development (Rojas-Barahona et al., 2015).

Nevertheless, we should not dismiss the idea that the development of vocabulary and verbal fluency can also result in the development of the child's executive functions (Botting et al., 2017; Henry, 2012; Fuhs, 2011; Lonigan, 2007). As Vygotsky noted, egocentric speech "...becomes a means of thinking in the proper sense, *i.e.*, it begins to fulfill the function of forming a plan for solving the problem arising in behavior" (Vygotsky, 1982, V. 2, p. 49). Therefore, a rich vocabulary and/or verbal fluency can open new opportunities for child's self-regulation. When it comes to current study results, we can assume that aforementioned rich vocabulary and/or verbal fluency allows the child to recognize, understand, and remember a larger quantity of verbal information.

Limitations

The results we obtained should be interpreted in the context of certain limitations. To start with, the entire sample came from the same region (the Republic of Sakha Yakutia). If we desire further research to replicate these results, a more diverse sample will be needed, which will be more representative. Another limitation was related to the age range of the respondents (only 6–7-year-olds participated in the study). This, unfortunately, was due to the constraints of existing organizational resources. If we want to explore the age dynamic in relation to vocabulary and verbal fluency, and its association with the regulatory functioning of mono- and bilingual children, a new study with a broader age range of the sample is required.

Yet, despite the indicated limitations, this study provides an important contribution to the research field focused on language development of bilingual children. This is due to the evidence we obtained of the positive effect of verbal working memory on children's vocabulary and verbal fluency (age, gender and non-verbal intelligence controlled).

Conclusion

This study's results confirmed that bilingualism in preschool years is negatively related to language development and demonstrated that the ability to preserve and reproduce verbal information is more significant for children's vocabulary and verbal fluency than the child's language group. The results obtained may be helpful in the elaboration of programs aimed at reducing learning difficulties for bilingual children.

Ethics Statement

All parents signed a written informed consent for their children to take part in the study. Both the study procedure and the consent form were approved by the Ethics Committee of Faculty of Psychology at Lomonosov Moscow State University (the approval No: 2021/138).

Author Contributions

Methodology: M.K, E.O., and M.D.; Formal analysis: M.G.; Funding acquisition: M.K.; Project administration: M.I., M.D.; Software: E.O., M.G.; Supervision: M.K., E.O.; Data curation: Z.A., M.I., and M.D.; Writing original draft: M.G.; Writing review and editing: M.K, E.O. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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Better Language — Faster Helper: The Relation Between Spontaneous Instrumental Helping Action and Language Ability in Family-Reared and Institutionalized Toddlers

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Background. Prosocial behavior is the key component of social and interpersonal relations. One of the elements of prosociality is helping behavior, which emerges already in early childhood. Researchers have identified several domains of helping behavior: instrumental helping, comforting another person, and sharing resources with others. The development of helping behavior can depend on a number of factors: children's age, the social situation of development, communication skills, and the ability to understand the feelings and needs of another person.

Objective. In Study 1, the main goal was to determine the effects of age and cognitive, language, and motor development on instrumental helping skills in early childhood. The goal of Study 2 was to estimate the effects of rearing in an adverse social environment by comparing the capacity for instrumental helping in family-raised and institutionalized children.

Design. The authors examined toddlers' (N=198) ability to initiate spontaneous helping and the factors that may influence it. Cognitive, language, and fine motor skills were measured by the Bayley Scales of Infant and Child Development, 3rd edition. Children's instrumental helping behavior was assessed according to the procedure presented by Warneken and Tomasello, with a few modifications.

Results. Study 1 demonstrated that children's ability to initiate helping was dependent on their age: the non-helpers were significantly younger than the helpers. Children's language skills also played a significant role in their helping behavior. The children with higher language skills helped the adult more often and more quickly. Study 2 demonstrated that institutional placement per se was not related to toddlers' ability to initiate helping. Language ability was associated with helping behavior both in institution- and family-reared toddlers.

Conclusion. Instrumental helping in early childhood is related to children's age, language skills, and rearing conditions.

Keywords:
Toddlers;
institutional
rearing;
prosocial
behavior;
instrumental
helping;
language
skills

Introduction

Prosocial behavior has been demonstrated to be an important aspect in people's lives in different populations (Inglehart et al., 2014; Köster, & Kärtner, 2019). According to Eisenberg, Fabes, and Spinrad (2006), prosocial behavior can be defined as voluntary action that is performed in response to others' needs and is intended to benefit others. Dunfield and colleagues (Dunfield, 2014; Dunfield & Kuhmeier, 2013; Dunfield, Kuhlmeier, O'Connell, & Kelley, 2011) developed this definition by proposing that prosocial behavior includes at least three specific domains focused on responding to different needs of others: instrumental helping as a response to others' inability to finish a specific goal-directed action; comforting as the ability to respond to others' emotional needs; and sharing as a response to others' lack of a desired material need. This study will focus on development of the instrumental helping domain.

Origins of Prosocial Behavior and Factors Affecting It

Warneken and Tomasello (2009) argued for an innate nature of prosocial behavior. In their opinion, human infants have a phylogenetic predisposition to help others. Taking this into account, we would expect that helping behavior should appear early in development and independently of the environment in which the child lives, as part of children's natural maturation process. In other words, the child's age should be a strong predictor of the ability. At the same time, prosocial behaviors are important components of the child's social functioning and are encouraged by human society (Warneken, Hare, Melis, Hanus, & Tomasello, 2007). Other research has demonstrated that prosocial behaviors develop early (Over & Carpenter, 2009; Paulus & Moore 2012; Svetlova, Nichols, & Brownell, 2010; Warneken & Tomasello, 2006), different domains develop quite independently of each other (Dunfield & Kuhmeier, 2013), and instrumental helping behavior is the first to emerge in one's development (Dunfield, 2014; Svetlova et al., 2010). Evidence for environmental influence on the development of instrumental helping behavior is somewhat contradictory. An early appearance of instrumental helping ability suggests some phylogenetical component in its development. In line with this, Brownell and colleagues (Brownell, Svetlova, Anderson, Nichols, & Drummond, 2013) demonstrated that parental reading of fairy tales and discussing the characters' emotions with their children did not affect the children's capacity for instrumental helping, but enhanced their comforting behavior. On the other hand, several studies have indicated that children's instrumental helping is influenced by their social motives and previous experience (Dunfield & Kuhlmeier, 2010; Kärtner, Schuhmacher, & Collard, 2014; Köster, Cavalcante, Vera Cruz de Carvalho, Dôgo Resende, & Kärtner, 2016; Over & Carpenter, 2009).

According to Köster and colleagues (Köster, Itakura, Omori, & Kärtner, 2019), emergence of instrumental helping during the second year of life becomes possible as the child's fine motor skills and social interactions continue to develop. Indeed, before helping behavior can take place, a child must understand that the other person is in need of help, and the child's motor system should be sufficiently developed to carry out the helping action. This idea was supported by Warneken and Tomasello (2006, 2007), who noted that 14-month-old toddlers are already developed enough not only

to understand when a person needs help to reach her goal, but also to perform instrumental helping in different situations. Moreover, the appearance of instrumental helping behavior coincides in time with the emergence of speaking ability, a scaffolding instrument for social interactions. Most children start to talk in about the second half of the second year, although understanding of speech appears earlier. Thus, it can also be assumed that individual differences in language, motor, and cognitive skills can influence the development of instrumental helping behavior (Cassidy, Werner, Rourke, Zubernis, & Balaraman, 2003; Ensor & Hughes, 2005).

Previous research gives the impression that social context is important mostly for the development of children's comforting behavior. Results are less convincing in the case of the earliest form of prosocial behavior — instrumental helping — assuming a weak influence of social environment on its development. On the other hand, environmental influence may depend on how adverse the environment is. Previous research explored the development of instrumental helping ability in multicultural contexts where all situations had one important thing in common: The children were involved in meaningful social interactions with their caregivers (Dahl, 2015; Dahl et al., 2017; Köster et al., 2016). However, there are situations where children are deprived of this opportunity, as for example, when growing up in adverse environments of institutional rearing.

Influence of Institutional Rearing on Children's Cognitive and Social Development

Institutional rearing remains the main alternative for child-care of orphans in many developing countries (Browne, 2005). It often implies a high children-to-caregiver ratio, frequent changes and multiple shifts of caregivers, in combination with highly regimented care (Dobrova-Krol, Van Ijzendoorn, Bakermans-Kranenburg, Cyr, & Juffer, 2008). Furthermore, the caregivers typically demonstrate low emotional engagement when interacting with children (McCall, Van Ijzendoorn, Juffer, Groark, & Groza, 2012).

There is a growing body of research that demonstrates abnormal neural development in young children living in an adverse environment of institutional rearing (Belalov, Dyagileva, Pavlenko, & Kochukhova, 2014; Kochukhova, Mikhailova, Dyagileva, Makhin, & Pavlenko, 2016; McLaughlin, Sheridan, & Lambert, 2014; Nelson, Bos, Gunnar, & Sonuga-Barke, 2012; Nelson & Gabard-Durnam, 2020; Smyke et al., 2007; Stamoulis, Vanderwert, Zeanah, Fox, & Nelson, 2017). For example, Sheridan and colleagues (Sheridan, Fox, Zeanah, McLaughlin, & Nelson, 2012) revealed that the reduction of resting EEG α -power is partly mediated by a general reduction of cortical white matter volume in Romanian institutionalized children. The white matter reduction implies fewer properly working connections between different brain areas engaged in information processing. On the behavioral level, these brain alterations are reflected in various developmental deviations. That, in turn, can be one of the factors that influence children's ability to provide help to other people, by both delaying the ability and by slowing the children's helping response.

In our previous studies, we evaluated the cognitive, language, and motor development in young children raised in families and compared their scores to children

of the same age raised in an orphanage (Belalov et al., 2014, Belalov et al., 2017). The orphanage-reared children demonstrated lower scores in all measured domains. To our knowledge, this was the only study in which the developmental status of children living in the Republic of Crimea was estimated by means of the Bayley Scales, which are known for their accurate measurement.

To sum up, based on the earlier research it can be suggested that the emergence of instrumental helping behavior can be influenced by several factors. One is children's general maturation process, as well as their individual characteristics in cognitive, language, and motor skills. On the other hand, the environment in which the children are raised can also be important.

Main goals of the study: We conducted two studies aimed at evaluating different factors that may influence children's helping behavior at an early age. In Study 1, we explored whether children's age or their test scores in cognitive, language, and motor skills could predict their ability to perform instrumental helping. In Study 2, we compared instrumental helping behaviors between children raised in their biological families and those reared in an orphanage, in regard to their cognitive and language development.

Hypothesis: The emergence of instrumental helping behavior in early childhood can be influenced by children's age, their cognitive, language, and motor skills, as well as the social environment in which they are raised.

Methods

Participants

Children from the family-reared (FR) group were recruited through announcements in kindergartens in Simferopol, Crimea. The FR children comprised 100 subjects (53 girls), aged between 259 and 1,113 days (mean age = 802 ± 207 days). All the parents stated that their children lived in two-parent families, and none of them had any history of institutionalization. Ninety of them were of Russian or Ukrainian ethnicity (Slavs) and 10 were Crimean Tatars. In the Crimean Tatar families, the parents reported that Russian was the main language of communication. In 69% of the families, at least one parent had a higher education diploma. At least one parent in each family had a full-time job. All the parents estimated their earnings as average for the region.

Children from the institution-reared (IR) group were recruited from a child residential care institution in Simferopol, Crimea. The group consisted of 49 toddlers aged between 650 and 1,256 days (15 girls, mean age = $1,015 \pm 165$ days). All participants from the institution-reared group had lived on a permanent basis in the child residential care facility since admission and had spent there between 47 and 1,143 days (3.4–95% of their lives; $M = 438$, $SD = 303$ days). The IR sample consisted of 46 children with Russian or Ukrainian ethnicity (Slavs); three children were Crimean Tatars.

Children were included in the study according to the following criteria: no genetic syndromes (e.g., Down syndrome), no expressed signs of fetal alcohol syndrome,

no HIV infection, cerebral palsy or chronic diseases, birth weight not less than 2,500 g, and right hand preference when drawing and eating.

Measures

Cognitive, Language, and Fine Motor Development

Cognitive, language, and fine motor abilities were assessed using the Bayley Scales of Infant and Child Development, third edition (BSID-III) (Bayley, 2006). BSID-III is developed for an age range of 1–42 months. The cognitive scale of development consists of items assessing various abilities, such as puzzle completion, search for hidden objects, imitation, comparison, elimination of irrelevant items, memorization, and understanding of cause-and-effect patterns. The Language Index is calculated as the average between the scores in Expressive and Receptive (auditory comprehension) language skills. It includes tasks aimed at assessing understanding and use of names of objects, verbs, pronouns, participles, past, present, and future tenses, synonyms and antonyms, understanding of colors, “parts and the whole”, size, etc. The fine motor scale assesses skills such as grasping, stacking blocks, drawing, lacing, and cutting with scissors. Each scale consists of a different number of tasks, organized into 17 blocks, ascending in difficulty. Each block corresponds to a specific age. Before testing, the child’s age in months and days is calculated. The test starts at the block of tasks appropriate to the child’s age. If the child fails to complete the first three items in this block, testing restarts with the items in the previous block. The testing stops if the child fails to complete five tasks in a row. All tasks are conducted in the form of a game.

Instrumental Helping

Children’s instrumental helping behavior was assessed according to the procedure presented by Warneken and Tomasello (2006), with some modifications. The child was placed on one side of a table, sitting opposite the experimenter. A box was placed in front of the child, with a narrow hole at the top and an open side directed toward the child (see *Figure 1*). Thus, the child was able to see what is in the box and could easily get objects out of it. The experimenter said that she needs to prepare some tea and went to another table in order “to make it”. She came back with a teacup and placed it on the box, where she continued “to stir the tea” with a spoon and “accidentally” dropped the spoon into the narrow hole in the box. Without looking at or saying anything to the child, she unsuccessfully tried to reach the spoon through the narrow hole. After 9–17 seconds (mean time = 13.3 s, $SD = 2$), if the child did not return the spoon, the experimenter said, “I dropped the spoon”, looked at the child, and continued to try to pick it up. If the child still did not return the spoon, the same procedure was repeated twice more.

We registered whether the child returned the spoon and measured the time delay before the child initiated the returning action. All of the children either returned the spoon during the first minute after “the accident” or did not return it at all. We estimated the time that passed before the child returned the spoon by examining the video records.

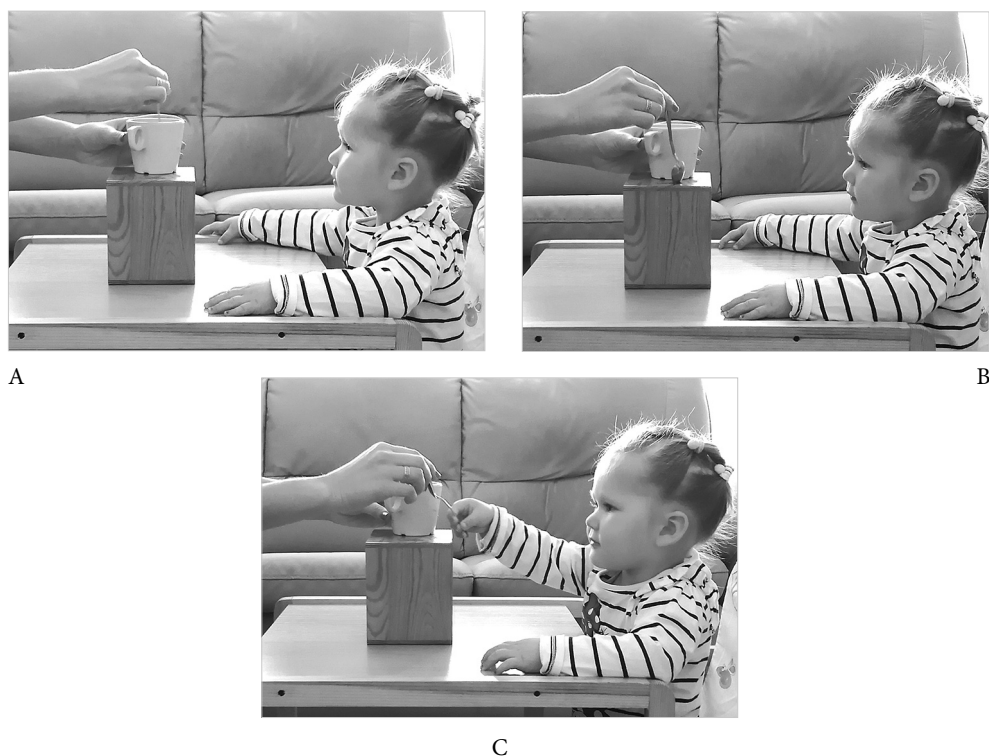


Figure 1. Experimental setup for assessing instrumental helping behavior in children. A. The experimenter places a teacup on the box and stirs the “tea” with a teaspoon. B. The experimenter accidentally drops the spoon through a narrow hole on the top of the box. C. The child hands the spoon to the experimenter

Procedure

Each child was tested individually. Two experimenters collected the data during two consecutive days.

Day one: A child came into the testing room where he/she could play freely with some toys to get used to the environment. Then the child was seated either on the caregiver’s lap or independently on a chair in front of a table. After that, assessment with the BSID-III cognitive scale was performed. Then the experimenter said that she would like to drink some tea and the helping behavior task started. The entire session with all pauses lasted about 30–60 minutes.

Day two: The testing session started with free play, and then the BSID-III language and fine motor scales were performed. The session took 30–40 minutes.

All family-reared children were tested in the presence of a parent or close relative in a testing room at the university campus. Institution-reared children were tested in the presence of the residential care psychologist in a separate room at the residential care institution.

Out of 100 children invited to participate in Study 1, one was excluded from further analysis because of the parent’s interference during the helping behavior test.

Language development scales were completed only for 86 children (eight children did not appear on the second day of the study; six lost interest during testing). In Study 2, two out of 49 FR children did not complete both language scales. Out of 49 IR children, five did not participate as they were absent from the orphanage for medical reasons or because of participation in cultural events. The actual numbers of children included in certain statistical analyses can be inferred by the degrees of freedom indicated, together with the calculated statistical coefficients.

Statistical Processing

The data were statistically processed using IBM SPSS Statistics v.24.

Study 1: Spearman rank correlations were calculated to measure the associations between age and cognitive, language, and motor skills, on the one hand, and helping action initiation and delay, on the other. T-tests were used to compare the Bayley scores of helpers and non-helpers.

Logistic regression analysis was performed to assess the predicting power of the variables: children's age and cognitive, language, and motor abilities for prediction of helping action. The equality of medians between children returning the spoon before and after the experimenter's phrase "I dropped the spoon" was tested using the Mann-Whitney U test.

Study 2: Pearson correlations were used to estimate the association between delay in helping and cognitive and language ability, separately for the FR and IR groups. T-tests were used to compare the Bayley scores of the FR and IR groups.

Logistic regression analysis was also performed to ascertain the effects of group affiliation and language ability on the likelihood that participants would perform a helping action. The equality of means of children returning the spoon before and after the experimenter's phrase "I dropped the spoon" was tested with the Mann-Whitney U test.

One-way ANOVA was used to estimate the effect of group affiliation (FR vs. IR) on the children's cognitive and language development.

Results

Study 1

The first aim of Study 1 was to explore the associations between the children's age and cognitive, language, and motor ability, and their ability to demonstrate instrumental helping behavior. The second aim was to evaluate the level of spontaneity in children's helping actions and whether it was associated with their age and cognitive, language, and fine motor abilities. Only family-reared children participated in Study 1.

On the Bayley scales, the children showed an estimated average value of 12.1 ($SD=2.5$) points on the Cognitive scale, 11.5 ($SD=2$) on the Language Index, and 12.8 ($SD=3.1$) on the Fine Motor scale.

Eleven out of 100 children did not help at all. The non-helpers were significantly younger than the helpers (643 ± 206 days vs. 819 ± 201 days, $t(97) = -2.6$, $p < .01$, $d = .87$) and had lower language ability for their age (8.8 ± 2.25 vs. 11.7 ± 1.97 ,

$t(84) = -2.6, p < .001, d = 1.45$; 95% CI: 0.79, 2.11). After the spoon was dropped, it took on average of 12.0 s ($SD = 11$) for children to initiate helping. In general, the ability to initiate helping was significantly related to the children's age ($r_s(99) = .25, p < .01$) and level of language development ($r_s(86) = .29, p < .01$). In order to explore which of these factors can predict helping action, we performed logistic regression analysis. The logistic regression model was statistically significant, $X^2(2) = 15.8, p < .001$. The model explained 42.3% (Nagelkerke R^2) of the variance in helping behavior and correctly classified 95.3% of cases. Only better language ability was associated with an increased likelihood of helping action ($OR = 1.94, p = .02, d = .37$; 95% CI: 1.11, 3.37).

In order to explore which factors are associated with the time delay before helping was initiated, we conducted correlation analysis between helping time delay and children's age and cognitive, language, and fine motor development. The results demonstrated that only the level of language development was associated with helping time delay, $r_s(79) = -.26, p < .02$.

During the helping trial procedure, in order to draw the child's attention to the task, the experimenter uttered the phrase "I dropped the spoon". We assumed that the association between helping delay, as well as helping action itself and the level of language development, could be influenced by the utterance. In order to check this, we performed additional analyses. Eighty-nine children returned the spoon to the experimenter. Sixty-three of them returned the spoon before the utterance took place. This subgroup did not differ in any measured variables from the children who returned the spoon after the utterance, except that the before-group had higher language ability ($Mdn = 12.5$ vs. $Mdn = 10.5, U = 374, p = .031, d = .94$).

Study 2

The second study had two purposes: First, we intended to explore whether an adverse environment of institution placement can be associated with children's helping behavior patterns, and second, to find out whether the results of Study 1 for family-reared children can be replicated. We presented 98 children aged 662–1,281 days with the same experimental setting as in Study 1. The participants comprised two groups: children residing at an institution and children living in two-parent families. All the children were old enough (according to previous studies) to perform helping action in situations even more complex than the one we presented. Based on this and on the results obtained in Study 1, we expected no significant influence of fine motor skills on children's helping behavior. Hence, we decided not to include fine motor skills measurement in the Study 2 design. The final sample of the family-reared (FR) group consisted of 49 toddlers aged 661–1,261 days (15 girls, mean age = 1021 ± 171 days). They were matched to the IR children for age and sex, differing in age by no more than 15 days. The description of the IR group is given in the Methods section.

After the spoon was dropped, it took an average of 13.3 s ($SD = 13.4$) for FR children to initiate helping. Only two children (4.1%) did not return the spoon. The institution-reared group demonstrated comparable time results with an average time

of 15.5 s ($SD=15$), $t(84)=.75$, $d=-.16$, *n.s.* Ten of the 49 children (20.4%) in this group did not return the spoon, which was significantly more in comparison to the FR group, $X^2(1, 98)=9.5$, $p<.002$, $d=.65$.

IR children performed significantly lower on the cognitive and language indices on the BSID-III scales compared to the family-reared group ($F(1,78)=38.5$, $p<.001$, $\eta p^2=.33$); mean cognitive development scores for IR (9.2 ± 1.6) vs. for FR (11.1 ± 2.4) group, $t(93)=-4.7$, $p<.001$, $d=.93$; language index scores: 8.3 ± 1.5 vs. 11.4 ± 2.5 , correspondingly, $t(81)=-6.7$, $p<.001$, $d=1.95$, Bonferroni-corrected.

The subgroup of IR children who did not return the spoon had a cognitive ability comparable to the IR children who did return it (9.7 ± 1.9 vs. 9 ± 1.5), but their language ability was significantly lower (6.86 ± 1.0 vs. 8.65 ± 1.4 , $X^2(1)=10.2$, $p<.001$, $d=.70$).

A logistic regression was performed to ascertain the effects of group affiliation and language ability on the likelihood that participants would perform helping action. The regression model was statistically significant, $X^2(2)=17.1$, $p<.001$, explained 39.6% (Nagelkerke R^2) of the variance in initiation of helping action and correctly classified 91.6% of observed cases. The only significant predictor of helping action was the children's language ability ($OR=2.593$, $p<.01$; $d=.53$; 95% *CI*: 1.29 5.20). Better language ability was associated with increased likelihood of helping.

In order to explore whether the children's cognitive ability, language development, or group affiliation were associated with how spontaneous the helping action was, we performed correlation analyses. The results demonstrated that only the level of language development was associated with a delay in helping in both groups of children (IR: $r(31)=-.43$, $p<.02$; FR: $r(43)=-.31$, $p<.05$). In other words, the better the language ability was, the less time it took for the children to initiate the helping action, and the more spontaneous they were.

The second study used the same procedure as Study 1. The experimenter attracted the child's attention with the phrase, "I dropped the spoon". When we compared the family-reared children who returned the spoon before and after the phrase was spoken, we could see that the only significant difference between these two subgroups was their language ability ($U=84.5$, $p<.002$). The children who returned the spoon before the phrase was spoken had higher language ability ($Mdn=12.5$ vs. $Mdn=10$). The same analysis was performed on the institution-reared group. The results did not demonstrate significant differences between children in the before- and after-phrase subgroups (language ability, $Mdn=9$ vs. $Mdn=8$, $U=112$, $p=.12$).

Discussion

Study 1 demonstrated that the ability to initiate a helping action is partially linked to children's maturational process. The non-helpers were significantly younger than the helpers. Language ability also played a significant role in the initiation of helping. The children with higher language development had a proclivity to help the experimenter more often and more quickly.

Other authors (Ensor and Hughes, 2005) indicate that, according to parents, toddlers who are better at speaking volunteer more often to help others (parents, teach-

ers, other children). In preschoolers (37–65 months of age), greater language ability was related to almost all positive social behaviors as rated by teachers, observers, and other children (Cassidy et al., 2003).

This can be interpreted in different ways. According to Köster and Kärtner (2019), early helping emerges in the context of social interaction, which includes processes of social learning. Thus, we can assume that the association between language development and instrumental helping is greatly underpinned by the role of language in the social interaction between a child and other people.

This line of reasoning is confirmed by the study of Dahl (2015), who demonstrated that more frequent encouragement and social reinforcement of helping behaviors in one-year-old children made them more inclined to help their parents later on. A similar pattern was also demonstrated in a laboratory setting. The experimenter's explicit scaffolding of helping behaviors (encouragement and praise) in 13–18-month-old children at the beginning of the study resulted in a significant increase of their instrumental helping reactions later on (Dahl et al., 2017). Thus, a relatively high level of language ability for a certain age facilitates children's perception of such encouragements.

It is interesting that the phrase "I dropped the spoon" provided additional stimulation to initiate helping action in children with a less developed language ability. By providing this phrase in the experimental setting, we planned to draw the child's attention to the situation without giving any direct clues what should be done. According to Lev Vygotsky's idea (Vygotsky, 1978), acquisition of language enables children to overcome impulsive actions and better control their behavior. Taking this in the context of the present study, it seems possible that children with better language skills were better able to follow the development of the situation. Other children could do the same with additional, spoken stimulation from the experimenter.

In Study 2, we demonstrated for the first time that instrumental helping behavior is significantly less developed in institution-reared toddlers than in family-reared ones. Significantly fewer IR children demonstrated helping action. Their helping behavior was not associated with the amount of time they had spent at the institution, supporting the idea that inability to initiate helping action was not related to the adverse environment of the institution per se.

It has already been noted that children raised in orphanages usually have a lower level of cognitive development (Berens and Nelson, 2015; Kolesnikova, Zhukova, & Ovchinnikova, 2018; Nelson, Zeanah, & Fox, 2019; van Ijzendoorn, Luijk, & Juffer, 2008) and delay in speech understanding and generation (Albers, Johnson, Hostetter, Iverson, & Miller, 1997; Belalov et al., 2014; Cermak & Daunhauer, 1997; Morrison, Ames, & Chisholm, 1995; Windsor, Glaze, Koga, & Bucharest Early Intervention Project Core Group, 2007). The results of this study of IR children conform well with the previous research. Thus, the IR group might had a greater problem seeing the goal of the experimenter's actions as she tried to retrieve the spoon, which is unreachable from her position; however, the level of cognitive development in the IR group, as well as in both FR groups, was not associated with an ability to demonstrate instrumental helping action. Considering that the ability to demonstrate helping action

was linked to the children's level of language development, it is possible that the IR children had difficulty understanding the situation because it was sketched with the help of several statements by the experimenter. First, the experimenter said that she needed to prepare some tea, and when the children did not return the teaspoon, she added the phrase "I dropped the spoon". This explanation is also supported by the FR groups' results from both studies. In both family-reared groups, the helpers had better language ability, and were also more spontaneous/quicker to initiate helping. The same tendency could be observed in the IR group. Although, the difference in language ability between quick helpers and those who helped after the task-attention phrase was uttered did not reach statistical significance, the language ability was somewhat higher in the before-phrase subgroup. It is possible that in the case of the IR children, we did not have enough statistical power. The number of children in the IR group who showed helping behavior was smaller than in the FR group (39 vs. 47). Further, the institution-reared children, in general, had a lower and a tighter range of language index scores (5.5–12 vs. 6–17 in family-reared children). So, these results can also assume that in order to be able to initiate spontaneous/quick helping action, language should be developed over some threshold level that helps the child to follow the dynamics of the situation. This idea is supported by the IR non-helpers' characteristics. Their cognitive development was comparable to the helpers subgroup, but their language abilities were significantly lower, as was also observed in the FR non-helpers in Study 1.

The discovered link between language development and instrumental helping actions is not to be explained, in our opinion, merely by language understanding. Better language ability can be based on better developed mechanisms of joint attention, letting the children more effectively engage in collaborative activities with others. According to Tomasello and his colleagues (Gräfenhain, Carpenter, & Tomasello, 2013; Tomasello, 2008), engagement in such activities structured by joint attention directly relates to how fast children begin to acquire their first linguistic conventions. In an institution, where a small number of teachers usually supervise a large number of children, there is much less possibility for formation of an adequate shared space of action. This can explain both delayed language ability and difficulties with initiation of helping action in institutionalized children.

Insufficient development of language in IR children is often seen as one of the grounds for emergence of so-called quasi-autistic behavior (see review in Berens and Nelson, 2015). Such children tend to interact with others in an inadequate manner, often play in isolation or in parallel with one another (Daunhauer, Coster, Tickle-Degnen, & Cermak, 2010). As a result, they have an underdeveloped capacity for reciprocal interactions with each other of a contingent or cooperative sort, which can also influence their ability to initiate helping action. Moreover, the formation of a shared action space for institutionalized children interacting with adults is usually structured in such a way that the children's actions are determined less by their own initiative than by the expectation of commands from adults. Based on the results of the present study, it is reasonable to conclude that in early childhood, motivation to help others may not be enough on its own for effective helping behavior. When language

and/or shared action space are underdeveloped, children need some additional guidance. That is what we observed in both FR and IR children with lower language ability.

An important factor that may underlie the link between helping behavior and language ability is the close multidirectional connections between language development and theory of mind (ToM) development (de Villiers, 2007). Language ability facilitates development of psychological understanding and through this helps a child to develop his/her theory of mind (Cassidy et al., 2003; de Villiers, 2007; de Villiers, J. & de Villiers, P.A., 2014; Milligan, Astington, & Dack, 2007). The earliest stages of communication depend on the infant's interest in and engagement with other social beings who possess minds of their own. It is through these interactions that children acquire knowledge of words and meanings. A regular practice of speaking with adults about other people's feelings and emotions leads to a more developed ToM in children, which helps them to better comprehend social situations. Such comprehension is critically important for understanding the goals underlying others' actions, in that supporting further helping behaviors.

We did not find any association between cognitive development and helping in all the groups of children. The occurrence of helping actions after the phrase is uttered that draws attention to the task suggests a possible connection between helping behavior, language development, and executive functions, namely attention. It is possible that the picture would be somewhat different if, instead of general cognitive ability, we had measured children's attention. This idea is partly supported by the studies of institutionalized toddlers that demonstrated deviant EEG patterns when processing verbal information (Belalov et al., 2014) and during a visual attention task (Kulenkova, Dyagileva, Pavlenko, Belalov, & Kochukhova, 2015).

To sum up, the relation between language development and helping actions revealed in this study requires more detailed research. It would be informative to study the characteristics of children's attention and joint attention ability and ToM development in relation to instrumental helping in different situations and also in relation to other prosocial behaviors.

Conclusion

Toddlers' ability to initiate instrumental helping is dependent on their age. The non-helpers were significantly younger than the helpers. The level of language development was significantly correlated with the capacity for instrumental helping in the family-reared group of children. The children with a higher level of language development had a proclivity to help the experimenter more often and more quickly. Institution-reared toddlers demonstrated less developed instrumental helping compared to family-reared ones. Institution-reared non-helpers showed less developed language skills compared to helpers.

Ethics Statement

The study was approved by the Ethic Committee of V.I. Vernadsky Crimean Federal University (Protocol 12, 14 June 2016).

Informed Consent from the Participants' Legal Guardians

The children's parents gave informed consent for their children to be involved in the study. Official permission was obtained from the manager and the medical personnel of the orphanage for institution-reared children to participate in the study, in the presence of the psychologist working in the orphanage.

Author Contributions

K.O. conceived of the idea and developed the research design, performed statistical analysis, and worked on the manuscript. D.Yu., M.A., and O.L. carried out the experiment, performed computations and drafted the manuscript. M.S. verified the analytical methods and participated in drafting the manuscript. P.V. supervised the project, verified the analytical methods, and participated in drafting the manuscript. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Cross-cultural Analysis of Models of the Relationship between the Cognitive Abilities and Academic Achievement in Primary School Education

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Background. The cognitive predictors of academic achievement are associated both with basic cognitive abilities such as the information processing speed, number sense and visuospatial working memory, as well as with general ability including nonverbal intelligence. However, the ratio between cognitive development and school achievement can depend on sociocultural conditions.

Objective. The results of a cross-cultural analysis of the relationship between cognitive development and academic achievement during primary education are presented. The analysis was conducted sampling schoolchildren from Russia and Kyrgyzstan, two countries that have a similar organization of the national education system but differ in the level of socioeconomic development.

Design. The study involved 732 schoolchildren aged 7.7 to 11.8 years studying in Russia and Kyrgyzstan. Information processing speed, visuospatial working memory, and number sense were assessed using each of "Choice Reaction Time," "Corsi Block-Tapping Test," and "Number Sense" computerized tests.

Results. According to the results, empirical data in both samples show that a model where in information processing speed signifies basic cognitive ability is a key predictor of nonverbal intelligence, working memory, and number sense, and each of these may contribute to individual differences in academic achievement. Notwithstanding the universality of this model, cross-cultural differences were seen to engender a reduction of schoolchildren's academic achievements, given possible impacts of less favorable educational conditions.

Conclusion. In the relationship between cognitive abilities and academic success at the primary school education, there are both similarities and differences between schoolchildren studying in Russia and Kyrgyzstan.

Keywords: Cross-cultural study; information processing speed; nonverbal intelligence; visuospatial working memory; number sense; academic achievement; primary school education; structural equation modeling

Introduction

The search for psychological predictors of individual differences in the academic achievements of schoolchildren is a socially significant task and is associated with problem of the relationship between cognitive development and learning success.

According to previous studies and their meta-analyses, among the individual psychological characteristics that affect school success, the leading factor is attributed to the cognitive sphere (Peng, Kievit, 2020; Tikhomirova, Malykh, Malykh, 2020; Rohde, Thompson, 2007; Laidra, Pullmann, Allik, 2007; Luo, Thompson, Detterman, 2006). These report that cognitive development indicators can explain up to 60% of the variability in academic success (Falch, Sangren Massih, 2011; Luo et al., 2006). In this context, we analyze the following basic cognitive development indicators: information processing speed (the ability to accurately and quickly respond to stimuli); visuospatial working memory (the ability to retain small pieces of information about the shape of stimuli and their spatial localization); number sense (the accuracy of the perception and assessment of objects without counting); and general abilities such as nonverbal intelligence. These basic and general cognitive abilities can improve or, conversely, worsen the prospects and level of academic success during schooling (Tikhomirova et al., 2020). Additionally, it was shown that of all cognitive indicators, working memory has a special role in individual differences in learning, and is a significant predictor not only of current educational achievements, but also of successful learning in the future (Demetriou, Kazali, Kazi, Spanousis, 2020; Tikhomirova, 2017). Studies show on the one hand that information processing speed is directly related to academic performance, but on the other that these do not necessarily have a direct effect on academic success (Tikhomirova, Kuzmina, Malykh, 2020; Tikhomirova et al., 2020; Brown, Brockmole, Gow, Deary, 2012). The influence of number sense on the academic achievement of schoolchildren, including success in mathematics, depends on the specific aspect of this cognitive ability associated with symbolic or non-symbolic representations of quantity (Kuzmina, Tikhomirova, Lysenkova, Malykh, 2020; Gebius, Reynvoet, 2012; Halberda, Mazzocco, Fergenson, 2008).

The role of cognitive abilities can vary significantly depending on the criteria used to evaluate learning success (for example, teacher assessments or standardized state examinations, Tikhomirova, 2017), the level of schooling (primary school or high school, Tikhomirova et al., 2020), academic discipline (language or mathematics, Tosto et al., 2019), etc. Previous studies have also reported on the mutual influence of cognitive development indicators and the specifics of their impact on academic success during schooling. For example, information processing speed, visuospatial working memory and intelligence fully explain heightened number sense associated with the operations of non-symbolically expressed quantities during primary school education (Kuzmina et al., 2020). In addition, intelligence is a moderator of the connection between various aspects of number sense that affect academic performance in mathematics but also changes with the influence of the first two years of primary education (Kuzmina et al., 2020; Tikhomirova et al., 2020). These data make it necessary to study the joint influence of cognitive abilities on academic success in different

stages of schooling, e.g. primary, secondary or high school education. In general, it has been demonstrated that at different levels of schooling, the influences of cognitive abilities have registered differences in school performance (Tikhomirova et al., 2020; Demetriou, Markis, Tachmatzidis, Kazi, Spanousis, 2019). Most significantly, working memory affects school achievement, particularly during the period of primary school education between the ages of 9 and 13 (Demetriou et al., 2019).

In studies conducted using the two-factor model of intelligence as a framework, statistical arguments were presented to demonstrate the influence of cognitive indicators on academic success through general cognitive ability, “g” (Kranzler, Benson, Floyd, 2015). These studies assumed that the cognitive indicators are loaded on the factor “g” to varying degrees, which affects the efficiency of assimilation of new knowledge and skills during the schooling process.

A number of studies have, however, demonstrated an opposite contribution of cognitive indicators to academic achievements of schoolchildren (Geary, 2011; Rindermann, Flores-Mendoza, Mansur-Alves, 2010; Rohde, Thompson, 2007), underlining the importance of overall academic success, generally evaluated on the basis of several indicators such as grades in several school subjects or several types of assessment in one subject (Tikhomirova et al., 2020). Other studies have noted high correlation coefficients between general cognitive ability and general academic success ranging from 0.77 to 0.94 (Kaufman, Reynolds, Liu, Kaufman, McGrew, 2012).

These works have provided data on more complex models of the relationship between the cognitive sphere and academic success (Tikhomirova et al., 2020; Rose, Feldman, Jankowski, 2011; Rindermann, Neubauer, 2004). Despite some differences in these models, the fundamental importance of information processing speed was postulated as underlying higher-order cognition, in particular, intelligence or creativity (Rindermann, Neubauer, 2004; Fry, Hale, 2000). For example, a study with participation of Russian schoolchildren showed that the model that fit the data the best was one in which reaction time was a key predictor of intelligence, working memory, and number sense. These in turn contribute as a factor of individual differences to general academic success (Tikhomirova et al., 2020).

Studies have recorded statistically significant effects of sociocultural conditions on the structure of the relationships between cognitive abilities and the academic achievements of schoolchildren (Tucker-Drob, & Bates, 2016; DeNavas-Walt, Proctor, 2014; Schneeweis, Skirbekk, & Winter-Ebmer, 2014). In a meta-analysis of research data from 45 countries, cross-cultural differences were associated, first, with the effectiveness of the functioning of the national education system at the level of $r=0.25$ at $p<0.001$ and the socioeconomic status of states at the level of $r=0.16$ at $p<0.001$ (Brouwers, Van de Vijver, Van Hemert, 2009). It was shown that in a less heterogeneous more effective educational environment the contribution of cognitive abilities to the formation of individual differences in academic success increases (Tosto et al., 2019; Tucker-Drob, & Bates, 2016). Additionally, greater school subject orientation of the national education system, such as towards mathematics, can influence the educational achievements of schoolchildren in this subject (Paik et al.,

2011). Finally, more intensive cognitive development under conditions of higher socioeconomic status has been reported to lead to changes in its relationship with academic success in different sociocultural environments (von Stumm & Plomin, 2015; Nisbett et al., 2012; Rindermann et al., 2010).

This cross-cultural study aims to identify relationships between cognitive abilities and academic success at the primary level of school education.

The analysis of the models of these relationships was conducted using samples of primary school age children from Russia and Kyrgyzstan, two countries that have a similar organization of the national education system but differ in the level of socioeconomic development and the effectiveness of education. In the 2020 International Ranking of the United Nations Development Program, which reflects achievements in the field of health care, education and social security, the Russian Federation is included in the group of countries with a very high level of human development (52 places), and the Kyrgyz Republic is included in the group of countries with an average level of human development (120 places). According to the OECD's Programme for International Student Assessment Kyrgyz 15-year-old schoolchildren had very low level performance in mathematics, with reading and science knowledge ranked at the bottom. Russian schoolchildren by contrast scored average.

It was concluded that these socioeconomic differences in the effectiveness of the functioning of national educational systems may lead to differences in the degree of development of cognitive processes, as measured by tests, but not in the relationship between these cognitive characteristics and learning success at the primary level of school education.

Methods

Participants

The study involved 732 schoolchildren aged 7.7 to 11.8 years studying in two public schools in Russia and Kyrgyzstan. These schools were similar according to the criteria of the departmental affiliation, qualifications and structural characteristics of the teaching staff, with corresponding the curricula in all school subjects, regional ratings, etc. These schools were state schools with no selection of pupils. In both samples, all children studying in the schools at Grades 2 to 4 participated in the study. The reasons for any child's non-participation were limited to illness or absence from school on the date of testing. The instructional language in both schools was Russian.

The Russian sample included 355 pupils in grades 2–4, aged 7.8 to 11.7 years, of which 50.1% were girls. The average age is 9.84 years. All children spoke Russian. The Kyrgyz sample consisted of 377 pupils in grades 2–4, aged 7.7 to 11.8 years, of which 51.5% were girls. The average age is 9.75 years. Kyrgyz-speaking children accounted for 84.1%, and Russian-speaking children accounted for 15.9%.

All subjects gave their informed consent for inclusion before they participated in the study. Parental informed consent was obtained for all participants. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Psychological Institute of the Russian Acad-

emy of Education (project identification code 2016/2–12). Data analysis was conducted using anonymized personal data.

Procedure

At the end of the academic year, all study participants completed computerized test battery tasks aimed at assessing information processing speed, visuospatial working memory and number sense.

Additionally, participants completed the paper-and-pencil test assessing their nonverbal intelligence. Data collection was conducted in the computer science room strictly according to the developed protocol under the supervision of the researcher. Quarterly grades were recorded at the end of the school year with the consent of the participants and their parents.

Measures: cognitive abilities

Information processing speed was assessed using a “Choice reaction time” test with four alternative choices (Tikhomirova et al., 2020). Numbers ranging from 1 to 4 appear 40 times on the computer screen in a random order at varying time intervals — from 1 to 3 seconds. The pupils need to press the key that corresponds to the number on the screen as quickly and as accurately as possible. The accuracy of the answer (correct/incorrect key pressed) and the reaction time are both recorded. In the present study, the reaction time indicator is used only for correct answers.

Visuospatial working memory was assessed using the “Sequences” test designed based on the “Corsi block-tapping” test (Tikhomirova et al., 2020). A certain number of cubes appear on the computer screen and “light up” one after the other in a certain sequence with an interval of 1 second. The minimum number of cubes in a sequence is 4, and the maximum is 9. The pupils are required to repeat the presented sequence by clicking on the cubes in the same order as they lit up using a computer mouse. The present study uses the indicator of the number of correctly reproduced sequences.

Number sense, which is associated with the perception and manipulation of non-symbolically expressed quantities, was assessed using the “Number sense” test (Kuzmina et al., 2020) in which an array of yellow and blue dots, differing in size and number, appears on the computer monitor within 400 ms. The tasks are grouped into three blocks of 50 arrays. The number of dots of each colour in the task varies from 5 to 21. The pupils need to decide within 8 seconds which colour dots — blue or yellow — there are more of, and press the corresponding colour key on the keyboard. The indicator of the total number of correct answers was used in the statistical analysis of the present study.

Nonverbal intelligence was measured using the printed version of the “Standard Progressive Matrices” test (Raven, 2003). The test consists of 60 tasks grouped into 5 series. The tasks become progressively more difficult within each series and from series to series. The pupils are required to select the missing element of the matrix from among 6 or 8 options. This study uses the indicator of the total number of correct answers on this test.

Measures: Academic achievement

The academic success indicator was calculated on the basis of the quarterly grades of the primary school students in Russian language, mathematics and biology, as assessed by school teachers.

Statistical analysis

During the first stage, the descriptive statistics of the cognitive abilities and academic success were calculated for the Russian and Kyrgyz samples of primary school children. One-way analysis of variance was conducted to understand cross-cultural differences in cognitive abilities — information processing speed, visuospatial working memory and nonverbal intelligence. Differences in all analysed indicators between Russian- and Kyrgyz-speaking schoolchildren studying in Kyrgyzstan were logged.

During the second stage, correlation analysis at the Russian and Kyrgyz samples was conducted to study the cross-cultural specifics of the relationship of cognitive abilities to academic success (IBM SPSS 20.0 statistical package).

During the third stage, theoretical models of the relationship between cognitive development and academic success were tested by applying the structural equation modelling method to the samples of Russian and Kyrgyz schoolchildren (OpenMX statistical package). The decision to accept or reject the tested model was made on the basis of the values of the conformity quality tests: root mean square error of approximation (RMSEA) < .06, the 95% confidence interval for RMSEA low = 0.00 and high < .08, comparative fit index (CFI) compliance score > .95, and the Tucker-Lewis index (TLI) > 0.90 (Hu, Bentler, 1999).

During the course of the structural modelling, the following theoretical models of the relationship between the cognitive development and academic success were tested on each of the analysed samples of schoolchildren.

Model 1: Cognitive indicators affect academic success through the latent variable of general cognitive ability 'g';

Model 2: The cognitive indicators — information processing speed, visuospatial working memory, number sense and nonverbal intelligence — contribute to the factor of general academic success 'e' ('education') allocated on the basis of grades in mathematics, Russian language and biology;

Model 3: Information processing speed is a key predictor of nonverbal intelligence, working memory and number sense, which in turn contribute to the 'e' factor of general academic success.

Results

The statistical analysis included cognitive abilities — information processing speed, visuospatial working memory, number sense and nonverbal intelligence — and teachers' assessments in Russian language, mathematics and biology as indicators of academic success.

Table 1 shows mean and standard deviations (in brackets) for the analysed indicators in the groups of primary school age children from Russia and Kyrgyzstan.

Table 1

Descriptive statistics of the cognitive abilities and academic success

Indicator	Schoolchildren from Russia	Schoolchildren from Kyrgyzstan
Information processing speed	.99 (.27)	1.03 (.25)
Visuospatialworking memory	2.70 (1.84)	2.75 (1.84)
Number sense	94.21 (14.15)	96.03 (14.23)
Nonverbal intelligence	38.21 (9.5)	32.13 (10.60)
Grades in Math	4.02 (0.6)	4.20 (0.6)
Grades in Russian language	3.87 (0.6)	4.19 (0.7)
Grades in Biology	4.45 (0.5)	4.64 (0.5)

Table 1 shows the total number of correctly completed test tasks for the visuospatial working memory, number sense and nonverbal intelligence. The minimum and maximum possible values are 0 and 12 for the “Sequence” test, 0 and 150 for the “Number sense” test, and 0 and 60 for the “Standard Progressive Matrices” test. Information processing speed is presented in seconds. The values of the quarterly grades in school subjects range from 2 to 5.

According to *Table 1*, for the visuospatial working memory and number sense indicators, slightly higher mean values were obtained by the group of Kyrgyz schoolchildren; and for information processing speed and nonverbal intelligence, higher values were obtained by the Russian schoolchildren.

Grades in all analysed subjects, including Russian language, were higher for Kyrgyz schoolchildren. It should be emphasized that the subjective nature of teachers’ assessments and differing criteria of success in teachers’ assessments of acquired knowledge in each of the national educational systems make it impossible to directly compare cross-cultural differences in pupils’ performance. During the course of further analysis, based on the grades in the three school disciplines, an indicator of overall academic success was calculated, which was applied in the context of its relationship with the cognitive sphere only within the context of a particular cultural group.

To assess the cross-country differences in and extent of the cognitive abilities, an analysis of variance was performed, and the following indicators were introduced as the dependent variables: information processing speed, visuospatial working memory, number sense, and nonverbal intelligence. Levene test values ($p > 0.05$) indicate the equality of the variances of all analysed cognitive variables for the samples compared.

Table 2 shows the results of the one-way analysis of variance where the factor of the country of residence — Russia or Kyrgyzstan — was used as the categorical factor.

As per *Table 2*, statistically significant differences between groups of primary school age children from Russia and Kyrgyzstan were obtained in terms of information processing speed with a small effect size of 1% and nonverbal intelligence with an effect size of 8% ($p < 0.001$). For both indicators, higher results were obtained for

the sample of Russian schoolchildren (see Table 1 for the descriptive statistics). Visuospatial working memory and number sense did not statistically significantly differ in the groups of schoolchildren studying in Russia and Kyrgyzstan ($p > 0.05$).

Table 2

The results of analysis of variance on cognitive abilities

Indicator	Sum of Squares (SS)	F-statistics (F)	p-value (p)	Effect size (η^2)
Information processing speed	0.79	11.31	0.00	0.01
Visuospatial working memory	91.59	21.44	0.10	0.001
Number sense	755.03	3.66	0.06	0.001
Nonverbal intelligence	9293.65	91.48	0.00	0.08

Analysis of variance was also conducted to assess the differences between Russian and Kyrgyz-speaking schoolchildren from Kyrgyzstan in terms of cognitive indicators and school grades. According to the results, no significant differences were found between schoolchildren that were native and non-native Russian speakers studying in Kyrgyzstan for all the analysed cognitive development indicators and teachers' assessments ($p > 0.05$).

Correlation analysis

The relationship between cognitive abilities and academic achievement in Math, Language and Biology was studied during the course of the correlation analysis.

Table 3

Correlation matrix for the cognitive abilities and academic achievement

	IPS	VSWM	NS	NI	Lang	Math	Bio
VSWM	-0.34** -0.38**	1					
NS	-0.21** -0.21**	0.33** 0.28**	1				
NI	-0.26** -0.39**	0.42** 0.42**	0.37** 0.34**	1			
Lang	-0.02 -0.03	0.15** 0.15**	0.24** 0.20**	0.47** 0.22**	1		
Math	-0.09* -0.06	0.22** 0.21**	0.26** 0.22**	0.48** 0.27**	0.79** 0.74**	1	
Bio	-0.06 0.11	0.17** -0.06	0.22** 0.12*	0.43** -0.07	0.74** 0.52**	0.72** 0.49**	1

Note. IPS =information processing speed, VSWM=visuospatial working memory, NS=Number sense, NI=Nonverbal intelligence, Lang=Grades in Russian language, Math=Grades in Math, Bio=Grades in Biology. ** $p < 0.01$; * $p < 0.05$.

Table 3 shows Spearman's correlation coefficients between information processing speed; visuospatial working memory; number sense; nonverbal intelligence; and success in learning mathematics, Russian language and biology in Russian (top line) and Kyrgyz (bottom line) samples.

As shown in Table 3, in the relationship between cognitive development and school achievement, there are both similarities and differences in the samples of Russian and Kyrgyz schoolchildren.

In particular, in both cross-cultural samples, information processing speed was unrelated to success in learning Russian language and biology ($p > 0.05$). Differences were obtained for mathematics. Only in Russian schoolchildren was a weak but statistically significant correlation found.

Visuospatial working memory and nonverbal intelligence were related to Russian language and mathematics assessments in both samples of children at the primary level of school education, and differences were obtained for biology. Only in the Russian sample was a statistically significant correlation found. As for the relationship between number sense and academic success for all analysed school subjects, both the Russian and Kyrgyz samples of schoolchildren were completely similar.

The structure of the relationships between the cognitive abilities — information processing speed, visuospatial working memory, number sense and nonverbal intelligence — is characterized by the similarity of the number and strength of relationships in the analysed samples of schoolchildren. Furthermore, in both sociocultural samples, the strongest relationship was obtained for nonverbal intelligence and visuospatial working memory ($r = 0.42$, $p < 0.01$), and the weakest relationship was obtained for information processing speed and number sense ($r = 0.21$, $p < 0.01$). In general, the coefficients of the correlation between the indicators of the cognitive sphere are moderately strong.

The relationships between the indicators of success in learning Russian, mathematics and biology in the sample of Russian schoolchildren were characterized by high correlation coefficients ($0.72 < r < 0.79$ at $p < 0.01$); and in Kyrgyz schoolchildren, these relationships were mostly moderate. An exception was the relationship between school grades in Russian language and mathematics. As in the Russian sample, the correlation coefficient in the sample of Kyrgyz schoolchildren reached a value of 0.74 at $p < 0.01$.

Structural equation modeling

Three models of the relationship between the cognitive development and academic success were tested using the structural equation modelling method on samples of primary school age children from Russia and Kyrgyzstan.

According to Model 1, the cognitive indicators influence success in learning school subjects through the latent variable of general cognitive ability. Model 2 assumed the opposite influence of all the analysed cognitive abilities on general academic success calculated on the basis of school grades in mathematics, Russian language and biology. In Model 3, the baseline cognitive metric—information processing speed—is a key predictor of nonverbal intelligence, working memory, and number sense, which in turn contribute to individual differences in general academic success.

The analysis of the structural models showed that the tested theoretical Models 1 and 2 corresponded poorly to the empirical data of Russian and Kyrgyz children at the primary level of general education ($RMSEA > 0.08$, $CFI < 0.95$, $TLI < 0.90$, and χ^2 significant ($p < 0.05$)). However, Model 3 best matched the data obtained in both the Russian and Kyrgyz samples.

The fit indices of theoretical Model 3 to the empirical data of samples of primary school age children from Russia and Kyrgyzstan are presented in *Table 4*.

Table 4

Fit indices of theoretical Model 3 to the empirical data of Russian and Kyrgyz samples

	AIC	BIC	CFI	TLI	RMSEA	RMSEA low	RMSEA high
Schoolchildren from Russia	6647.17	-14125.86	0.996	0.991	0.027	0.000	0.055
Schoolchildren from Kyrgyzstan	6515.67	-13495.08	0.942	0.894	0.059	0.004	0.024

Note. AIC = Akaike information criterion, BIC = Bayesian information criterion, CFI = comparative fit index, TLI = Tucker Lewis index, RMSEA = root mean square error of approximation, RMSEA low = the lower limit of the 95% confidence interval for RMSEA, RMSEA high = upper limit of 95% confidence interval for RMSEA

According to *Table 4*, the fit indices for Model 3 indicate good agreement with empirical data. Thus, for the sample of schoolchildren studying in Russia, $RMSEA \leq 0.06$, 95% confidence intervals — $RMSEA\ low = 0.00$ and $RMSEA\ high < 0.08$, $CFI > 0.95$, and $TLI > 0.90$. Furthermore, the χ^2 value is not significant ($p > 0.05$), which reflects a good fit of the model. Satisfactory fit indices were obtained for the sample of schoolchildren from Kyrgyzstan (see *Table 4*), and the χ^2 value was not significant ($p > 0.05$).

Figure 1 show a model of the relationship between information processing speed (IPS), visuospatial working memory (VSWM), number sense (NS), nonverbal in-

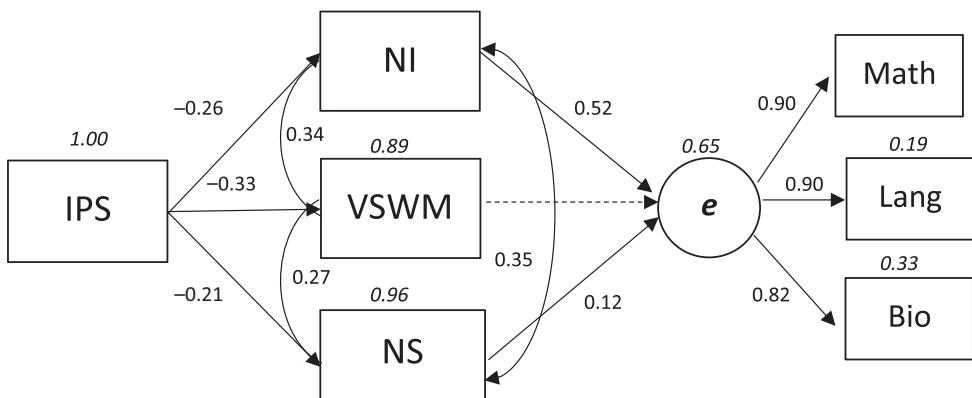


Figure 1. Model of the relationship between the cognitive abilities and academic achievement for the sample of Russian schoolchildren

telligence (NI) and academic success for the sample of primary school children from Russia. The model included standardized structural coefficients ($p < 0.05$), and dashed lines were used to indicate statistically nonsignificant relationships ($p > 0.05$).

As seen in *Figure 1*, the model considers general academic success as a latent variable based on the three indicators of academic success: mathematics, Russian language, and biology performance. These indicators of academic success were almost equally loaded on the latent factor of general academic success 'e' (ranging from 0.82 to 0.90).

According to this model, information processing speed is considered the basic cognitive indicator underlying higher order cognitive abilities: intelligence, working memory and number sense. In turn, these cognitive abilities influence academic success. Comparing the standardized structural coefficients at the primary level of school education, information processing speed had the most influence on working memory ($\beta = -0.33$), followed by the nonverbal intelligence ($\beta = -0.26$) and number sense ($\beta = -0.21$) indicators. The regression weights between nonverbal intelligence, visuospatial working memory, and number sense ranged from 0.27 to 0.35. Of all cognitive abilities, nonverbal intelligence had the greatest influence on the academic success factor ($\beta = 0.52$).

Consequently, in the sample of Russian schoolchildren, most of the influence of the cognitive sphere on academic success can be seen in the trajectory of the indirect influence of information processing speed through nonverbal intelligence. Standardized path coefficients, calculated in accordance with the principles of structural equation modelling (Rinderman, Neubauer, 2004; Hu & Bentler, 1999), statistically confirm this fact. Thus, the regression weight of the path "Information processing speed — Nonverbal intelligence — Academic achievement" is $-0.26 \times 0.52 = -0.13$. The standardized structural coefficients for other possible paths in which the cognitive development might influence academic success are shown below. It must be noted that a model with a direct influence of information processing speed on the

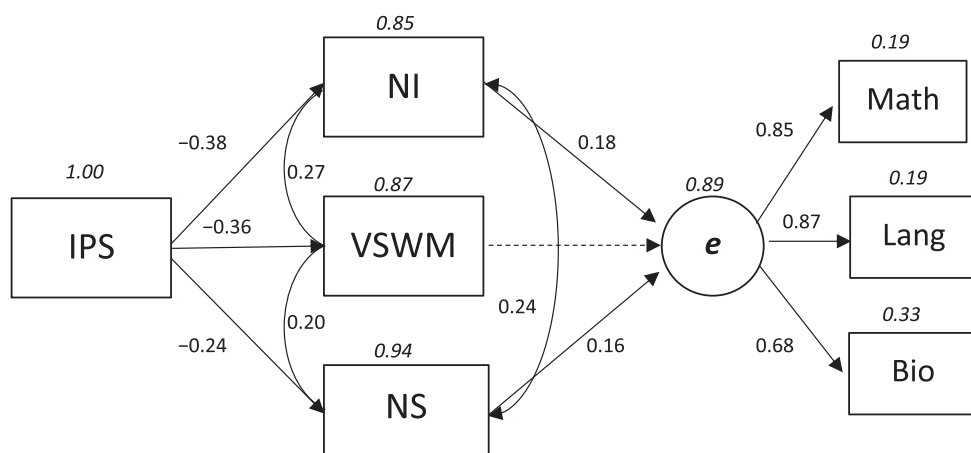


Figure 2. Model of the relationship between the cognitive abilities and academic achievement for the sample of Kyrgyz schoolchildren

academic success factor has unsatisfactory indicators of fit. According to *Figure 1*, the residual variance of general academic success is 0.65. Thus, in a sample of primary age schoolchildren from Russia, using the analysed cognitive abilities, 35% of the variance in academic achievement was explained.

Figure 2 shows a model of the relationship between information processing speed (IPS), visuospatial working memory (VSWM), number sense (NS), nonverbal intelligence (NI) and academic success for the sample of schoolchildren from Kyrgyzstan. The model shows standardized structural coefficients ($p < 0.05$), and dashed lines are used to indicate statistically nonsignificant relationships ($p > 0.05$).

According to *Figure 2*, in the sample of children from Kyrgyzstan, school performance indicators in mathematics, Russian language and biology were loaded on the latent factor of general academic success to varying degrees (from 0.68 to 0.87).

Comparison of standardized structural coefficients confirmed the fact that information processing speed had the most influence on nonverbal intelligence ($\beta = -0.38$), followed by the working memory ($\beta = -0.36$) and number sense ($\beta = -0.24$) indicators. The regression weights between nonverbal intelligence, working memory, and number sense ranged from 0.20 to 0.27. As in the sample of Russian primary schoolchildren, of all the cognitive abilities, nonverbal intelligence had the greatest influence on general academic success at the primary school education but with a significantly lower contribution ($\beta = 0.18$).

Structural equation modelling yielded standardized path coefficients that confirmed that in the Kyrgyz sample, the way cognitive functioning influences academic success is the indirect impact of information processing speed through nonverbal intelligence, as in the Russian sample. The regression weight of the path “Information processing speed — Nonverbal intelligence — Academic achievement” is $-0.38 \times 0.18 = -0.07$. According to *Figure 2*, in the Kyrgyz sample, the residual variance of general academic success is 0.89. This means that in the sample of primary school age children from Kyrgyzstan, only 11% of the variance in academic achievement was explained using the analysed cognitive abilities.

Discussion

During the course of this study, a cross-cultural analysis of the structure of the relationships between the cognitive abilities and academic achievement was conducted using groups of primary school children studying in countries with different socio-economic statuses and educational effectivenesses — Russia and Kyrgyzstan.

Among the cognitive development indicators, cross-cultural differences in nonverbal intelligence were observed with an effect size of 8%. According to the results, primary-level schoolchildren studying in Kyrgyzstan performed worse on the “Standard Progressive Matrices” test than their Russian peers. This result concurs with the data of cross-cultural studies on the “sensitivity” of intelligence measured by the “Standard Progressive Matrices” test to educational conditions (von Stumm & Plomin, 2015; Nisbett et al., 2012; Rindermann et al., 2010). Thus, studies, including those with the participation of Russian and Kyrgyz schoolchildren, reported advantages of children studying in more favourable macro and micro socioeconomic conditions

(Kuzmuna et al., 2020; Nisbett et al., 2012). Additionally, it is noted that cross-country differences are reduced during the course of schooling (Kuzmuna et al., 2020). It has also been shown that schooling leads to a gradual reduction in the range of variability in a number of cognitive abilities, such as intelligence, information processing speed, and number sense associated with the ability to accurately determine the position of a number on a number line (Tikhomirova et al., 2020; Nisbett et al., 2012). Thus, a longitudinal study reports a significant decrease in interindividual differences in terms of the accuracy of assessing symbolically expressed quantities under the influence of formal schooling from the first to the fourth year (Kuzmina et al., 2020).

In the present study, no differences were found between schoolchildren from Kyrgyzstan with Russian and Kyrgyz as their native languages, which may also confirm the effects of the influence of the socioeconomic status of the country overall. Minor cross-cultural differences were obtained for the information processing rate with an effect size of 1%. Regarding visuospatial working memory and number sense, no differences were found between younger schoolchildren studying in Russia and Kyrgyzstan. Similar data were obtained in studies with the participation of respondents from other age and cultural groups (for example, Brown et al., 2012).

In the relationship between the cognitive abilities and success in learning various school subjects at the primary school education, both similarities and differences between schoolchildren studying in Russia and Kyrgyzstan were found.

Regarding the similarities, it should be noted that the relationships between visuospatial working memory and number sense and the indicators of successful learning of Russian language and mathematics are almost identical in strength. Additionally, in both samples, the connection between information processing speed and school achievement indicators was absent. An exception was a weak relationship between information processing speed and mathematics success in the sample of Russian schoolchildren. These data agreed with the results of studies conducted with the participation of Russian respondents (for example, Tikhomirova et al., 2020) and may hint towards the presence of indirect relationships with academic success. Despite the identified similarities in the relationship between the cognitive sphere and school performance, the analysis revealed some cross-cultural differences. For example, the most significant difference is the ratio of nonverbal intelligence and assessments in all analysed school subjects. In particular, it was shown that in the Russian sample of children at the primary level of school education, the strength of the relationship was almost twice as high when compared with that of the Kyrgyz sample. This result confirms assumptions about the greater role of cognitive abilities (in particular, intelligence) in the formation of individual differences in learning in favourable and homogenous educational environments (Tucker-Drob, & Bates, 2016).

The best indicators of fit with the empirical data for both samples of schoolchildren were found for the model with information processing speed as the basic predictor of intelligence, working memory and number sense, which then together contribute to general academic success. Nonverbal intelligence plays a central role in this model, and its importance for academic achievement has been repeatedly reported in studies with differing cultural and age contexts (Deary, Johnson, 2010; Ritchie, Bates,

Deary, 2015). These data contribute to the notion of universal applicability of this model, already confirmed by previous studies, including those with the participation of schoolchildren from Russia (Tikhomirova et al., 2020). It should be noted that in the study with the participation of German schoolchildren, the most satisfactory model was recognized as that wherein information processing speed affects school achievements through higher order cognitive abilities such as intelligence and creativity only indirectly (Rindermann, Neubauer, 2004).

Along with the invariance of the model, the cross-cultural specificity of the relationships within this structure was shown. In particular, in the sample of Russian schoolchildren, the regression weight of the relationship between information processing speed and academic success through intelligence turns out to be more significant compared to the data of Kyrgyz schoolchildren (modulo 0.13 versus 0.07). Notably, the significantly greater contribution of intelligence to the indicator of general academic success in the Russian sample of primary school age children compared to the Kyrgyz sample is consistent with research data on the effects of national education systems on the structure of relationships between the cognitive sphere of schoolchildren and their educational achievements (Nisbett et al., 2012).

According to the results of this study, at the primary level of education, the contribution of the cognitive abilities to the general academic success of schoolchildren from Russia was estimated at 35% of the variance of the school achievement indicator; and in the sample of schoolchildren from Kyrgyzstan, the contribution was only 11%. In other words, in a more unified and effective educational environment (in terms of international rankings and assessments of student educational achievement), there was an increase in the role of cognitive indicators in individual differences in academic success at the initial level of general education. Such a tendency towards an increase in the influence of cognitive development on the success of schooling may be associated with the specifics of the requirements of developing educational programs and assessment of academic achievements in different socio-cultural conditions.

Conclusion

The cross-cultural analysis of the models of the relationship between cognitive development and academic achievement revealed a universal applicability for one of the models tested for primary-level schoolchildren studying in Russia and Kyrgyzstan. According to the structural equation modelling results, the baseline cognitive metric (information processing speed) was a key predictor of nonverbal intelligence, visuospatial working memory and number sense. These which together seem to contribute to individual differences in general academic success, and constitute a model best suited to the empirical evidence.

Along with the universality of the model, cross-cultural differences in the relationship between the cognitive development and school success indicators were revealed, differences yielding a significant decrease in the influence of the cognitive abilities of a schoolchild on his or her academic achievements, given less favourable educational conditions. Presumably, in such a case, other personal and/or motiva-

tional resources may make more significant contributions to the formation of individual differences in academic success as measured by teachers' assessments. These results of our study can be used, we suggest, in educational practice to improve the efficiency of the functioning of the national education system.

Future research directions relate to the analysis of the joint influence of cognitive, personal and motivational traits on school achievement.

Limitations

In this study academic achievements were measured only by grades in Russian language, mathematics and biology as assessed by school teachers. At the same time, various indicators — grades, standardized test assignments and state exams scores in school subjects can be used to assess school achievements.

Ethics Statement

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Psychological Institute of the Russian Academy of Education (project identification code 2016/2–12). All subjects gave their informed consent for inclusion before they participated in the study.

Informed Consent from the Participants' Legal Guardians

Parental informed consent was obtained for all participants. All subjects gave their informed consent for inclusion before they participated in the study.

Author Contributions

The conceptualization and methodology of the study were done by S.M. and T.T. Research methods, data curation, and analyses were done by A.M. and I.L., with feedback from S.M. and T.T. Original draft preparation, review and editing were done by S.M. and T.T. Funding acquisition was done by S.M. All authors have read and agreed to the published version of the manuscript (T.T., A.M., I.L. and S.M.).

Conflict of Interest

The authors declare no conflict of interest.

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The “Moon Test”: A Step Towards Evaluating Comprehension of Educational Text through Model Mediation

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Background. This paper addresses the issue of educational text comprehension, which is one of the major problems in secondary schools, especially when such texts are introduced in the natural sciences. Studies on text comprehension often regard reading as a standalone skill: its mechanisms are discussed from leading theoretical approaches (cognitivism, constructivism, etc.), and variables are distinguished and evaluated. Most of the researchers consider text comprehension to be active reconstruction of the meaning which the text delivers, and regard the application of the information retrieved from the text to problem-solving as the indicator for a deep comprehension level. Since we work within the framework of Cultural-Historical Activity Theory (CHAT), we consider educational text comprehension to be mediated through special content-related models which students have to acquire. Unfortunately, there are no studies which have directly linked reading, corresponding problem-solving, and working with content-related models (symbolic means, schemes); hence, with this research, we are seeking to fill in the gap.

Objective. Our goal is to elaborate the perspective on educational text comprehension as mediated through mastering special modeling (symbolic) means. In this article we illustrate this approach with the “Moon test” — an assessment procedure which we designed to materialize the components of orientation of students’ action as they succeed or fail to solve problems by relying on the educational text provided.

Design. We conducted the “Moon test” among the fifth graders (10-12 years old). The text, which told the students how to use the moon’s visual transformations as a calendar, was followed by 12 tasks on the topic. The tasks required using the text to master the model provided, and then solve challenging tasks which only referred to the model implicitly.

Keywords:
Scientific literacy;
assessment;
reading
comprehension;
model
acquisition and
application;
transfer from
primary to
secondary
education

Results. To analyze the results, we grouped the tasks in four blocks: 1) model acquisition; 2) mastering; 3) application; and 4) experience. The results showed a statistically significant decrease in the students' performance on tasks of the third and the fourth blocks, which required reasonable application of the models. Further analysis of individual patterns of performance allowed us to distinguish clusters of students with different levels of success in each block.

Conclusion. Our results attest to the importance of model mediation for reading comprehension and the development of scientific literacy.

Introduction

Learning Natural Sciences in primary and secondary school demands special educational texts: they deliver the cultural templates for handling natural objects and phenomena which are to be applied in corresponding tasks. Unfortunately, as many studies show, the comprehension of these texts has always been an issue for students (NCES, 2019; Osnovnyye rezul'taty..., 2007; Zuckerman, Kovaleva, & Kuznetsova, 2013).

Issues around educational text comprehension are often considered in terms of reading competencies in general, and different groups of variables such as the texts' characteristics and the readers' individual skills are discussed accordingly (National Research Council, 2014). The mechanism of reading comprehension is acknowledged to be a complicated procedure aimed at reconstructing the meanings embedded in the text: active work by the students is implied (Woolley, 2011). Success may be considered the result of causal inferential processes and the application of other metacognitive skills (León & Escudero, 2015; McNamara, Kintsch, Songer, & Kintsch, 1996); reference to prior knowledge (Broughton, Sinatra, & Reynolds, 2010; Hynd & Alvermann, 1986; Kendeou & Van Den Broek, 2007; Mason, Gava, & Boldrin, 2008; Mikkilä-Erdmann, 2002; Wang & Andre, 1991); construction of appropriate content and textual schemas (Armbruster, 1986), and so forth. The mechanisms of text comprehension, as well as ways to improve educational texts' design, have been investigated by many researchers from different theoretical perspectives; substantial overviews of these studies are presented elsewhere (León & Escudero, 2017; Otero & Graesser, 2014; Van Hout-Wolters & Schnotz, 2020; Woolley, 2011).

On the other hand, reading comprehension is also considered in terms of literacy — the ability to solve real-life problems using the information retrieved from texts (see PISA and PIRLS — Mullis et al., 2009; Schleicher, Zimmer, Evans, & Clements, 2009). Indeed, comprehension assessment procedures mostly include a text and corresponding tasks, which may be multiple choice questions or open tasks (Albacete et al., 2016; León & Escudero, 2015), which are also common ways to assess disciplinary literacy. The text often concerns some meaningful problem, and a series of tasks challenge students to perform solutions based on the text (Folk, Miller, van Garderen, Lannin, & Palmer, 2020; Tamassia, & Schleicher, 2002; Zuckerman et al., 2013). In respect to the texts in textbooks, this level of comprehension (problem-solving based on the information from the text) is most desirable, since it was for this purpose that the texts were written.

There is a tendency today to consider texts somewhat “peripheral” to teaching and rather emphasize the importance and necessity of complementary activities such as solving problems (especially real-life problems), inquiry-based learning, group discussions, and so on (Khalaf, 2018; Peacock & Gates, 2000; Schilling & Hammond, 2019; National Academies..., 2017). But educational texts in general (which also include task outlines and teachers’ explanations) cannot be excluded from the learning process. In this article we suggest an approach to the issue of educational text comprehension within the Cultural-Historical Activity Theory (CHAT) framework. This allows us to pose the question: What should students do as they read the text, in order to solve the problems which rely on text comprehension?

Educational Text Comprehension and Modeling: the CHAT Perspective

Within the Cultural-Historical and Activity Theory framework, the problem of educational text comprehension should be considered in relation to the conceptual content which these texts refer to. Students’ psychological development, the evolution of their thinking as a result of school education, relies on the acquisition and mastery of “school” concepts (Vygotsky’s term is “scientific” concepts, Vygotsky, 1986) as opposed to common everyday notions.

According to Galperin (1992), concepts are acquired through special actions which gradually evolve from the materialized form towards mental action. The materialized form of action is the most important part, as it is there that the students’ orientation is extended and made tangible through special symbolic means, such as graphs, schemas, diagrams, and so forth. The quality of these modeling tools and the extent to which students adopt them as their actual means of dealing with the problems, define the future development of the concepts and the overall quality they thus acquire.

Researchers (Salmina, 1981) distinguish between common “visuality” and “materialization.” There is an abundance of visual aids in textbooks meant to facilitate students’ comprehension by providing vivid illustrations for students to observe. “Materialization” refers to the students’ own actions, aimed at transformation of the object and operations with them (“transformative” action in CHAT terminology) and implies the design of special objects for these actions: the models. Davydov went a step further and elaborated the materialized form of action in particular, which he and his colleagues referred to as modeling or modeling actions (Davydov & Vardan-yan, 1981; Rubtsov, 1994). Modeling, in Davydov’s words, is the reproduction of the “genetically initial, universal connection that determines the content and structure of the entire entity in the given concepts... in particular, object-related, graphic, or symbolic models that permit its properties to be studied ‘in pure form.’” (Davydov, 1990, p. 174)

It is necessary to stress that in CHAT terminology, models differ from “models as representation” (a prototype) and “models as students’ mental constructs (epistemic artefacts)” (Armbruster, 1986; Gilbert, & Justi, 2016). They are content-related, substantial models which materialize the conceptual (cultural) way of thinking about the matter and how to handle it; for example, the bar diagrams for part-whole re-

lations in early algebra (Elkonin, & Davydov, 1966; Polotskaia, 2017), the dots-in-box model for proportional reasoning about the buoyancy problem (Smith & Unger, 1997), the technological chart for natural sciences (Vysotskaya, Khrebtova, Lobanova, Rekhtman, & Yanishevskaya, 2018), and so forth. Teaching experiments within this approach have shown that these actions are essential for grasping the conceptual content of the matter, building one's own solution for particular problems, and overcoming the pitfalls of visibility and routine experience (Davydov, 2008; Elkonin, & Davydov, 1966; Galperin, 1992).

As we consider reading educational texts as part of learning in general, we have to regard text comprehension within a text-model-problem triad (Figure 1).

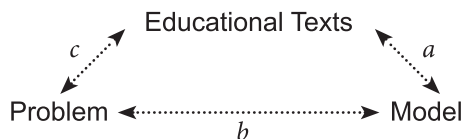


Figure 1. The text-model-problem triad: students' work within each link between two "angles" (a, b, c) has to be mediated by their reference to the "third" one

Note: Example for "a" and "c" links: What does a student do, when he understands the educational text? He reconstructs the materialized part of the action as mediated with the appropriate model provided — thus, the model actually becomes his working instrument in problem-solving. How can we tell that the student understood the text from his book? He can solve the related problems. How does this connection work? The connection works if the conceptual grounds for solving the problems were grasped from the text. How do we identify the conceptual grounds? We materialize the desired action through symbolic means, i.e., special content-related models.

Thus, we assume that the materialized form of action and its special objects, the models, are crucial for educational text comprehension and corresponding problem-solving, as well as being the backbone of concept acquisition in general. The assessment of reading comprehension should focus on the students' actions with models which are appropriate for the conceptual content delivered through the educational text.

Educational Text Comprehension and Modeling: Principles of Assessment Design

The application of models to reading educational texts has received little attention, although modeling in general is considered to be important for learning the sciences as a standalone skill (Gilbert & Justi, 2016; Van Der Valk, Van Driel, & De Vos, 2007). Within the CHAT approach there are substantial studies on informational text comprehension (Zuckerman & Obukhova, 2012) and on modeling (Chudinova, 2021); yet these studies do not relate reading and modeling directly.

However, they present some principles of text comprehension assessment design which we find crucial. Critical tasks are designed to contrast "what it seems to be" and "what it is," prompting students to follow the lead of illustrative material without applying conceptual knowledge, which eventually leads to mistakes. Galperin (Engeness, 2021; Galperin, 1992) considered such tasks to indicate the "reasonability" of the orientation content of students' actions and related concepts. Samples of assess-

ment tools based on the divergence between the “visual” and the “conceptual,” were designed within Galperin’s approach (Karpov, & Talysina, 1989; Pavlova, 2008; Sidneva, 2010; Sidneva, & Vysotskaya, 2019; etc.).

Following Davydov’s theory, we tried to connect students’ success in solving challenging problems to their comprehension of the corresponding educational text through their working with an appropriate model, which corresponds to the materialized form of the desired action. To bring forth the connection between educational text comprehension and appropriate model acquisition, the assessment procedure requires challenging students with tasks and problems which directly or implicitly demand using a model. Most challenging tasks should be unsolvable for those students who fail to reconstruct the general context of concept-mediated work that the text implied, and to master the materialized part of the action.

One of the feasible ways to design the tasks is to use the discrepancy between the “visual” and the “conceptual,” as mentioned above. The tasks are to be preceded by an educational text — a story which conveys the general way of solving problems concerning some matter. The materialized form of the students’ desired actions is to be provided alongside the adequate representation of the object the students are to handle (an appropriate model); we do not expect students to “invent” it themselves. While reading the text, students have to find direct guidelines and hidden clues in order to reconstruct the orientative content of actions behind the concepts. Accomplishment of the tasks, thus, would attest to the fact that the students have 1) managed to master the model presented by the text, and 2) applied the model adequately.

The “Moon Test”: the Assessment of Students’ Work within the Text-Model-Problem Triad

To assess model-mediated reading and problem-solving among graduates of primary school, we designed the “Moon test” (Yanishevskaya, Vysotskaya, & Lobanova, 2021), which includes a short text about the visual moon’s transformations and 12 tasks referring to the topic. The Moon’s transformations were chosen, because most students are familiar with the phenomenon either through the primary natural science curriculum or through casual observation. The text is not long (less than 350 words) and reads like a story about how people used the moon’s transformations in establishing their first calendar, which allowed them to count the days by weeks and months. Here is an excerpt:

The moon is constantly changing its shape: some day we see a whole circle in the sky — a “full moon;” then only a “half” is visible, or a beautifully outlined narrow sickle appears, which over time either “gets fat,” or “grows thin” until it disappears. In Russian such a sickle is not even called the moon, but the month.

However, one-twelfth of the year is also called a month. This is no coincidence. The moon made it possible to keep track of the days, and many peoples, including the Slavs, used the “lunar calendar,” in which the week and month were “natural” measures of the days gone by.

The subsequent 12 tasks were of four types, according to the way they engaged students in working with the model. The first three tasks (block 1) introduced the

model itself — the schematic of the moon's transformations (see the “moon dial” — *Figure 2*) — and asked the students to relate the descriptions from the text and the model (the *a* connection on *Figure 1*).

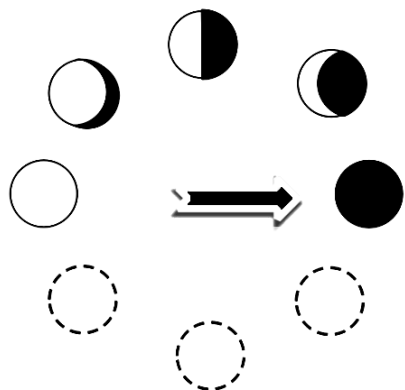


Figure 2. The model (the moon dial scheme) was introduced with three missing symbols. One of the tasks asked the students to complete the sequence

The moon dial is a symbolic representation of visible moon transformations during a one-month period; it was specially designed to scaffold the materialized form of students' action, as they deal with measuring time passed or remaining, as people in the story did. The moon dial resembles a common clock, where weeks are counted instead of hours. This model appeals to the way people used the moon transformations they observed; thus, it is more of a model of actions than a model of the moon itself. It is not the moon as a natural object which interested people, but its surprising ability to be an accurate “timer” for people to calculate the passage of time. The central task of the “Moon test,” and the Tom Sawyer's problem detailed below, demonstrates the necessity of this kind of representation for the calculation of time:

#9. By all accounts Tom Sawyer and Huckleberry Finn were supposed to reach the destination town in three weeks, as they floated down the river on a raft. However, after a few days, they lost count, and they could no longer say how long they had been traveling. Lights appeared on the shore. The raft moored to the shore. But is this the right place? Huck remembered clearly that they started on a night with a full moon... Throughout the cloudless night and even in the morning they looked at the sky, but the moon did not appear.

Based on this, the boys drew the necessary conclusion. Which one?

- 1) they had already arrived;
- 2) they had to raft for another week;
- 3) they had to raft for another two weeks;
- 4) they should have gone ashore a week ago.

The materialized form of the students' action, as they found the solution for this problem, can be presented on the moon dial as follows as presented on *Figure 3*.

Solving this task requires conscious, comprehensive time calculations using the moon dial, and at the same time does not demand or even hint that the students

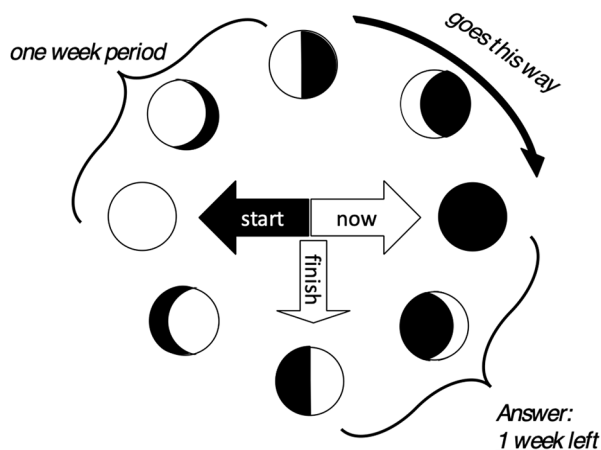


Figure 3. The full model design of the moon dial for Tom Sawyer's task

should use the model. Moreover, the very terms of the calculation are not stated directly. If they were, the instructions would have read: “It is a new moon now. It was a full moon, when someone started on a journey that takes three weeks. Choose the correct statement.” The wording itself presents a whole text, a narration, which does not indicate the instructions for application of the model. Thus, students will have to reconstruct the whole problem on the basis of the moon dial and compose these instructions themselves.

Tom Sawyer's task and two more tasks of the same kind comprised the third block of tasks and were the culmination of the test. They involved the *c* connection of Figure 1: two texts (the introductory and the task narration) were to be used to solve a real-life tricky problem — and reference to the model was the only way for students to do it. We anticipated (and the results testified to it) that these tasks would be achieved by only a minority of the students. Thus, these tasks were preceded by others that referred more clearly to the model and provided the opportunity to master the time calculation using the moon dial. They used the *b* link of the text-model-problem triad (Fig. 1); the students had to solve the problem posed on the moon dial, and in order to solve it, they could refer to the text. There were also tasks which involved the “moon context” but referred to other models (diagrams) which were supposed to be acquired in primary education (block 4).

Thus, the tasks which formed our diagnostics comprised four blocks: 1) matching the text and the model directly; 2) mastering the model by relying on the text; 3) referring to the model to solve difficult problems when not asked to do so explicitly; and 4) referring to models from the students' prior experience. However, the central block of these tasks was the third one. It contained three tasks which could not be solved “directly” without applying the model implied in the text. Moreover, the necessity of using the model was not openly stated by the task, and the terms of the task did not point to the model either; thus, we considered success in these tasks as the indicator of concepts' true functionality. The first two blocks of tasks were designed

to see where the students failed when they were not able to solve the tasks of the third block, and the tasks of the fourth block were added to analyze their previous experience with using models.

Using the “Moon test” which we designed, we evaluated students’ educational text comprehension as related to their ability to reconstruct, adopt, and apply the modeling tools implied by the text.

Methods

Sample. We conducted the Moon test with a sample of fifth graders. The sample comprised 419 students 10–12 years old from three Moscow urban schools. The schools were not chosen for any special qualities: they were three regular state schools which agreed to participate.

Procedure. The assessment was conducted within regular natural science lessons as individual written work in class. To exclude anxiety, the students were told that this work would not affect their grades, but at the same time they were asked to do their best. Those who did not want to participate for some reasons were not forced to; they received another assignment from their teacher. It takes about one lesson’s time to complete the test, yet many students passed their papers in earlier than that.

Examples of the tasks from each of the four blocks are below:

Block 1: **Acquiring the model** (the acquaintance with the model was based on matching the text and the moon dial). The tasks demanded either finding information in the text to fill in the gaps in the model or vice versa (*Figure 4*).

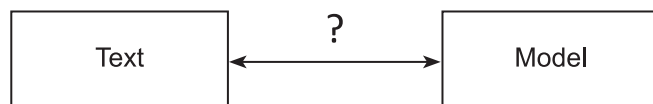


Figure 4. Block 1 exploited the “direct” relationship between the text and the model

#2. The hand on the moon dial follows the changes of moon images. How long will it take before it shows the same figure again?

#5. The moon dial drawing was not finished. Complete the drawing (*Figure 2*)

Block 2: **Mastering the model** (working directly with the model as the tasks focus on its implicit laws). The tasks required the students to explicate how the moon dial works. The “trap of visuality” was laid here on purpose. Whereas a month consists of four weeks, the moon dial has eight figures (the full moon and the new moon, two crescent moons, two almost-full moons at the opposite sides, and two half-moons). The central question went as follows:

6. Currently the hand is pointing at the new moon. Show the position of the hand on the moon dial after a week has passed.

One answer that “popped up” was to draw an arrow pointing at the next figure after the new moon, which would be a mistake. As was clearly stated in the text:

...The first week the moon “grows,” and at the beginning of the second, it is already visible as a semicircle...

Although the answer could be found in the text, the task demanded that the student draw an arrow on the moon dial, where one “hand” was already present. In other words, it asked him or her to transform the model according to the text, to make the “moon dial” work, to “wind up the clock.” Does the students’ comprehension of the text mediate their work over the model (*Figure 5*)?

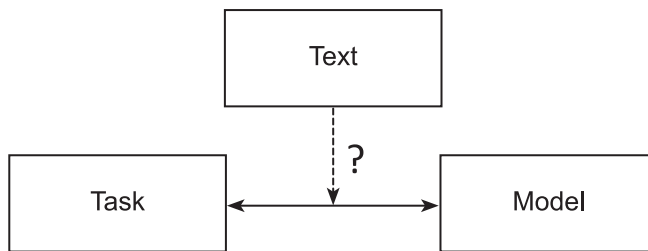


Figure 5. Solution of tasks from Block 2 should be mediated by referring to the text

Block 3: **Model application** (referring to the model initiated by the students). The tasks about Tom Sawyer and Huckleberry Finn belonged to this block: the problems introduced students to a narration and demanded an answer to a request to help the story’s characters. The necessity of referring to the model was not explicitly stated (*Figure 6*).

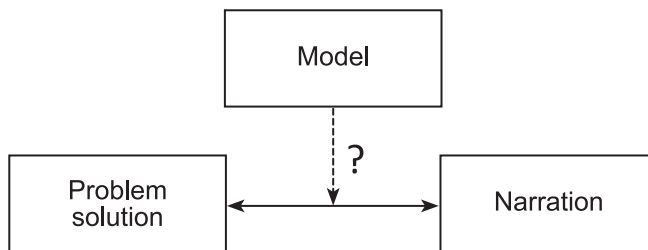


Figure 6. The solutions for tasks from Block 3 imply model application, though not stating it openly

Block 4: **Model experience** (referring to other models). There were two tasks, both of which had an essential part of the task data presented with a diagram (*Figure 7*).

11. The Moon weighs about 80 times less than the planet Earth. Therefore, it orbits the Earth, and not vice versa. In order for the students to clearly imagine the difference, the teacher asked them to show the masses of the Earth and the Moon on a grid paper.

One student sketched the mass of the Earth as shown in the figure. Draw how the mass of the moon should be shown in the same diagram.

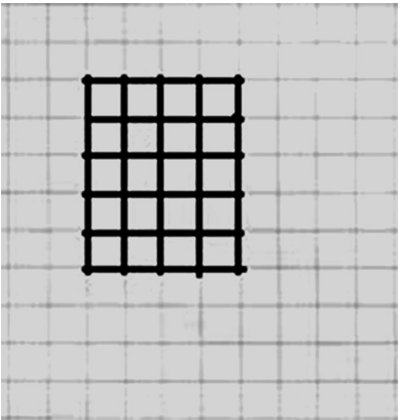


Figure 7. Rectangle on a grid paper, drawn to represent the mass of the Earth according to task #11

Each of the task’s answers was evaluated with a 0 (the task is skipped or failed), or a 1 (the task is done correctly).

Data Analysis. Data Analysis was performed using Spearman’s rank correlation coefficient, the Wilcoxon signed-rank test, and Fisher’s criteria φ .

Results

Below are the results for each task separately (Figure 8) and grouped by the four blocks (Figure 12).

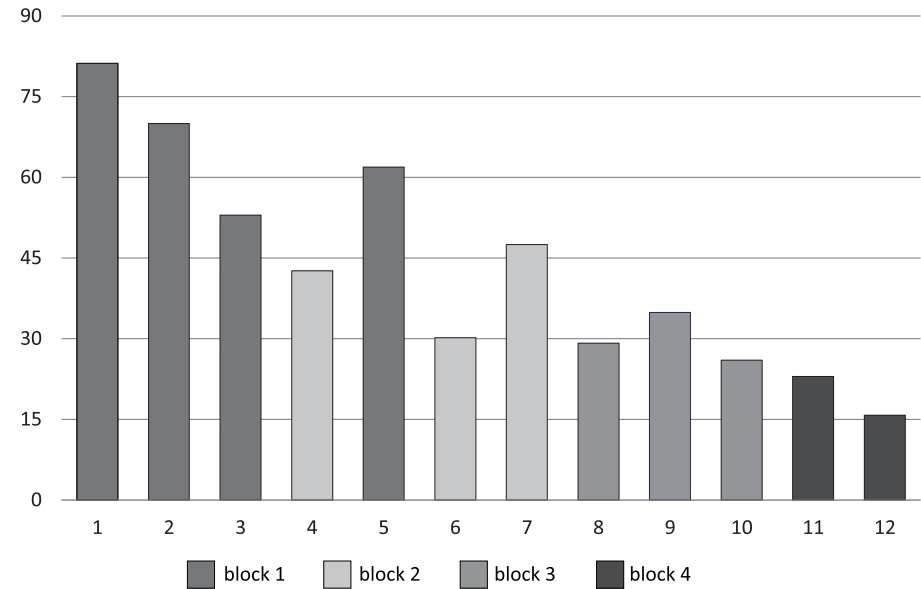


Figure 8. Students’ performance on the “Moon test” (percent of right answers for each task)

The qualitative analysis of the students’ answers provided us with a number of observations. The most common mistake on task 5 (“complete the moon dial,” when the three circles on the bottom are originally empty) was to color the bright part of the growing moon with the pencil, instead of coloring the dark part (see Figure 9). The moon, marked by the arrow, and the next symbols, would be correct if we reversed the colors.

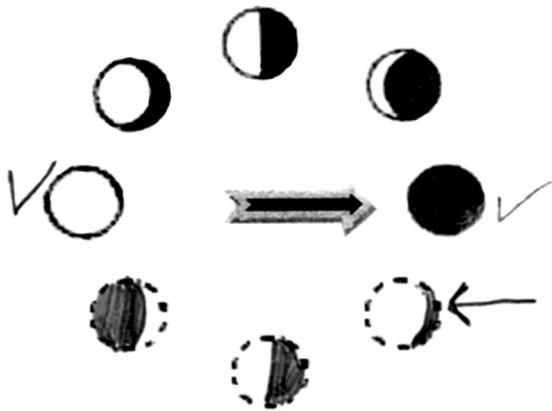


Figure 9. A completed moon dial

Note: The check mark points out the full moon (task 3); the arrow points at the moon a week after the new moon (task 6), which is incorrect. The correct arrow should be pointing at the half-moon symbol.

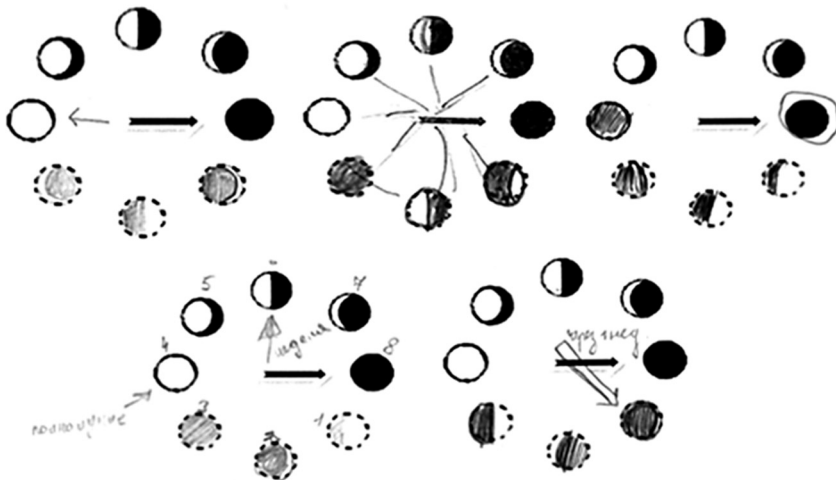


Figure 10. Examples of students’ mistakes on completing the moon dial and pointing the hand position after a one-week period

Task 6 was another crucial task, as it indicated whether the student “fell into the trap of visibility” and confused a week’s period with visual moon phases. As the results show (Figure 10), most of the students could not accomplish this task success-

fully. That coincided with the results of model application in the tasks that followed (the correlation between the students' performance on task 6 and on the tasks of the third block was significant: Spearman's rank correlation coefficient was $r_s = 0.232$, $p < 0.01$).

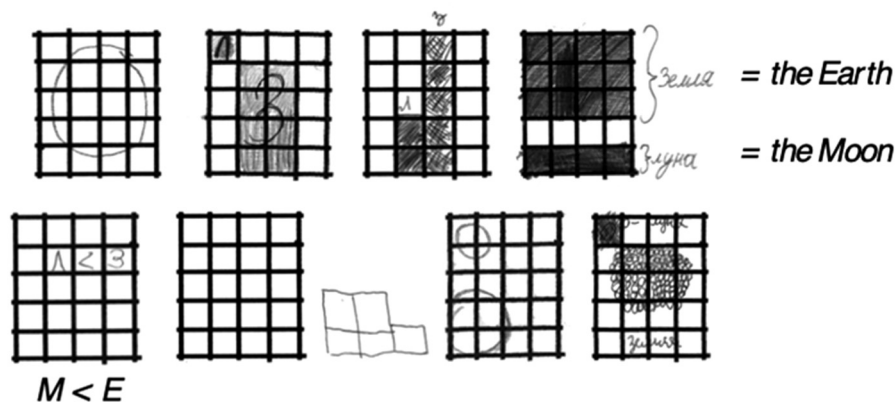


Figure 11. Examples of students' mistakes on task 11

Task 11 was the one which referred to the multiplicative context while constructing diagrams. The mistakes the students made showed that many of them had no experience in modeling magnitudes and their comparison whatsoever. The task exploited the conflict between the number of visual squares — 20 — and the stated difference in weight between Earth and the Moon, which is 80 times. However, many students failed to even approach the drawn rectangle as part of a symbolic representation for proportionalities between the two magnitudes (see Figure 11 above). Students wrote or drew in the squares which represented the mass of the Earth, sketched the Moon and Earth there, and colored some of the grids to show both objects at the same time (but depicted the wrong ratio).

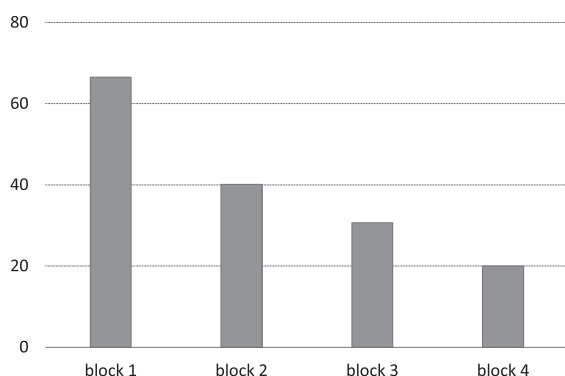


Figure 12. Students' performance grouped according to the role of the model in problem-solving

Figure 12 presents the students' results in solving the problems grouped by the blocks outlined above. We tested the consistency of tasks for each block (Kronbach's

α was 0.688; 0.782; 0.723; 0.708 from the first to the fourth respectively). The differences between the results in each block were statistically significant (Wilcoxon signed-rank test, $p < 0.01$).

However, there were different patterns of task accomplishment among the students. The substantial decrease of success on the tasks of the fourth block, which is observed in the general results, was not representative for each individual's work. The results in model acquisition (block 1) and model mastering (block 2) significantly correlated with model application (block 3); students who were careful in the tasks of first two blocks and used the model when directly told to, were more likely to succeed in difficult tasks when they referred to the model.

This distinction between the four blocks of tasks proved to be crucial for diagnostic purposes. The differences between the students' performance on these tasks indicated the “formality” of the students' attitude toward models: they often regarded them as mere illustrations attached to the text and did not work over them properly. That resulted in their poor problem-solving. In part, our grouping of tasks according to the role of model in problem solution can be justified by comparing the students' results on tasks 2 and 7 (the latter is an inversion of task 2).

2. The hand of the moon dial turns according to the changes in moon's appearance. How long will it take until the hand shows the same symbol again?

7. How will the moon dial show that exactly a month has passed?

At first glance, 7 appears easier than 2. Yet the students performed significantly worse on task 7 (Fisher's criteria $\phi = 6.94$, $p < 0.01$), which required direct appeal to the model, rather than searching for the information provided ready-made in the text.

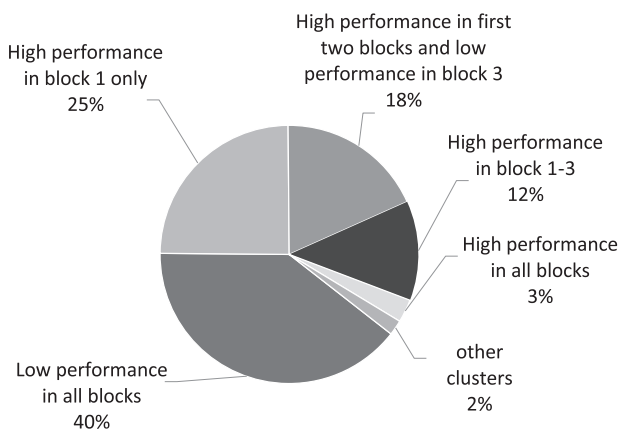


Figure 13. Clusters of students distinguished by patterns of their operating with model schemes

Note: For “high” performance we considered half and more of the tasks in the block done correctly. Less than half done was considered as “low” performance.

We have conducted a closer analysis of the most frequent patterns of students' success within the four blocks and established six clusters of students, which to our minds represent the "state of art" in natural sciences education (see *Figure 13* above).

Many students (40%) performed poorly on all tasks, although there were only a few who skipped most of the answers. They often wrote comments that they did not understand a thing. Twenty-five percent of the students were successful on the tasks of the first block but failed the tasks of the second and third blocks. This cluster we can mark as "formal acquaintance:" these students demonstrated that they understood the drawings of the moon phases and could find appropriate pieces of information in the text to answer simple questions, but failed to transform and apply the model. Why did they fail other tasks concerning the moon dial, despite the fact that the model of the moon dial was actually helpful? Perhaps they did not consider the moon dial a working instrument. We assume that they merely thought of it as an illustration that goes alongside the text: a "broken clock" that has nothing to do with the text.

The third cluster (18%) was comprised of those who succeeded in acquiring and mastering the model, but failed to use it. These students were good at working with the dial as a special standalone object for investigation. However, dealing with the model directly did not guarantee its successful application later, although it definitely was an important step towards model mediation.

The last two clusters (high performance on all blocks [3%] and high performance on all blocks but the fourth [12%]) could be merged into one considerably larger cluster of those who performed well (15%). The difference between these two clusters may be attributed to the students' previous education in primary school, where they might not have learned the skill of dealing with magnitudes and thus could not rely on previous skills.

Discussion

The significant difference between the students' performance on the tasks of the different blocks confirmed our general idea on the role of model mediation in text comprehension and problem-solving. All relationships within the text-model-problem triad are essential, as we approach the problems of science education. A direct application of the text descriptions of moon phases to solving the problems will possibly lead to right answers, but most students failed to make this link work. On the other hand, the model of the moon dial made the ideas behind time calculation, based on moon changes, tangible for students and allowed them to solve even the trickiest tasks if they used the model as a mediator for constructing a solution.

The results on tasks from blocks 3 and 4 showed that the models (moon dial and diagrams) were not functional for the majority of students. These students rather perceived them formally — as "an illustration." A desired result of education, thus, is "de-formalization" of models: students have to apply models as a means of doing their own work. Models are symbolic representations which contain the conceptual basis for the orientation procedure in the materialized form, and thus, they are actual thought instruments for mediating solutions to problems. A discrepancy between the

students’ performance on tasks of the first block, and the third and fourth blocks, is an important characteristic which has to be considered a prognostic factor towards their future learning of natural sciences (although thorough research on this matter is yet needed).

In this respect, the results, presented in the research on informational texts’ comprehension (Zuckerman, Kovaleva, & Kuznetsova, 2013; Zuckerman & Obukhova, 2012) — the absence of substantial progress during secondary education — can be regarded as an indicator of some deficits in curriculum design. As the students failed to solve problems related to the educational text, we have to question whether the content of these students’ education provided them with the substantial symbolic means to support the materialized part of their action, which is appropriate for concept-formation. Is an adequate learning situation being organized, and is the right action being demanded with challenging tasks which do not allow “bypass” (not concept-mediated) solutions?

In line with Davydov’s work, we attribute this “formalism” of modeling mainly to the content of primary school education and emphasize the necessity of implementation of Developmental Instruction principles to curriculum materials’ design (Davydov, 2008). The students’ performance on the tasks of the second block showed that working with models was the weak point which has to be elaborated. The situation, as presented by the “Moon test,” is common for regular school science classes: there is a text in the textbook followed by tasks which students often cannot solve. Teachers hence introduce model schemas and diagrams to facilitate the problems’ solutions.

There are also many ready-made models which are attached to scientific texts: the Solar system model, sequence of insects’ transformations, water cycle, and so on. However, students may not perceive the provided models in the way that teachers expect them to: they regard them as illustrations rather than working instruments. Only 40% of students were able to change the model so that it would provide the answer, which was still only the first step towards reasonable model application. There is yet special work to be organized in order for students to be able to accept and adopt the functionality of models (see our samples of developmental curricula for the natural sciences — Vysotskaya et al., 2018, 2020a, 2020b). If this kind of work is skipped, a mere demonstration with a model is unlikely to result in a successful problem-solving process.

Conclusion

Since we follow the CHAT approach in psychology in general, and Davydov’s theory in particular, we consider educational text comprehension, as well as corresponding problem-solving, as part of a wholesome learning process, which has materialized form of action with special models at its core. Thus we assume that the evaluation of reading comprehension, as mediated through modeling, may both provide a comprehensive diagnostic tool for students’ difficulties with learning the sciences, and at the same time contribute to our understanding of the role of model mediation.

Limitations

The comparison of our results with the performance of the same students on other diagnostics concerning educational (informational) text comprehension is one of our future tasks. A more in-depth analysis of the students' results in block 4 (previous students' experience with models) is also needed.

Ethics Statement

The study followed the ethical guidelines of the institutional ethics review board, and did not require special ethical approval because the research procedures involved no more than minimal risk.

Informed Consent from the Participants' Legal Guardians (if the participants were minors)

All study participants were informed about the purpose of the study, as well as that the data would only be used for scientific purposes in an anonymous form. All subjects participated voluntarily. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author Contributions

Elena Vysotskaya conceived of the idea. Mariya Yanishevskaya performed the computations. Anastasia Lobanova wrote the text in English. All authors discussed the results and equally contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest

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A Picture of Trait Anxiety and Aggressiveness among Adolescents from Different Types of Educational Institutions

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Background. This study is an attempt to identify psychological markers for pupils' maladaptive states. Aggression is seen as behavior while aggressiveness is seen as the state of being ready for such behavior. Anxiety is considered a stable personality trait. Two hundred and sixty pupils of the 8th grade from five different schools took part in the research. Schools that have a selection principle for admission are called prestige schools.

Objective. The purpose of this study was to discover correlations between trait anxiety and aggressiveness among adolescents in different types of educational institutions. At the same time, we were interested in manifestations of maladaptive perfectionism and destructive personality tendencies as revealed by quantitative and qualitative research methods.

Design. The first stage of the study was a survey to define risk groups for hostility and anxiety among the adolescents. All tests except the one for sociometry were done on an individual basis. The second stage included methods for qualitative analysis of personality. The pupils from identified risk groups were paid special attention. We were interested in the recurrence of destructive personality tendencies as they appeared in each method.

Results. About one third of all the participants from four out of the five schools formed the hostility risk group. In the prestige and non-prestige schools alike, hostile adolescents were more likely to find themselves at least somewhat isolated in their social group (class). Hostile teenagers have more self-esteem problems and issues with forming a Self-concept in general, as well as pronounced destructive personality tendencies in some cases. However, the pictures of trait anxiety in prestige and non-prestige schools were different. Hostile teenagers from non-prestige schools were more likely to greatly underestimate their intelligence and communication skills. In this case, according to the teachers' expert opinion and the results of participant observation, that assessment reflected the reality.

Keywords:

Aggressiveness;
hostility;
trait anxiety;
perfectionism;
destructive
tendencies of
personality

The hostile teenagers at the prestige educational institutions presented a different picture of trait anxiety. Objectively, the achievements of these pupils were great, but they constantly procrastinated, didn't believe in success, and had communication problems.

Conclusion. This study has shown that the markers of a pupil's maladaptive state are trait anxiety (school, interpersonal, self-esteem), hostility, and maladaptive perfectionism.

Introduction

The number of auto-aggressive manifestations among pupils, children, and adolescents has increased over the last years, resulting in deliberate self-injury, toxic substances overdose, etc. This phenomenon can be found in different kinds of educational institutions and educational systems. Non-suicidal auto-aggression can be in the form of deliberate and accidental self-injury, dissatisfaction with one's own body, and eating disorders. Each finalized suicide of a youth 25 years old or younger occurs after a number of auto-aggressive manifestations.

According to the Serbsky Center, suicide mortality in our country is about 1.5 times higher than murder mortality and almost two times higher than that from car accidents. The Serbsky Center reports that over the last 20 years, the frequency of suicides among young people in Russia has increased by three times, and among children and adolescents ages 5 to 14 years, by eight times (Federal State Statistics Service, 2009). Over the last 20 years finalized suicide in Russia has been recorded at more than 20 cases per 100 thousand people (Polozhy, & Vasiliev, 2014). As elsewhere in the world, the highest increase in suicide frequency has been recorded in the age group of 10 to 24 years old (Polozhy, & Vasiliev, 2014). But what are the psychological markers of such maladaptive behavior? Is their early detection possible?

Like A.M. Prikhozhan, we consider anxiety to be a stable personality trait with a pronounced adaptive nature (Prikhozhan, 2009). Children's anxiety is associated with defending their habitual impressions about themselves, self-esteem, and Self-concept. The Psychology Dictionary edited by A.V. Petrovsky and M.G. Yaroshevsky offers the following definitions for the above-mentioned terms: "Self-esteem is the assessment of oneself, one's potential, qualities, and place in society by a personality," (1990, p. 352) while Self-concept is an integral multilevel system of impressions a person has about himself/herself and about what he or she is doing (*ibid.*). Of course, as a component of Self-concept, self-esteem largely depends on a person's socio-cultural context. It is being defined and corrected continuously during communication and the usual course of life, *i.e.*, it's dynamic.

Thanks to a sense of self-esteem, a person can balance his or her resources for their purposes and tasks; this is how its regulatory function works. The self-esteem of anxious people is unstable and full of conflict; they don't believe in success. Moreover, anxious people often stick to a low self-concept because it allows them to avoid making uncomfortable choices: "I won't succeed anyway. There is no point in trying. I'm a loser." Anxiety becomes a psychological defense mechanism. At the same time,

a free-floating, generalized anxiety reflects an unrealized need for stable positive self-esteem. Thus, a neurotic vicious circle appears.

In our thesis research, we defined the risk group for school anxiety and maladaptation as follows: secure, inadequately anxious children. These children demonstrate high performance, and have good appearance and social status, but they manifest constant super-anxiety (Tarasova, 2015). On the one hand, a conflicted sense of self-esteem makes them strive for success. On the other hand, it causes constant doubts like “what if I haven’t achieved enough?” The real “self” never approaches the level of the ideal “self;” it demands infinite improvement up to psychophysical exhaustion and “giving-up.”

The physiological marker of such maladaptation is a high level of cortisol in spit samples (Tarasova, 2016). The risk group consistently includes 30-35% of all children and adolescents during this time in school. As both participant and consultancy observations have shown, these pupils are prone to auto-aggressive behavior, sometimes even to the surprise of their class teacher or their parents. We called this risk group “maladaptive perfectionists.”

One can differentiate between healthy and pathological, normal and neurotic, and adaptive and maladaptive perfectionism. Whereas adaptive perfectionism is a characteristic of a harmonious personality striving for success, maladaptive perfectionism doesn’t make a person feel happy about his or her achievements. In the academic literature this idea is reflected in the terms “normal vs. neurotic,” “healthy vs. pathological,” “positive vs. negative,” “self-oriented vs. socially prescribed,” and “destructive narcissism.”

This conceptual framework has, for example, been realized in the Slaney model (2001). According to Slaney, high personality standards and striving for order comprise adaptive perfectionism. Anxiety while completing tasks, the experience of non-conformity, failing to start an activity due to the fear of bad performance, emotional instability, and the resulting difficulties with interpersonal relationships characterize maladaptive perfectionism. A maladaptive form of perfectionism is manifested in ongoing attempts to convince oneself and society of one’s own success and to gain recognition and praise from significant other people, even at the cost of exhaustion. The essence of maladaptive perfectionism lies in fundamental insatiability. A teenager assigns unreal expectations of himself or herself to significant other people and strives to live up to them to buy acceptance and approval. The teenager’s ideal “self” never coincides with the real “self.”

The reason for such maladaptive forms of perfectionism lies in the phenomenon of conditional acceptance in a parent-child relationship (“I will love you, if you ... study well, clean your room, prepare tasty food ...;” “You will be good for me, if you ... are well-shaped, return home on time, enter a university...”). Conditional acceptance is a variant of educational practice, a family scenario leading to maladaptive perfectionism. Maladaptive perfectionism is related to auto-aggressive manifestations, including suicide (Hamilton, 2000; Miller, 2007; Hobgood, 2011; Roxborough, 2012; Kiamanesh, 2014; Hassan, 2014; Kiamanesh, 2015; Ventriglio, 2016; Limburg, 2017; Smith, 2018; Sommerfeld, 2019; Lucas, 2019; Galvez-Sánchez, 2019; Eskander, 2020; Luca Katzenmajer-Pump, 2021).

Now let's consider the notions of aggression and auto-aggression. We agree with S.N. Yenikolopov that aggression is a type of behavior aimed at doing physical or psychological damage or harm that goes against social standards, and brings on negative feelings, fear, and depression (Tarasova, Osnitsky, & Yenikolopov, 2016). Aggression may have an external as well as internal personality vector, and in this case, we are talking about auto-aggression (Psychology Dictionary, 1990). Hostility is a negative attitude towards other persons or a group of people that is manifested in the negative assessment of them. Both aggressiveness and hostility are factors in the propensity for aggressive behavior.

According to Freud's classical psychoanalysis, hostility and negative feelings can be redirected inward via the mechanism of introjection. In the 1960s, there was a suggestion to differentiate between hostility directed outward and hostility directed toward oneself (self-reproach, self-effacement, and depression). At the same time, as clinical studies have shown, depressed patients are often irritable and verbally aggressive. Nasty temper and emotional lability are characteristics of depression (Lemogne, 2011). There is good reason to suggest that hostility towards others and hostility towards oneself have the same root. Both aggressiveness and hostility are factors which lead to proneness to aggressive behavior. Attempts have been made to find biological markers for hostility (Suneson, 2019). In turn, anger is an emotion that can accompany both hetero- and auto-aggression. The correlation between anger and suicidal ideas has also been shown (Hawkins, 2013).

Thus, the markers of a teenager's maladaptive state are considered to be trait anxiety (school, interpersonal, self-esteem and/or magic), hostility, and maladaptive perfectionism. We hypothesized that in the risk group for self-esteem anxiety, the levels of aggression and hostility would positively correlate with the level of maladaptive perfectionism. The same adolescents can demonstrate auto-aggressive personality tendencies.

The purpose of the research was to find correlations between trait anxiety and aggressiveness among adolescents from different types of educational institutions. At the same time, we were interested in manifestations of maladaptive perfectionism and destructive personality tendencies as revealed by quantitative and qualitative research methods.

Method

Our method for studying the Self-image of teens in the age group of 12-17 years old (A.M. Prikhozhan) included the following factors: 1) *Behavior*, or how the teenager's behavior complied with adulthood's demands (according to self-report); 2) *Intelligence and position at school*, or the self-evaluation by the teenager of his or her own intelligence and school performance, as compared to the real situation in the class; 3) *Appearance and physical attractiveness* as factors of being popular among peers (according to self-report); 4) *Anxiety*, or self-evaluation of one's anxiety level; 5) *Communication*, or self-evaluation of communication skills; 6) *Happiness and satisfaction*, or feeling satisfied or dissatisfied with one's life situation; 7) *Family position*, or the teenager's satisfaction with his or her position in the family; and 8) *Self-confidence*, or the self-evaluation of one's self-confidence.

We used the following questionnaires to measure the students' personality traits:

- The Buss-Perry Aggression Questionnaire as adapted by S.N. Yenikolopov. The Russian-language version of this questionnaire consists of the following scales: 1) *Physical aggression* — self-report on one's behavioral tendency for physical aggression (behavioral component); 2) *Anger* — self-report on one's tendency for irritation (emotional component); and 3) *Hostility* — a scale consisting of two subscales, *Suspicion* and *Sensitivity to offense* (cognitive component).
- The APS-R Perfectionism Scale as adapted by S.N. Yenikolopov. The scales of the Russian-language version of the APS-R can be technically divided into those measuring healthy, adaptive perfectionism and maladaptive, neurotic perfectionism, which can be a risk factor for a number of mental disorders. *Adaptive perfectionism* leads to self-confidence, boosts self-esteem, and is reflected in concern for: *Standards* — measures one's pursuit of high personal standards in activities and life; and *Order* — reflects tendency to maintain order, be accurate, organized. *Maladaptive perfectionism* is characterized by *Non-conformity* (the key factor according to Slaney) — the feeling of being unable to adhere to self-established high standards. The scale measures the distress caused by the discrepancy between one's high standards and their achievement; *Relationships* — difficulties in interpersonal relationships as a consequence of too high standards and constant distress; *Procrastination/Anxiety*, where procrastination is the propensity for delaying, the inability to start doing something, and anxiety is caused by the inability or fear of not conforming to predefined high standards. This factor reveals such personal traits as emotional instability, dependency, anxiety, and the propensity to delay things. More details about the Russian-language adaptation of APS-R can be found in the article by Yasnaya and Yenikolopov (2013).

This study combines quantitative survey methods with qualitative semi-projective methods. We were interested in the recurrence of the destructive personality tendencies we found in the various surveys in the results of the projective methods. Such an approach allows cross-checking the results. We used the following projective tests:

- *Incomplete sentences*. This method was used to identify the participants' personal problems. The focus was on identifying destructive personality tendencies.
- *The Hand Test*. An interpretative projective technique used to interpret the meaning of hand poses for those surveyed. This has been used as a traditional pathopsychological technique of identifying meaningful needs, motives, and personality conflicts. The following criteria for assessment and further analysis have been identified: *Active and Passive response*, *Tension*, *Aggression*, *Direction*, *Communication*, *Exhibition*, *Dependence*, and *Crippled* (Semago, N.Ya., & Semago, M.M., 2016). Also, the test is aimed at defining *Aggression expectation* (Semago, N.Ya., & Semago, M.M., 2016).

- *Pathopsychological test*. This method was used for examination of the participants' mental activity and their adaptation potential.
- *Extended clinical conversation*. Gathering of the teens' psychological histories. These methods were used to examine the participants' social situations and their adaptation potential. In addition, we addressed relatives to gather psychological histories and thus to verify manifestations of destructive personality tendencies by the participants.
- *Torrance figurative subtests*. They were used to define the level of originality of thinking. Also, the figurative subtests were analyzed in the same way as projective drawing techniques.
- *Sociometry*. *Demand* — the number of positive choices in the class of the given child; *Isolation* — the number of negative choices; *Status* — the difference between positive and negative choices; *Satisfaction* — the number of mutual positive choices; *Tension* — the number of mutual negative choices; *Frustration* — the number of rejected positive choices; *Egocentrism* — the number of in-demand negative choices.

The subject and homeroom teachers were surveyed about the victims of bullying at their schools. Their expert opinion was compared to the results of the participant observation.

Methods of data analysis

We used methods of descriptive statistics for the analysis of the data. The correlation analysis (Spearman's rank correlation coefficient) and analysis of intergroup differences (Mann-Whitney U-test) were carried out.

The qualitative analysis of the meaningful needs, motives, and personality conflicts of the participants was done based on the results of the whole range of tests.

Participants

The research was carried out in five schools of different types: School 1 was a general secondary school in Dmitrov (comprised of so-called deviant classes); School 2 was a gymnasium in Dmitrov; School 3 — a rural school in Moscow region near Dmitrov; School 4 was a school with a focus on learning English in Moscow (located at Kutuzovsky Prospekt); and School 5 was a general secondary school in Moscow.

We defined schools 2, 4, and 5 as prestige, and schools 1 and 3 as non-prestige. The gymnasium selects children and adolescents with high aptitude, standard academic performance in main subjects, and good behavior. Children and adolescents from problematic families, and difficult teenagers whose parents or legal representatives are on the radar screen of Children's Services, are found in the so-called deviant classes. The total number of adolescents who participated in the research was 260, including 144 boys and 116 girls. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. The participation was voluntary. After the psychological tests, feedback was provided upon the request of children and their parents/representatives.

Procedure

The research consisted of two stages.

The first was a survey to define risk groups for hostility and anxiety among the adolescents. All tests except sociometry were done on an individual basis. They were planned taking into account the schedule of the school's qualification tests, to order to avoid an increase in state anxiety among the adolescents. Sociometry was carried out in a given social group (class).

The second stage included methods of qualitative analysis of personality. The pupils from identified risk groups were paid special attention. We were interested in the recurrence of destructive personality tendencies found in the first stage in the second.

Results

Below are the final results for the prestige and non-prestige schools (see *Tables 1 and 2*).

Table 1

The results of descriptive statistics on factors of propensity for aggression in prestige schools

Measures	Factors of the Buss-Perry method		
	Physical aggression	Anger	Hostility
Medium	22.98	19.33	21.80
Minimum	9.00	7.00	10.00
Maximum	41.00	31.00	40.00
Standard deviation	7.19	6.19	7.14
Median value	23.50	19.00	21.50
Mode	Multiple	Multiple	Multiple

Table 2

The results of descriptive statistics on factors of propensity for aggression in non-prestige schools

Measures	Factors of the Buss-Perry method		
	Physical aggression	Anger	Hostility
Medium	21.00	20.19	19.44
Minimum	14.00	10.00	11.00
Maximum	35.00	29.00	25.00
Standard deviation	5.34	5.04	4.44
Median value	19.50	19.50	20.50
Mode	19.00	19.00	25.00

In each school a risk group for hostility as a factor of propensity for aggressive behavior was identified. For this purpose, we divided pupils from every class into two contrasting groups according to the *Hostility* factor: one with an index of > 22 and

the other with an index of < 22 . The risk group accounted for 35% of the research participants in School 1, 17% in School 2, 26% in School 3, 31% in School 4, and 38% in School 5. As we can see, the number of highly hostile adolescents in School 2 — the gymnasium in Dmitrov — was relatively low, while in the rest of the schools, they comprised about one third of the research participants.

Then we analyzed the differences between the highly hostile (> 22 scores) and low hostile (< 22 scores) pupils using the Mann-Whitney U-test. The most significant differences were found in School 5, the general secondary school in Moscow. Highly hostile adolescents were more worried about non-conformity with their self-imposed standards ($p=0.0006$) and had more communication problems ($p=0.00007$) than low hostile teenagers. The procrastination level of the highly hostile teenagers was also higher ($p=0.00004$). Similar data was received in School 4 at Kutuzovsky Prospekt. Highly hostile adolescents were more worried about their non-conformity with self-imposed standards ($p=0.005$) and had more communication problems ($p=0.003$) than the teenagers with low hostility. This tendency was also seen in the gymnasium in Dmitrov. Highly hostile adolescents were more worried about non-conformity with their self-imposed standards ($p=0.056$).

We compared highly hostile adolescents from the three prestige schools. Taking into account the Bonferroni correction, the new critical level had to be $0.05/3 = 0.017$. Highly hostile pupils in the gymnasium in Dmitrov ($p=0.0013$) and in the general secondary school in Moscow ($p=0.00005$) had higher values of adaptive perfectionism than in the school at Kutuzovsky Prospekt. The level of procrastination in the Moscow school was higher too ($p=0.017$). On the perfectionism side, both schools — those in Dmitrov and in Moscow — didn't differ from each other.

In these three schools some statistically important correlations between the Buss-Perry method and APS-R Perfectionism Scale were identified (see *Tables 3, 4 and 5*).

Table 3

The results of the correlation analysis of the scale values from the aggression questionnaire and the perfectionism scale in the gymnasium in Dmitrov

Scales	Spearman's rank correlation coefficient		
	Physical aggression r	Anger r	Hostility r
Non-conformity	.31*	.49***	.63***
Relationships	n.s.	.41**	.55***
Procrastination / Anxiety	n.s.	.51***	n.s.

Symbols: n.s. — a non-significant value; symbols indicate the significance level: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$.

We can see slight differences between the schools, but in general the picture is similar. The school at Kutuzovsky Prospekt has a long tradition of focusing on success. The gymnasium in Dmitrov also has a long history with its own cherished traditions which, however, may be more associated with the achievements of their pupils.

Since 2007 the gymnasium in Dmitrov has been in the top 10 schools of the Moscow region by annual results. A similar picture is seen at School 5.

Table 4

The results of the correlation analysis of the scale values from the aggression questionnaire and the perfectionism scale in the school at Kutuzovsky Prospekt

Scales	Spearman's rank correlation coefficient		
	Physical aggression	Anger	Hostility
	r	r	r
Non-conformity	n.s.	.39**	.44***
Relationships	n.s.	n.s.	.43***
Procrastination / Anxiety	n.s.	n.s.	n.s.

Table 5

The results of the correlation analysis of the scales values from the aggression questionnaire and the perfectionism scale in the general secondary school in Moscow

Scales	Spearman's rank correlation coefficient		
	Physical aggression	Anger	Hostility
	r	r	r
Non-conformity	.28*	.31**	.46***
Relationships	n.s.	.36**	.51***
Procrastination / Anxiety	.27*	.28*	.52***

How are the results on adaptive and maladaptive perfectionism correlated with the components of Self-concept? The correlations appear in *Table 6*.

Table 6

The results of the correlation analysis of the Self-concept components and maladaptive perfectionism in prestige schools

Schools	Spearman's rank correlation coefficient		
	Non-conformity and self-assessment of the school situation	Non-conformity and self-assessment of appearance	Non-conformity and self-assessment of communication skills
	r	r	r
School 2	-.45***	-.26*	n.s.
School 4	-.48***	-.29*	-.44***
School 5	-.42***	n.s.	-.39**

However, the strongest correlations between the components of Self-concept and perfectionism were found in School 2, *i.e.*, in the gymnasium in Dmitrov (see *Table 7*).

Table 7

The results of the correlation analysis of the Self-concept components and maladaptive perfectionism in the gymnasium in Dmitrov

Scales	Spearman's rank correlation coefficient		
	Order (adaptive perfectionism scale)	Interpersonal relationships	Procrastination/Anxiety
	r	r	r
Behavior	.64**	-.62*	-.70*
Intelligence	.54*	-.72*	-.74***
Situation at school	.62**	-.74***	-.76***
Appearance	.53*	n.s.	n.s.
Anxiety	-.70**	.73***	.76***
Communication	.66**	-.53*	-.69*
Happiness and satisfaction	.61**	-.58*	-.62*
Family situation	n.s.	-.59*	n.s.
Self-confidence	.66**	n.s.	-.48*

As these results show, almost all the components of Self-concept were crucial for self-esteem anxiety among the gymnasium students.

We then decided to look at the percentages within the trait anxiety risk group. We calculated the number of teenagers from the risk group expressing the *Anxiety, self-assessment of the anxiety level*, factor from the Self-concept research method for the 12-17 age group by A.M. Prikhozhan. For this purpose, we divided the pupils from every class who expressed the *Anxiety, self-assessment of the anxiety level* factor into two contrasting groups: one with scores of > 8 and the other with scores of < 8 (Prikhozhan, 2009. Appendix 10). The study showed that there were no pupils in the gymnasium who had both a high level of emotional well-being and a low level of adaptive anxiety. In the other schools the number of teenagers from the risk group varied from 16% to 20%.

Some interesting gender differences were identified among the gymnasium students. Girls were more anxious than boys as measured by the Procrastination/Anxiety scale ($p = 0.01$). Girls also had higher levels of anger ($p = 0.02$). This can be explained by the fact that, starting from the 5th grade, when pupils are distributed according to their specialization, classes come onto the school administration's radar screen. Participant observation and conversations with teachers showed that the levels of anxiety among teachers at this school are also very high. The teachers have a strong focus on performance and thus give a lot of tests. In this context, the Spielberger trait anxiety questionnaire was added to those given at the gymnasium in Dmitrov. Although we tried to take into account the school test schedule in order to exclude the increase of situational anxiety as much as possible, most of the research participants showed the high level of anxiety (72%). Also, none of the gymnasium classes which participated in the research contained pupils with the low level of anxiety. Girls were much more anxious than boys, according to the Spielberger test ($p = 0.002$).

Consider this case from the gymnasium: a 14-year old girl with the highest scores on the non-conformity scale on the perfectionism questionnaire. This score means she doesn't measure up to her own high personality standards. Her difficulties with interpersonal relationships as a result of too high standards are also high. According to her scores on the *Anxiety* scale of the Prikhozhan questionnaire, this girl falls into the risk group (borderline state, *i.e.*, neurotization level; negative level of self-attitude).

In addition, her non-conformity to her own standards is seen in her incomplete sentences test. Some examples: "It's better for me to study with people of the same knowledge level as mine;" "The teachers at school underestimate my skills;" "People I study with are too intelligent;" "I think my dad rarely can be attentive;" "I would have been very happy, if I had been more myself when communicating with others;" "In comparison to most of other families my family is too religious;" and "When I was a child, I believed in God too much." Her hand test results also revealed high values for the *Anxiety* and *Aggressiveness* criteria, and a high level of expectation of aggressive behavior was determined. It should be added that if we analyze her Torrance figurative subtest as a projective drawing technique, we can see clear hatching and blackening. This is an indirect characteristic of a high level of anxiety, or neurotization.

We did not administer the perfectionism survey at the rural school and in the deviant classes because the pupils found the questions too complicated. Correlations for other psychological characteristics were found, however. In the general secondary school (School 1) the levels of physical aggression negatively correlated with self-assessment of one's behavior as normal ($r = -0.54$, $p < 0.05$). Hostile teenagers more often assessed their own intelligence ($r = -0.58$, $p < 0.05$) and communication skills ($r = -0.77$, $p < 0.001$) at a low level. In this case the assessment reflected the reality: according to the expert opinion of the teachers and sociometry results, hostile pupils are isolated in their social group (class) ($r = 0.52$, $p < 0.05$).

Similar results were gotten at the rural school (School 3). Hostile teenagers were more often not self-confident ($r = -0.63$, $p < 0.05$). The pupils who lacked self-confidence assessed their intelligence at a low level ($r = 0.68$, $p < 0.05$). As in the general secondary school in Dmitrov, in this case the assessment reflected reality: hostile pupils are isolated within the social group (class) ($r = 0.69$, $p < 0.05$). Therefore, hostile adolescents in the rural and the so-called "deviant" schools more often had self-esteem problems and were isolated in their social group (class). The crucial factors were intelligence, appearance, family situation, and happiness.

Previously we identified the pupils who fall into hostility risk groups by using survey methods. Now, we found that the same teenagers demonstrated destructive tendencies in the pathopsychological test, the hand test, the Torrance figurative subtest, and the participant observation data. Therefore, the qualitative analysis methods confirmed the survey methods.

Take the case of F.M., a boy from the 8th grade at the rural school, who is in the risk group for hostility and aggressiveness (having scored the highest values on the Buss-Perry Questionnaire). This teenager breaks all rules and was the object of constant complaints from his teachers and classmates. He heated his house key with

a lighter and scorched classmates with it. The teachers also noted that F.M. often brought sharp and cutting things to the school and walked around with a razor blade in his mouth.

His social situation was as follows: F.M. lives with his mother, her father-in-law, and a younger sister. He doesn't have contact with his biological father. According to the teachers, F.M. suffered a family tragedy two years ago. The boy and his younger brother decided to play snowballs at home. They crumpled paper imitating snowballs. The boys were overwhelmed by the game when one of the "snowballs" fell behind the microwave. There was an electrical short and the paper went up in flames. The younger brother rushed up the stairs to call for the mother, who was upstairs with the boys' younger sister. She ordered the two younger children to stay in the room and went down to fight the fire. She didn't succeed, and the house got engulfed by flames. Since she was pregnant, she realized that she needed to get out of the house immediately, pushed out F.M., and got out herself. The two younger children died in the fire. After the accident she blamed F.M. for a long time.

F.M.'s hand test results showed that aggressive and dominant tendencies in F.M. dominate his social cooperation mindset. This also means a high level of hostility. Here are the examples of his answers in the hand test: "The man is killed, like that, into the Adam's apple;" "A torch and a man in the dark, it's raining. The buddy got out of the house and followed the victim. He is a maniac; he will kill the first one whom he meets. But not a child — a man or a woman, no difference;" "Somebody is sleeping or dead. She has cut her veins, a suicider. Somebody offended her, she came home, took a knife, cut her veins, and died;" "A kid goes up the crane. He is completing a task from the Blue Whale challenge."

The death theme was also present in his incomplete sentences test. For example: "I would do everything to forget the fire;" "I would have been much happier if not for the fire;" "My dad rarely was at home;" "Hope for death;" "If everybody is against me, I hit them." During the conversation he admitted to playing "kill yourself" and the Blue Whale challenge. The boy said that he had completed tasks from these games: he ran between two heavy-duty trucks and climbed up the crane to receive money for that.

It should be noted that analysis of the Torrance figurative subtest can be used as a projective test. Analyzing the Torrance figurative subtests as projective techniques may reveal destructive personality tendencies.

As shown above, there is not much difference between the pictures of anxiety and aggressiveness in the rural and so-called deviant schools. Also, no statistically meaningful difference was found between urban and rural schools for aggression and self-esteem anxiety indicators. However, in the rural school the positive assessment of the school situation by the pupils tended to be higher ($p = 0.05$). This may be related to the rural area being less developed in terms of entertainment and technology, so-called digitalization. For adolescents from a small village, a school is one of the important places where they can communicate with friends, take part in different events, and "have a rest from home and parents." The educational process doesn't imply the use of computers and the Internet. Therefore, the school is perceived by pupils not only as a place where they get knowledge, but also as a social circle.

At the same time, pupils from the urban schools are exposed to higher requirements in terms of technical support of the educational process. New school technologies require pupils to have Internet access, and are used to monitor tasks, and transmit homework, news, and test scores in electronic form. This results in less face-to-face communication. Teachers are unable to pay sufficient time and attention to the adolescents because of the avalanche of paperwork. That's why pupils from the urban school don't see the school situation as satisfactory; they don't get adequate attention and communication at school, which is so much needed at their age. According to the participant observation, a mobile phone is used more actively in an urban school than in a rural school. We can probably talk about the side effects of digitalization for the psychological and personality health of adolescents.

According to the results of the sociometry in the prestige schools (schools 2, 4 and 5), the Buss-Perry results were correlated with the sociometric index *Isolation* (from $r = 0.24$ to $r = 0.27$ if $p < 0.05$).

Discussion

To sum up, in both the prestige and non-prestige schools alike, the more hostile teenagers were isolated in their social group (class) to a greater or lesser degree. In addition, they had problems with self-esteem and in forming their Self-concept in general, as well as pronounced destructive personality tendencies in some cases. However, the pictures of a pupil's self-esteem from a prestige school and a non-prestige school were different. The teenagers from the hostility risk group in the non-prestige schools assessed their intelligence and communication skills at a low level. In this case, according to the teachers' expert opinion and the participant observation data, the assessment corresponded to reality. In the prestige educational institutions, we observed a different picture of self-esteem anxiety. Objectively, the pupils' achievements were great, and even brilliant, but the teenagers constantly procrastinated and didn't believe in success, which led to communication problems with peers and adults.

The maladaptive perfectionism phenomenon has its roots both in the family and in society in general. By teen age, standards and settings established by the family will have been interiorized. Normally, adaptive perfectionism should have been formed, namely, a tendency to be accurate and organized, take adequate responsibility, and have a harmonious self-image. Teenagers from neurotic families develop maladaptive perfectionism when they feel that they don't live up to their own standards. Their inability to meet self-established high standards leads to and maintains a high anxiety level.

We shouldn't forget the cult of success in modern society, including in relation to appearance. Non-conformity to an "ideal" image may be the reason for bullying. The media and Internet play critical roles in this, since their influence combines with the already aggravated teenage crisis. Teenagers are not free of maximalist conceptual mindsets and are more conformable than adults. The imposition of standards, such as the ideal body standards, leads to eating disorders. In this case, self-esteem anxiety and maladaptive perfectionism become intermediating factors for the pupils' maladaptive behavior.

The imposition of unrealistic standards may also take place in the real world, but on the Internet the tendency is less controlled by parents, even if they have a positive emotional connection with their children. In addition, there is power in the printed word. The Internet makes it possible to form and establish a social identity based on personality traits that clinical psychologists usually characterize as pathological. A wide diversity of online communities opens the door for overindulgence in self-expression by socially marginal and clinically pathological personalities. In turn, pathological posts act as magnets for attention. Teenagers, as is well known, have idols, and these are usually not their parents. Therefore, it is very important that idols like Billie Eilish show a psychologically sound and harmonious self-image.

We can thus identify some negative side effects of digitalization for the psychological and personality health of adolescents. First, there is the Blue Whale challenge. The Internet is the place where young people encounter stories and talks about suicide, and such influence, especially in the form of discussion clubs, fosters suicidal thoughts. Second, adolescents can strive for digital distraction from anxiety and distress arising from their live communication with peers. Regulation of emotions is an important skill that develops in childhood and adolescence, when people learn how to deal with strong emotions by recognizing them and developing inner regulatory processes. Psychological theory has widely admitted that regulation of emotions is an important component of mental health, while any problems with it lead to different psychopathological disorders, including depression. If a person escapes from live communication to living on the Internet, he or she will never learn how to communicate in real space.

Time spent online displaces face-to-face communication. A vicious circle forms. For these people such displacement of interpersonal communication with network communication, carried out in order to escape threatening situations, can be cyclically reinforced, and this makes a person even more isolated and anxious. Thirdly, there is the anxiety arising as a result of fear of not being “online.” Social media (text and instant messages, email) have become the main methods of communication for most adolescents, and interruption of such networks can heighten the level of anxiety. When a teenager doesn’t receive a response to his or her message, he or she can feel the fear of being rejected.

Seven pupils from the identified risk group for hostility were the most isolated in the class. According to the results of participant observation, their psychological histories, and the teachers’ expert opinions, these same seven pupils were the victims of bullying and cyberbullying. In this study we didn’t focus on bullying and cyberbullying, but other research we have carried out has shown that victims of bullying have similar characteristics: they are stably and highly hostile and highly anxious, and have problems with self-esteem (2016). There is danger of their victimization as well as of the victim turning into an aggressor in the future.

This result corresponds to the results of other studies. Researchers have shown a correlation between maladaptive perfectionism and suicide risk among children and adolescents, with the intermediating factors being bullying and social despair (Roxborough, 2012).

Cyberbullying, like conventional bullying, rapidly becomes part of our life. (Juvonen, 2008; Kowalski, 2014; John, 2018). Previous and current experiences of traditional humiliation are associated with both the victims and performers of cyberbullying.

Cyberbullying can be worse than bullying. According to some data, the prevalence rate of cyberbullying ranges from 6% to 35-40% (Aboujaoude, 2015). In one study, where participants were picked from a popular website, the prevalence rate was significantly higher — 72% (Juvonen, 2008). Bullying on the Internet usually takes place in late teenage, starting from 14 years old, when pupils spend more time on their smartphones and social media. It is reinforced by Internet usage for more than three hours per day, the use of messaging, web-cameras, posting personal information, etc. Cyberbullying can reach more people than traditional acts of humiliation because it takes place in cyberspace, which has weakened or no social control. Those guilty of cyberbullying also have a degree of anonymity that is impossible in traditional acts of humiliation, and the potential suffering and embarrassment of a victim is more pronounced. One can bully a classmate in his or her own house or in any other place at any time, and even if he or she deletes the profile, messages are often accumulated and read by a wide audience. Besides, it is not easy to just delete information from the web.

Cyberbullying is a proven predictor of suicidal behavior among adolescents. Victims of cyberbullying and humiliation at school have higher risks of suicidal thoughts, plans, and attempts. For example, in the Zaborskis survey, 39% of adolescents reported that over the past year they had been experiencing emotions that hindered their ordinary course of activities; 18% of adolescents had considered a suicide attempt; 12% of adolescents had drawn up a suicide plan; and 9.5% of adolescents had attempted a suicide (Zaborskis, 2019). Victims of humiliation often have mental health problems, shown by depression symptoms, self-injury, and suicidal behavior (Krešić Ćorić, 2020). Thus, cyberbullying poses a serious risk to pupils' mental health.

Even in the face of these results, it is important to admit that the social character of the Internet also makes it an effective resource for psychotherapeutic support. Active participation in online support groups can potentially result in lower stress because it provides wider access to helpful messages. The nature of the influence of the Internet on behavior depends on the particular information to which access is provided and on the people with whom one is in contact. To sum up, there is an ongoing process of adaptation to these new technologies, and, thus, the side effects of civilization that bring both the positive and negative with it.

Whatever the reason for teenage anxiety and maladaptation, professional psychological assistance is highly recommended. For example, schools have to engage clinical psychology experts to solve such problems.

Conclusion

1. Our empirical study has shown that the markers of a pupil's maladaptive state are trait anxiety (school, interpersonal, self-esteem), hostility, and maladaptive perfectionism.

2. Schools with a selection principle of admission have been traditionally called prestige schools. In prestige and non-prestige schools alike, hostile teenagers were more often isolated in their social group (class) to a greater or lesser degree. They had problems with self-esteem and in forming their Self-concept in general, as well as pronounced destructive personality tendencies in some cases. However, the pictures of a pupil's trait anxiety from a prestige school and a non-prestige school were different. Hostile teenagers from non-prestige schools more often assessed their intelligence and communication skills at a low level. In this case, according to the teachers' expert opinion and the participant observation data, that assessment corresponded to reality.
3. In the prestige educational institutions, we observed a different picture of trait anxiety. Objectively, the pupils' achievements were great, but the teenagers constantly procrastinated, didn't believe in success, and had communication problems.
4. About one third of the research participants (from 26% to 38% in different classes) from four out of the five schools fell into the hostility risk group. According to the results of the pathopsychological test, the hand test, the Torrance figurative test, and the participant observation data, the same teenagers demonstrated pronounced destructive tendencies.

Limitations

This research has been restricted by a relatively small number of participants. We tried to offset this by carrying out pathopsychological tests with the research participants from the risk groups for hostility and aggressiveness.

Ethics Statement

All subjects gave their informed consent for inclusion before they participated in the study. Parents and legal representatives gave their written consent for the psychological tests. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Psychological Institute of Russian Academy of Education (Project identification code 05-4/19. 2019 May 16)."

Informed Consent from the Participants' Legal Guardians

Written informed consent to participate in this study was provided by the participants' legal guardians/next of kin. After the psychological tests, feedback was provided upon the request of children and their parents/representatives.

Conflict of Interest

The authors declare no conflict of interest.

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Two Generations of Mother-Child Relationships: A Self-determination Theory Analysis of the Social Situation of Development

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Background. This study used self-determination theory to examine the intergenerational continuity of the social situation of development with a focus on what determines a woman's basic psychological need support for her child.

Objective. To assess the relationship between the basic need support a woman received from her own mother, the woman's basic need support toward her own child, and the quality of the woman-child interaction.

Design. The scales, "Parent-child interaction" and "Basic Psychological Needs," were administered. Eighty-seven women (29-40 years old) with children age 4-5 years assessed the basic need support provided for them by their mother in childhood and at present, and her estimate of the basic need support she herself provides to her own child. Analyses included descriptive statistics, Wilcoxon signed-rank tests, factor analysis, and multiple linear regression.

Results. The ratio of levels of basic need support demonstrated continuity across generations. Intergenerational continuity in the child's basic need support mainly concerns the needs for competence and relatedness: the more they were supported in childhood and are now supported by the woman's mother, the more the woman supports them in her own child today. Such continuity was not found for autonomy support. A woman's own basic need support by her mother, in childhood and currently, and the woman's provision of basic need support for her child predicted most of the woman-child interaction parameters.

Conclusion. Intergenerational continuity with respect to provision of basic need support was shown. The woman-child interaction was predicted by basic need support across intergenerational relations.

Keywords:

Social situation of development; parent-child interaction; intergenerational continuity; basic psychological needs; basic need support; self-determination theory (SDT)

Introduction

Research problem

The concept of the “social situation of development” is one of the central concepts pertaining to age-related development in the Cultural-Historical theory of L.S. Vygotsky (1984). It has become an alternative to the concept of “environment” and denotes the entire completeness and uniqueness of the child’s relationship with the world at every stage of their development. The structure of the social situation of development includes such components as the child’s place in the system of relationships, the attitude of the environment towards the child, the attitude of the child to those around them, and their attitude toward their place in the relationship system. Despite the theoretical, heuristic nature of this concept, further development of the methods of its theoretical and empirical analysis is necessary.

In psychology, the attitude of the parents to the child, as a component of the social situation of development, is most actively investigated (Smirnova, 2017; Sobkin et al., 2016); the attitude of the child to the parents is somewhat less studied (Markovskaya, 2007). At the same time, research results are rarely generalized to characterize a holistic social developmental situation. Among the determinants of parental attitudes towards a child, the most often considered are the individual characteristics of the parents, and the individual characteristics of the child, including the child’s state of health.

Self-determination theory offers a framework for analyzing the social situation of development by exploring parental support for the child’s basic psychological needs, or, more briefly, basic needs. There has been substantial empirical support for the claims of self-determination theory (SDT) regarding the importance, for the child’s psychological well-being and healthy development, of support by the proximal environment for the child’s basic psychological needs for autonomy, competence, and relatedness (Ryan & Deci, 2017; Vasquez, Patall, Fong, Corrigan, & Pine, 2016). A look at the social situation of development through the prism of basic psychological needs and their support provides a rich portrait for analysis. In turn, research on intergenerational continuity can be an effective way to uncover the factors that influence the ability of adults to provide basic need support to the child, with respect to the needs for autonomy, competence, and relatedness. The Vygotskian notion of the social situation of development makes it possible to substantiate, theoretically, the existence of such continuity. The child, interacting with the environment, masters not only symbolic means as internal tools of mental functions, but also internalizes the entire drama of relationships in which these means were included (Vygotsky, 1983).

The key role of the mother-child relationship in the formation of the child’s personality is widely known. At the same time, little is known about what exactly determines a woman’s ability to provide basic need support for her child. Perhaps this support depends on the extent to which the woman’s own mother supported her basic psychological needs during childhood, and the extent to which she continues to do so today. Psychologists have shown the transferability of parental behavior patterns

from generation to generation (Bailey, Hill, Oesterle, & Hawkins, 2009), although the main focus has been on the transmission of maladaptive parenting strategies (Seay, Jahromi, Umaña-Taylor, & Updegraff, 2016). We assume that positive basic need support for a child's needs for autonomy, competence, and relatedness can also be passed on from generation to generation, specifically, that the basic need support a woman received and currently receives from her own mother, has an influence on her interactions with her child. Until now, there have been no studies in Russia, based on SDT, on the continuity or intergenerational transmission of basic need support towards a child.

In psychology, ever since the work of Freud, much attention has been paid to the attitude of parents toward their children. It is known that the relationship between parent and child greatly influences many characteristics of the child. In particular, much attention has been paid to the study of negative and traumatic influences. Such studies do not lose their relevance at the present time. Researchers have shown intergenerational continuity in antisocial behavior (Thornberry, Freeman-Gallant, Lizotte, Krohn, & Smith, 2003) and in the use of psychoactive substances (Bailey et al., 2009). Yet, some scientists have shown that the influence of parents on child development is not as unambiguous as earlier researchers assumed, but is also not as insignificant as modern critics argue (Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000).

Continuity of generations in the way a parent interacts with a child

An earlier generation, consciously or unintentionally, psychologically influences the parenting attitudes and behavior of the next generation (Van Ijzendoorn, 1992). For example, there is a significant correlation between mothers and grandmothers in the use of physical punishment and material rewards (Covell, Grusec, & King, 1995).

Studies on the transmission of negative parenting practices such as harsh parenting (Simons, Whitbeck, Conger, & Chyi-In, 1991), aggressive and hostile parenting (Conger, Neppl, Kim, & Scaramella, 2003; Hops, Davis, Leve, & Sheeber, 2003; Scaramella & Conger, 2003), child abuse (Seay et al., 2016), tight parental control and discipline (Bailey et al., 2009), and conditional regard (Assor, Roth, & Deci, 2004), have shown that poor parenting practices are transmitted through generations of parents and children, and that this has a mediated effect through the development of antisocial and delinquent behavior in the child by the time of adolescence (Capaldi, Pears, Patterson, & Owen, 2003). Even the high quality of the current relationship between caregivers does not eliminate such negative effects (Belsky, Youngblade, & Pensky, 1989).

The emphasis on the study of the transmission from generation to generation of destructive models of parental attitude to the child, naturally led to the question of how this also applies to positive models of behavior. Indeed, research has shown the intergenerational continuity of constructive parenting (Chen & Kaplan, 2001). Not only has the continuity of a positive relationship been investigated, but also its mech-

anisms (Neppl, Conger, Scaramella, & Ontai, 2009; Prokhorov, Chernov, & Yusupov, 2015), and the role of other circumstances and mediators in explaining continuity and influencing the magnitude of its effect between generations (Belsky, Sligo, Jaffee, Woodward, & Silva, 2005; Schofield, Conger, & Neppl, 2014).

Parental support for the basic needs of the child and the child's well-being

Parental basic need support is essential for the child's effective development and well-being. In self-determination theory (SDT), there is substantial evidence of this for children of different ages. Supporting a child's basic needs has a positive effect on the child's psychological health, academic performance in school, behavior, etc. When basic need support (from the parent) leads to basic need satisfaction (in the child), this need satisfaction mediates between the child's perception of psychological control and the internalization of distress. Moreover, parental psychological control has been found to be a better predictor of distress internalization than low parental autonomy support (Costa, Soenens, Gugliandolo, Cuzzocrea, & Larcán, 2015).

SDT pays special attention to supporting the need for autonomy. Moreover, it is important to distinguish support for autonomy, from the promotion of permissiveness or independence (Ryan & Deci, 2017). Many authors present studies that examine how parental support for autonomy, as one of the basic needs recognized in SDT, contributes to the healthy development of children of different ages (Joussemet, Landry, & Koestner, 2008). Maternal support for autonomy contributes to the development of autobiographical narrative skills in children (Leyva, Reese, Grolnick, & Price, 2008). When parents are perceived by their children as autonomy-supportive, children more highly rate their satisfaction of talking to the parent about shared memories (Van der Kaap-Deeder, Soenens, Mouratidis, De Pauw, Krojgaard, & Vansteenkiste, 2020). Support for the adolescent's autonomy by her mother predicts increased emotional integration and decreased suppressive regulation in adolescents (Brenning, Soenens, Petegem, & Vansteenkiste, 2015).

SDT is also used in intervention and corrective practices to improve the effectiveness of parenting, by helping parents to be more consistent in providing basic need support for their children. Several studies show that SDT-based intervention programs are effective (Allen, Grolnick, & Córdova 2019). By helping parents to support the child's psychological needs for autonomy, competence, and relatedness, such programs help increase the child's autonomous self-regulation (i.e., their ability to internally self-regulate), and consequently reduce behavior problems in children (Grolnick, Levitt, Caruso, & Lerner, 2021).

Cross-cultural differences in parental basic need support

Cross-cultural research confirms the universality of basic psychological needs and the positive impact of their satisfaction on the well-being and healthy development of the child (Chen et al., 2015; Ryan & Deci, 2017). For example, a study conducted

in Japan found that when fathers had relatively high goals in life, both fathers and their teenage children experienced greater satisfaction of basic psychological needs (Nishimura, Bradshaw, Deci, & Ryan, 2021). Supporting basic psychological needs affected the life aspirations and psychological well-being of South African 16 year-old students (Roman et al., 2015).

At the same time, researchers have also identified some cultural differences. For example, supporting the need for autonomy has been associated with positive outcomes among adolescents, but this link in collectivist cultures is unclear, as manifested when comparing adolescents from the United States and Ghana (Marbell-Pierre, Grolnick, Stewart, & Rafferty-Helmer, 2019). In a survey of Russian subject-matter teachers, kindergarten teachers, pedagogical psychologists, and managers of education departments, the need for autonomy was valued less compared to the needs for relatedness and competence (Lynch & Salikhova, 2016; see also Lynch, in press).

Generational continuity in basic need support by the parent

Little research has been done on intergenerational continuity in the provision of basic need support, but there is evidence that it exists. Costa et al. (2019) showed that parents who have experienced high levels of basic need support from their own parents tend to provide more support for the need for autonomy in their relationships with their children. Conversely, if parents experienced a high level of frustration of their own basic psychological needs during childhood, then they were more likely to use psychological control and cause feelings of need frustration in their children (Costa, Gugliandolo, Barberis, Cuzzocrea, & Liga, 2019). The mother's perception of parental experience (in the family of origin) has been shown to be associated with the self-reported use of psychological control by mothers during early childhood (Brenning, Soenens, Van der Kaap-Deeder, Dieleman, & Vansteenkiste, 2020), and there is evidence of generational transmission of parental conditional regard, as well (Assor et al., 2004). We note here that control and conditional regard are considered, from the perspective of SDT, to be parenting strategies that are antithetical to support for the child's basic needs, in particular, the need for autonomy.

Purpose and hypotheses of the current study

The aim of the study was to reveal whether there is intergenerational continuity of the social situation of development with respect to basic need support for the child. Based on self-determination theory, we made the following predictions:

Hypothesis 1 (H1): The level of basic need support that a woman receives from her mother, and that she provides to her own child in the present, are similar.

Hypothesis 2 (H2): A woman who herself experienced basic need support from her mother, both in childhood and at present, will be more likely to provide basic need support to her own child.

Hypothesis 3 (H3): The nature of the woman's interaction with her child in the present will be predicted by the child's basic need support across intergenerational systems.

Methods

Participants

This study involved 87 women 29–40 years old ($M = 34.7$, $SD = 3.1$). All women live in Nizhny Novgorod (Russia) and belong to the ethnic majority (Russians); 82% had higher education, and 18% had specialized secondary education. The majority (93%) had a job; 7% indicated that they were housewives. Each woman had a child age 4–5 and her own still-living mother, with whom the woman was currently interacting.

Measures

“Basic Psychological Needs Scales”

(La Guardia, Ryan, Couchman, & Deci, 2000)

This measure contains nine questions that together determine to what extent, in the context of a particular interaction, a person perceives their need for support for: autonomy (3 items, α 's ranging from .59 to .71); competence (3 items, α 's ranging from .61 to .78); and relatedness (3 items, α 's ranging from .64 to .76). Items were scored on a scale of 1 (completely inaccurate) to 7 (completely accurate). A high cumulative score on each scale indicates greater support for the corresponding need. Sample items include: “When I am with my mother, I feel free to be who I am” (autonomy); “When I am with my mother, I feel very capable and effective” (competence); and “When I am with my mother, I feel a lot of closeness and intimacy” (relatedness).

“Parent-child interaction” (Markovskaya, 2005)

This measure assesses 10 parameters of a woman's interaction with her child: “undemanding — exactingness” (5 items, Cronbach's $\alpha = .69$); “softness — strictness” (5 items, Cronbach's $\alpha = .67$); “autonomy — control in relation to the child” (10 items, Cronbach's $\alpha = .63$); “emotional distance — emotional closeness of the child to the parent” (5 items, Cronbach's $\alpha = .72$); “rejection — acceptance of the child by the parent” (10 items, Cronbach's $\alpha = .77$); “lack of cooperation — cooperation” (5 items, Cronbach's $\alpha = .74$); “disagreement — agreement” (5 items, Cronbach's $\alpha = .61$); “inconsistency — consistency” (5 items, Cronbach's $\alpha = .63$); “parental authority” (5 items, Cronbach's $\alpha = .80$); and “satisfaction with the relationship” (5 items, Cronbach's $\alpha = .71$). Items were scored on a scale of 1 (no, absolute disagreement) to 5 (undoubtedly yes, very strong agreement). Higher scores on the first eight scales correspond to the right pole of these scales and, for the last two scales, to a greater extremity with respect to the measured parameters.

Procedure

This study was conducted in a kindergarten. The women took part in the study because they were interested in receiving feedback from a psychologist. Each participant was provided with the results of their own scale scores, and the interpretation of the results was explained to them during a specially-organized lecture.

Participation was voluntary, with no compensation, and anonymity was guaranteed. All participants gave verbal consent to the use of their data in anonymized form for the purposes of scientific research. All measures were taken at the same time.

Each woman who participated in the study responded to items on the “Basic Psychological Needs Scales” scale three times, with respect to three different relationship contexts. Specifically, we obtained three indicators of support for autonomy, competence, and relatedness, once for each of three different relationship systems. First, each woman assessed how her mother supported her basic needs in her childhood (Woman – Her Mother – Childhood system, abbreviated W_HM_Ch), yielding indicators of support for autonomy (A_W_HM_Ch), competence (C_W_HM_Ch), and relatedness (R_W_HM_Ch). Second, each woman assessed how her mother was providing basic need support to her at the present time (Woman – Her Mother – Now system, or abbreviated W_HM_Now), which yielded indicators of support for autonomy, (A_W_HM_Now); competence (C_W_HM_Now); and relatedness (R_W_HM_Now). Thirdly, she answered from the perspective of her child and assessed how she herself provided basic need support to the child, from the point of view of her child (Woman – Baby – Now system, or abbreviated W_B_Now), and these yielded indicators of support for the child’s autonomy (A_W_B_Now); competence (C_W_B_Now); and relatedness (R_W_B_Now). Then each woman responded to items on the “Parent-child interaction” scale.

Data analysis

First, a factor analysis of basic need support in all studied relationship systems (W_HM_Ch, W_HM_Now and W_B_Now systems) was carried out. The purpose was to analyze whether a woman, answering the same questions for three different systems of relationships at the same time, distinguished these systems from each other.

Then, using descriptive statistics and the two-samples paired Wilcoxon test, we compared, first, basic need supports within each of the relationship systems, and secondly, basic need support across different relationship systems, in order to test Hypothesis 1 (H1).

Finally, we used multiple linear regression to examine, first, the extent to which basic need support by her mother now and in childhood was a predictor of a woman’s support for the basic psychological needs of her child (H2); and secondly, to what extent basic need support in all studied systems of relations was a predictor of the parameters of child-parent interaction between a woman and her child (H3). Before carrying out multiple linear regression, using the curve estimation procedure, functions were determined that optimally approximated the relationship between the independent and dependent variables of the models.

Results

The results of factor analysis are presented in *Tables 1* and *2*. Principal components analysis (rotation method: direct oblimin) makes it possible to assert greater similarity between variables within one system of relationships than between systems: three automatically-generated factors coincided in their content with the three systems of relationships we are considering (see *Table 1*). Moreover, the scores of the basic need support items in the relationship of a woman with her mother now and in childhood, according to the interfactor correlation matrix, turned out to be more similar than they were with the child's need support scores (see *Table 2*). This suggests that the participants, when completing items with respect to the various targets, clearly distinguished the systems of relationships they assessed.

Table 1

Factor loading matrix of basic need support in various systems of relationships (method of principal components, rotation method — direct oblimin with Kaiser normalization)

	Factors		
	Factor 1 (W_HM_Now)	Factor 2 (W_B_Now)	Factor 3 (W_HM_Ch)
C_W_HM_Now	0.900	0.065	0.000
A_W_HM_Now	0.880	-0.070	0.052
R_W_HM_Now	0.650	0.083	-0.378
A_W_B_Now	0.058	0.878	0.190
C_W_B_Now	-0.223	0.844	-0.166
R_W_B_Now	0.301	0.651	-0.144
A_W_HM_Ch	-0.139	-0.061	-0.940
C_W_HM_Ch	0.071	0.113	-0.847
R_W_HM_Ch	0.297	0.015	-0.699
Percentage of variance	44.7%	17.3%	14.4%

Note. Factor solution explains 76.4 % of variance. The factor loadings that are most closely related to components are highlighted in bold.

Table 2

Correlation matrix of components

	Factor 2 (W_B_Now)	Factor 3 (W_HM_Ch)
Factor 1 (W_HM_Now)	0.200	-0.326**
Factor 2 (W_B_Now)		-0.265*

Note. * $p < 0.05$; ** $p < 0.01$.

Comparison of measures of basic need support are presented in *Table 3*.

Table 3

Comparison of measures of basic need support

System of relationships	Autonomy	Competence	Relatedness	Friedman test		Comparison of needs support	Wilcoxon test	
	M SD	M SD	M SD	χ^2	p		Z	p
W_HM_Ch	15.05 2.799	16.45 2.782	16.70 3.328	32.829	0.000	A / C	-5.037	0.000
						A / R	-4.619	0.000
						C / R	-1.343	0.179
W_HM_Now	19.03 1.877	19.01 2.414	18.38 3.100	3.801	0.150	A / C	-0.058	0.953
						A / R	-1.930	0.054
						C / R	-2.348	0.019
W_B_Now	17.94 2.253	19.16 1.516	19.47 2.188	55.565	0.000	A / C	-5.704	0.000
						A / R	-5.193	0.000
						C / R	-1.624	0.104

Note. M — mean score; SD — standard deviation; χ^2 — Pearson's chi-squared test; Z — Wilcoxon Rank-Sum test statistic; p — significance.

As we can see, support for autonomy was lower than all other needs, while support for relatedness and competence were not significantly different in the W_HM_Ch and W_B_Now systems of relations.

Comparison of measures of basic need support between different systems of relationships is presented in *Table 4*.

It can be seen that women rated their mother's current basic need support higher, compared to her basic need support in childhood.

The woman herself believed that she currently supports the basic needs of her child more than her mother supported her basic needs in her childhood.

A preliminary assessment of the curvilinear relationship between basic need support of a child by their mother, and of a woman by her mother in childhood and now, as well as between basic need support in the studied systems of relationships and interaction (Markovskaya, 2005) in the mother-child system, showed that in 90% of the relationships between the dependent and independent variables, quadratic models explained more variance in the dependent variable than linear models. In the remaining 10% of the relationships, the linear and quadratic models explained the same percentage of variance in the dependent variable. Therefore, in the subsequent analysis, both basic need support scores and squares of these scores were included in the regression models as independent variables. The results of regression analysis in relation to the variables of a woman's basic need support for her child and the parameters of parent-child relationships, for which significant predictors were identified, are presented in *Tables 5 and 6*.

Table 4
Comparison of measures of basic need support between different systems of relationships

Support of needs	W_HM_Ch		W_HM_Now		W_B_Now		Friedman test		Comparison of relationships systems		Wilcoxon test	
	Mean	SD	Mean	SD	Mean	SD	χ^2	p			Z	p
Autonomy	15.05		19.03		17.94		78.426	0.000	W_HM_Ch / W_HM_Now		-7.602	0.000
	2.799		1.877		2.253				W_HM_Ch / W_B_Now			
									W_HM_Now / W_B_Now			
Competence	16.45		19.01		19.16		52.234	0.000	W_HM_Ch / W_HM_Now		-6.163	0.000
	2.782		2.414		1.516				W_HM_Ch / W_B_Now			
									W_HM_Now / W_B_Now			
Relatedness	16.70		18.38		19.47		55.063	0.000	W_HM_Ch / W_HM_Now		-5.014	0.000
	3.328		3.100		2.188				W_HM_Ch / W_B_Now			
									W_HM_Now / W_B_Now			

Note. M — mean score; SD — standard deviation; χ^2 — Pearson's chi-squared test; Z — Wilcoxon Rank-Sum test statistic; p — significance.

Table 5
Multiple linear regression (stepwise selection method) of the dependence of basic need support of a child in relationships with their mother (according to mother's assessment) on the woman's basic need support in relationships with her mother in her childhood and at the present time

Dependent variable: basic need support	R ²	Durbin- Watson statistic	ANOVA		Independent variables: basic need support	Coefficients		
			F	p		B	SE	β
A_W_B_Now	0.059	1.897	5.327	0.023	Constant	14.698	1.425	
					R_W_HM_Now	0.177	0.076	0.243
C_W_B_Now	0.099	2.148	9.375	0.003	Constant	17.716	0.497	
					C_W_HM_Ch (square)	0.005	0.002	0.315
R_W_B_Now	0.458	2.029	17.326	0.000	Constant	-9.395	4.644	
					R_W_HM_Ch	2.818	0.563	4.285
					R_W_HM_Ch (square)	-0.085	0.018	-4.134
					C_W_HM_Ch	0.281	0.088	0.357
					C_W_HM_Now (square)	0.005	0.002	0.204

Note. B — non-standardized coefficient of the regression equation; SE is the standard error; β is the standardized coefficient of the regression equation; R2 is the coefficient of determination; F = Fisher's F-test; p = significance. Critical probability = 5 %.

Table 6
Multiple linear regression (stepwise selection method) of the dependence of a woman's quality of interaction with her child on the woman's basic need support in relationships with her mother in her childhood, at the present time, and the basic need support of her child in relationships with the woman (according to the woman's assessment)

Dependent variable: parameters of a woman's interaction with her child	R ²	Durbin-Watson statistic	ANOVA F	p	Independent variables: basic need support	B	SE	β
Undemanding — exactingness	0.089	1.560	8.297	0.005	Constant R_W_B_Now	22.068 -0.362	2.461 0.126	-0.298
Softness — strictness	0.203	1.840	7.050	0.000	Constant A_W_HM_Ch A_W_HM_Now (square) C_W_B_Now (square)	10.735 -0.380 0.012 0.012	2.454 0.102 0.004 0.005	-0.385 0.295 0.238
Autonomy — control	0.125	1.935	12.140	0.001	Constant A_W_HM_Now	24.033 -0.470	2.578 0.135	-0.354
Rejection — acceptance	0.317	2.151	7.522	0.000	Constant R_W_B_Now (square) R_W_B_Now C_W_HM_Ch (square) C_W_HM_Ch R_W_HM_Ch	35.529 0.151 -5.116 0.012 3.685 -0.209	16.054 0.057 2.081 0.033 1.112 0.094	4.807 -4.527 -4.345 4.146 -0.281

Dependent variable: parameters of a woman's interaction with her child	R ²	Durbin-Wat- son statistic	ANOVA		Independent variables: basic need support	Coefficients	
			F	p		B	SE β
Lack of cooperation — cooperation	0.473	2.371	14.564	0.000	Constant	-19.416	7.365
					C_W_HM_Now	-0.676	0.127
					A_W_HM_Now	0.636	0.153
					C_W_HM_Ch (square)	-0.170	0.027
					C_W_HM_Ch	5.541	0.896
					A_W_B_Now	-0.211	0.097
Inconsistency — consistency of the parent	0.196	1.859	10.267	0.000	Constant	-13.287	11.183
					C_W_HM_Ch (square)	-0.143	0.042
					C_W_HM_Ch	4.354	1.379
Satisfaction with the relationship	0.266	2.124	10.033	0.000	Constant	-3.170	7.304
					R_W_B_Now (square)	0.008	0.003
					C_W_HM_Ch (square)	-0.098	0.028
					C_W_HM_Ch	2.938	0.922

Note. B — non-standardized coefficient of the regression equation; SE is the standard error; β is the standardized coefficient of the regression equation; R2 is the coefficient of determination; F = Fisher's F-test; p = significance. Critical probability = 5 %.

The results showed that there are linear associations between a woman's basic need support in childhood by her mother and the woman's basic need support of her own child. First, the more a woman's mother supports her need for relatedness now, the more a woman supports her child's need for autonomy. Second, the more a woman's mother supported her need for competence in childhood, the more the woman supports the child's need for relatedness now.

In addition to the linear ones, quadratic dependences were also found. According to the results, if the mother very highly supported, or very little supported, the woman's need for competence in childhood, then the woman supports her child's need for competence more in the present, and there was an asymmetry towards a positive relationship in this regard.

If the mother very highly supported, or very little supported, the woman's need for relatedness in childhood, then in the present the woman supports the need for relatedness in her child less, and again there is an asymmetry towards a positive relationship. The combination of this quadratic relationship with a linear one means the asymmetry of the relationship is in the direction of a positive relationship.

If in the present the mother very highly supports, or very little supports, the woman's need for competence, then the woman supports the need for relatedness in her child more, and here there was also an asymmetry towards a positive relationship.

Support for basic psychological needs in all three studied relationship systems became a statistically significant predictor for seven out of ten parameters of the "Parent-child interaction" questionnaire. At the same time, the percentage of the variance of the variables of the mother-child relationship explained by the support of these needs varied from 8.9 to 47.3. To the greatest extent, basic need support predicted such parameters of interaction as cooperation and acceptance, and did not at all predict emotional closeness, agreement, or parental authority.

A mother's support for a woman's need for competence in her childhood was a predictor of most (4 out of 7) parameters of a woman's interaction with her child, namely, acceptance, cooperation, consistency of the parent, and satisfaction with the relationship. The support for the relatedness need that a woman received from her mother during childhood predicted the acceptance parameter, while the support she received during her childhood for autonomy predicted the parameter of strictness in her interaction with her own child.

The basic need support that a woman receives from her mother in the present was also a predictor of the mother-child interaction parameters. A mother's support for the woman's autonomy need in the present, predicted less control, more cooperation, and more or less strictness (nonlinear, U-shaped connection), while the mother's support for the woman's competence need in the present, predicted less cooperation in the mother-child interaction.

A woman's basic need support for her child also predicted the parameters of the mother-child interaction. Supporting relatedness predicted acceptance (nonlinear, U-shaped connection), less exactingness, and greater satisfaction with the relationship; support for autonomy predicted less cooperation; and support for competence predicted strictness (nonlinear, U-shaped connection).

Discussion

The picture of how a woman supports the basic needs for her child is similar to how those needs were supported by a woman's mother in her childhood, and this confirms the first hypothesis: support for competence and relatedness were substantially the same in these intergenerational relationship systems, and both were significantly higher than support for autonomy in the respective system. Since similar results have been obtained using other methods and with a different population (Lynch, Salikhova, & Ereemeeva, 2020), this pattern may characterize the attitude towards the child in Russian culture. Support for autonomy reaches the level of support for competence and relatedness only in the relationship of the mother to the adult woman.

Overall, we observed an increase in support for basic needs from generation to generation. We would like to think that this is due to the tendency of changes in Russian cultural standards towards greater support for the psychological needs of the child.

Results of the present study also supported the second hypothesis. What was most important for a woman, in order to support her child's basic needs, was how her mother supported her competence and relatedness as a child. Interestingly, both extremely low and extremely high estimates of the support of a woman's needs for competence and relatedness in her childhood by her mother, had a similar effect on the woman's support of the corresponding needs of her own child. However, in the case of the support of a woman's need for competence by her mother in childhood, both extremely low and extremely high scores predicted that she more strongly supported this need of her own child. On the other hand, in the case of the need for relatedness, both extremely low and extremely high scores predicted that in the relationship with her child, she would support this need less.

Another predictor of a woman's basic need support for her child was how the mother supports her competence and relatedness now. The support of a woman's need for relatedness by her mother in the present, was a predictor of a woman's support for her child's need for autonomy. At the same time, the mother's support of the woman's autonomy, whether in childhood or at present, did not play such a role, which distinguishes our results from those obtained in the Italian sample noted earlier (Costa et al., 2015).

The support of a woman's competence by her mother in childhood turned out to be most widely associated with the various parameters of interaction of a woman with her child, and this confirms the third hypothesis. In general, the more that in a woman's recollection, her mother in childhood supported her need for competence, the less acceptance, cooperation, consistency, and satisfaction in the relationship were present in the woman's current relationship with her child. However, these associations were nonlinear, quadratic in nature: with extremely low values of competence support of a woman in childhood by her mother, smaller values of the same parameters of interaction between a woman and her child were observed.

To a large extent, these results correspond with the ideas developed in recent years by Grolnick, Raftery-Helmer, Marbell, Flamm, Cardemil, and Sanchez (2014), which emphasize that what is important is not only the very fact of support for a

particular need of the child, but also how this support is carried out. In these studies, different means of supporting competence led to the child experiencing different degrees of their own autonomy (Grolnick et al., 2014), and different ways of controlling behavior, or, more precisely from the SDT perspective, differences in how mothers exercised authority, led to differences in the autonomous self-regulation and emotional state of the child (Levitt, Grolnick, Caruso, & Lerner, 2020). A more detailed study of the ways in which Russian women support their child's need for competence may help to uncover more deeply the psychological mechanisms that lie behind our results.

It can be assumed that some means of supporting a person's competence may be perceived as reflecting a highly evaluative attitude on the part of the parent. Alternatively, if a woman's competence was very highly-supported in childhood, then, perhaps, she will be less ready to perceive her own child's imperfection. This is probably why, in our data, there was less acceptance and cooperation with one's child. On the whole, these results support Ryan and Deci's suggestion (2017) that further research is needed to disentangle the various cross-cultural issues in providing basic need support.

It turned out that greater support for a woman's need for autonomy during childhood was a predictor of her own less strictness with her child, which fully corresponds to an SDT perspective.

The present study showed that in the minds of Russian women, the highest levels of basic need support, with respect to the competence and autonomy needs in particular, were associated with negative consequences for a woman's attitude towards, or interaction with, her child. From a self-determination theory perspective, it will be very important to disentangle this apparent paradox when optimizing child-rearing practices in ways that are cross-culturally appropriate.

Conclusion

The social situation of development (to borrow Vygotsky's concept) indeed demonstrated intergenerational continuity in such an important component as basic need support. In particular, support for the needs for relatedness and competence prevailed over support for the need for autonomy, both in the system of a woman's relationship with her child and in the system of her relationship with her mother in childhood.

The main lines of continuity with respect to the child's basic need support related to the needs for competence and relatedness, are that the more these needs were supported for the woman in her own childhood and were currently being supported by the woman's mother, the more the woman supported them currently in her own child. At the same time, no intergenerational continuity was found in supporting the need for autonomy.

Basic need support in different intergenerational systems of relations was a predictor of most characteristics of a woman's interaction with her child. These characteristics of the parent-child interaction were predominantly predicted by a woman having experienced support for competence by her own mother during childhood,

by the mother supporting the woman's needs for autonomy in the present, and by the woman supporting her own child's need for relatedness in the present.

The present research can be used in the development of educational programs for expectant and current mothers, in particular with an emphasis on facilitating the woman's psychological readiness to build effective interactions with her child while overcoming ineffective interactions; these goals can be addressed within the framework of family and parental counseling. Particular attention should be paid to the importance of supporting the child's need for autonomy and the best, most effective means of supporting the need for competence, taking into account relevant cultural considerations.

Limitations

The main limitation of this study is that only the responses of the woman herself were surveyed, and that she rated all three systems of relationships. It would be important to develop this research in the direction of interviewing her mother as well, and also through application of methods for observing the real interaction of a woman with her child.

The study is also limited by the sample size and the lack of control over some variability in the socio-demographic characteristics of the participants.

Ethics Statement

Participants in the current study were recruited in an ethical manner. The study was approved by the Ethical Committee of the Institute of Psychology and Education of Kazan Federal University. We affirm that all participants gave informed, voluntary consent before taking part in the study.

Conflict of Interest

The authors declare no conflict of interest.

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Defining Digital Competence for Older Preschool Children

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Background. Recent studies show that by the age of 5–7, children have already had experience using technology for several years. Discussions about the impact of digital interaction on children are ongoing. Nevertheless, it is becoming clear that there is a need to develop concepts and tools that will help children in the process of exploring the digital world. One of such concepts can be that of digital competence. It refers to the readiness of an individual to apply digital technologies efficiently and safely in various spheres of life.

Objective. To determine the content of digital competence for modern children of older preschool age.

Design. The study included interviewing children, organizing interaction of a child with a digital device, playing a card game, and having their parents answer survey questions.

Results. Our study found that older preschool children had a general idea of how to use digital technologies and could name those functions which they had observed or used themselves. The main purpose of the children's interactions with digital devices was entertainment. Most of the preschoolers demonstrated low motivation for learning how to use digital devices, and had not developed ideas about how to use digital devices in everyday life safely and effectively.

Conclusion. The concept of digital competence can be applied to the study of issues related to the interaction of older preschool children with the digital environment. The results we obtained can help educators and parents to develop strategies for the appropriate and child-friendly interaction of preschoolers with the digital environment.

Keywords:
Digital
competence;
digital devices;
parents;
preschool
children;
online risks

Introduction

The digital environment was not originally designed for children; yet it plays a significant role in children's lives (United Nations Committee on the Rights of the Child, 2021). According to recent studies, children under two have already used digital devices (Chaudron, Di Giota, & Gemo, 2018; Common Sense Media, 2013; Dardanou et al., 2020). Some parents introduce their children to mobile technologies and tablets at the age of 12–24 months (Archer, Wood, & De Pasquale, 2021), preschool educational institutions actively integrate multimedia in the process of education (Dore & Dynia, 2020), and more and more children are becoming regular Internet users before starting primary school. Children in Russia start using devices at the average age of 3 years old (it varies from 1.5 to 5 years old) (Chaudron et al., 2018).

Most Russian children were born into, or are being raised in, households having two TV sets, Internet access, a tablet, a smartphone, a laptop, a DVD, a home video game console, and other devices (Korotkova et al., 2018). Forty-two percent of children in Russia between 3 and 6 years old have a personal smartphone or tablet, and more than half of all children between 0 and 12 years of age may use their parents' digital devices and watch TV. Apart from that, preschool children often use digital devices every day with no supervision by their parents (Veraksa, Bukhalenkova, Chichinina, & Almazova, 2020). The average daily time spent on digital activity by Russian children 5–10 years old is 1 to 3 hours (Soldatova & Vishneva, 2019).

While the world of children is gradually digitalizing, what kind of impact the technologies have on today's children is still a subject of debate. Some research focuses on identifying the challenges of interaction with the digital world on a child: apprehensions about the effect of screen time (Radesky, Schumacher, & Zuckerman, 2015); the negative impact of media and information products (Karabanova & Molchanov, 2018; Tisseron, 2013); and the potential for intensifying traditional childhood risks, such as bullying, cyberaggression, and risks related to content; and fueling new forms of child abuse and exploitation (UNICEF, 2017; United Nations Committee on the Rights of the Child, 2021). Other researchers are studying the opportunities opened by digital technologies to young members of the digital community: the educational and developing value of apps (Liu, Tan, Huang, Chen, & Liu, 2021; Papadakis, 2021; Papadakis, Alexandraki, & Zaranis); the impact of computer technologies on perception in the learning process (Hoffman, 2014); the development of preschoolers' executive functions by computer-based technologies (Veraksa & Bukhalenkova, 2017); the development of the creative potential of a gifted child (Bochkarev, 2019); opportunities for learning and education; and access to information (UNICEF, 2017).

Nevertheless, both positive and negative influences are dependent upon the development of skills for the competent use of digital opportunities. Researchers have already well formulated the formal features of the interaction of preschool children with individual electronic devices or resources. However, the perception of the digital world by this age group remains understudied. What motivates children to use particular gadgets? Do they want to learn anything new about the technology? How do they feel in the digital environment? Do they experience any negative effects and

how do they cope with them? The answers to these questions are partially known when it comes to adolescents, but there is a gap in the case of preschoolers. For this reason, the values and motivation of preschoolers require research to enable a consistent and purpose-driven education aimed at developing the most important digital competencies.

The Concept of Digital Competence

Confident and critical use of Information Society Technology for work, leisure, and communication is defined as digital competence (Recommendation of the European Parliament... 2006). Digital competence is regarded as one of the key competencies of a modern person (Cortesi, Hasse, Lombana-Bermudez, Kim, & Gasser, 2020).

To specify the concept, the European Commission's Joint Research Center has developed the Digital Competence Framework for Citizens (DigComp) (Carretero, Vuorikari, & Punie, 2017; Ferrari, 2013; Kluzer & Pujol Priego, 2018; Vuorikari, Punie, Carretero, & Van den Brande, 2016).

Education researchers are also working on identifying the frameworks and structure for the new term. One of the models of digital competence was designed in the process of elaborating new tools for assessing the complex system of skills and knowledge in the field of computer technology in high school students (Calvani, Fini, Ranieri & Picci, 2008). The authors of the model propose to consider digital competence in its cognitive, technological, and ethical dimensions.

Russian researchers consider digital competence to be "based on continuous acquiring of competencies (a system of relevant knowledge, skills, motivation, and responsibility), the ability of an individual to confidently, effectively, critically, and safely select and apply info-communication technologies in different spheres of life (work with content, communication, consumption, technosphere)" (Soldatova, Nestik, Rasskazova, & Zotova, 2013, p.17). Some works describe this concept as an integral part of social competence. With this approach, the skills and culture of communication on the Internet and safe navigation in the virtual world come to the fore in defining the essence of digital competence (Denisov, 2018).

The social and emotional aspects of using and understanding digital devices have been identified as the basis for digital competence (Ilomäki, Paavola, Lakkala, & Kantosalo, 2016). A fundamental difference between digital competence and digital literacy (or other related terms) is the inclusion of a motivational component in the essence of the concept, which determines, inter alia, its psychological and pedagogical orientation.

Model of Digital Competence of Older Preschool Children

To date, researchers have conducted in-depth studies of the problems involved in the development of digital competence in adolescents; however, the digital competence of children of other age groups has not yet been studied. More specifically, even though several models of digital competence already exist (Calvani et al., 2008; Carretero et al., 2017; Ferrari, 2013; Soldatova et al., 2013), no model has yet been developed for preschool children. To study this age group, the model proposed by the researchers

of the Foundation for Internet Development is more applicable; specifically, a model which includes the components of knowledge, skills, motivation, safety, and responsibility (Soldatova et al., 2013). In our opinion, it is possible to speak about acquiring the basics of digital competence in children of older preschool age. In this age cohort, motivation and responsibility become the central components of digital competence as a psychological and pedagogical category. Nevertheless, the age characteristics of this group of children require clarification of these components of the model.

In our study we viewed motivation as the pursuit of improving one's literacy. However, in studying the motivational component in older preschool children, we were not only interested in the wish or unwillingness to learn how to use digital technologies, but also in the children's specific motives, be they cognitive, game-related, external, social, etc. At the age of 5–7 years, a child cannot bear full responsibility for his/her actions and is unable to ensure their technical safety. For this reason, our study identified the principal component of the digital competence of an older preschool child as the awareness of the family rules for using digital devices, and the behaviors which the child chooses when faced with technical problems and online environment risks.

It must be also clarified that, from our point of view, the level of skills and the ability to independently use familiar digital devices, and learn how to use unfamiliar ones, are not very important in older preschool age, because they are directly associated with the duration and intensity of interaction with digital devices. For this age category, it is more relevant, in our opinion, to address the existing experience of using digital devices in various spheres of a child's life.

The meaning of the components of digital competence of older preschool children, which we adhere to in this work, can be presented in the form of a table (Table 1).

Table 1

Digital competence of older preschool children

Component	Content
Knowledge	Knows a variety of uses for digital devices and understands that digital devices can be used for more than just entertainment purposes Has an idea of the existence of various risks in the digital environment, including online risks Has an idea of how the Internet functions and understands that they are an Internet user
Skills	Has the minimum skills required to use digital technologies as a tool for self-studies, self-development, creative activity, and communication
Motivation	Is motivated to learn how to interact with digital devices for pragmatic purposes Has motivation, which includes both external and internal motives
Safety and responsibility	Knows the family rules for the use of digital devices and tries to comply with them When facing risks in the digital environment, asks for help from an adult/parent

Methods

Aims and Research Questions

Our research aimed to explore how the content of digital competence can be defined for modern children of older preschool age. The study sought to determine the particularities of perception and use of digital technologies, areas of knowledge about technologies, motivation for the use of technologies, and ideas about safe behavior when using technologies, shown by this age group. The study also examined the attitude of parents toward the use of technology by their children, and their strategies and methods of parental control over it.

The main questions this study sought to answer were:

- How often and for what purposes do older preschool children use technology?
- What knowledge do children have about the world of technology?
- How do children assess themselves as digital users? Do they want to improve their digital competence?
- How do children relate to technologies? What feelings and emotions do they experience when using them?
- How do older preschoolers understand security in the digital world, and how do they deal with online risks?
- How do parents view the use of technology by their children, and for what purpose do they give and buy digital devices for their children?

Participants

The study involved two groups of respondents: 1) children of older preschool age who attend kindergarten and live in St. Petersburg, and 2) their parents. Participants were selected from families enrolled in different education groups at the same public kindergarten. Simple random sampling was used. The employees of the kindergarten were involved in the dissemination of information about the research to be conducted.

Parents who did not answer all the questions in the questionnaire were excluded from the sample. The final number of parents who participated in the study was 43. Twenty-four (55.8%) of the respondents were parents of girls, and nineteen (44.2%) were parents of boys. Forty-one (95.3%) were mothers, and only two (4.7%) of the respondents were fathers. The age of the adult respondents ranged from 24 to 47 years. Thirty-two (74.4%) of the respondents had higher education.

The answers of the children-participants during the interviews were included regardless of their completeness. The total number of children involved was 41. Of these, 61% (25) were girls; 39% (16) were boys. The ages of the respondents were distributed as follows: respondents age 5 years = 41.5% (17); 6 years = 26.2% (11); and 7 years = 31.7% (13). Of the total number of respondents, 61% (25) had older siblings, and 39% (16) did not.

Procedure

Our study was based on the materials used in the international research on the interaction of children from 0 to 8 years old with digital technologies (Chaudron, 2015), and on a questionnaire developed by the Foundation for Internet Development in collaboration with the Levada Center for the all-Russian study “Digital competence of adolescents and parents” (Soldatova et al., 2013). The first was used as a basis for drafting the interviews with the children; the second was used as a basis for compiling the questionnaire for parents. Both survey instruments were adapted for the purpose of this study: the age characteristics of the children’s group were taken into account; questions to respondents were structured according to the components of digital competence.

The researchers interacted with the children in an environment with which they were familiar: in the child’s room at home or in the playroom of the kindergarten they go to. The interview with each respondent took about 25–30 minutes. Before getting to the main part of the interview (*i.e.*, to identify the children’s preferences) and in order to make the child comfortable, a card game was used. The cards featured images of various digital devices and electronic or traditional toys. In the course of the game, the respondents were asked to place cards on the scale “Like/use”–“Don’t like/don’t use,” which helped us to understand how important digital technologies were in the children’s lives, compared to other elements of modern childhood.

In the main part of the interview, thematic sets of questions were asked in order to identify the selected components of digital competence:

1. A set with questions about the child’s user activity: digital devices, applications, and Internet resources used, the frequency and intensity of use, and purposes of use: “Which of these devices do you have at home?”; “Which of them can you use?”; “What can you do with this device?”; “Which of these activities is your favorite?”; “Which applications in this device can you call your favorites?” etc.
2. A set with questions aimed at identifying the child’s experience in using digital devices in various fields of technology application: “Do you use this device alone, or does someone help you?”; “How did you learn to use this device? Who helped you with this?”; “Do you know how to study/buy something, take a photo, make a video, record a song, draw a picture, etc./communicate with someone using this device?”; “Can you show me how you usually do it?” etc.
3. A set of questions aimed at identifying the respondent’s knowledge about digital devices, including the areas and methods of the application of technologies, and the impact on people and society: “Can this device be used to study, buy something, take a photo, make a video, record a song, draw a picture, etc./communicate with someone using this device?” “How would you explain what the Internet is?”; “Why do people use it?” etc.
4. A set of questions aimed at identifying the child’s motivation for learning to use digital devices, and his/her specific motives, as well as identifying the child’s attitude toward digital devices: “Do you think it is important to learn

how to use this device?”; “Do you still need to learn or do you already know how to use it?”; “Why is it important to learn to use this device?”; “How would you explain why you use this device?”; “In your opinion, does this device bring more good or bad things to people? And to you personally?” etc.

5. A set of questions about safety when using digital devices, including knowledge of family rules, the pursuit of complying with them, and a model of behavior in case of facing online risks: *“Do you use this device alone, or does someone help you?”; “Can you use this device for as long as you want? If not, why not?”; “Can you use this device everywhere?”; “Can you use this device alone or should someone be with you?”; “Are there any rules for using this device? Who sets these rules? Do you follow them? What happens if you break any of them?”; “Have you ever felt unpleasant/scared/sad when you used this device? What made you feel so?”; “What did you do in this situation?” etc.*

At the end of the interview, in order to identify the child’s skills in using a digital device, the interviewer asked participants to demonstrate their skills when using a tablet (iPad). The process of using the device was monitored.

The questionnaire for parents consisted of 39 questions, including dichotomous choice (yes/no), multiple-choice, open-ended, and closed-ended questions. Collection of the parents’ answers was organized through the online-service Google Forms. Respondents were asked questions about the types of digital devices used by their child; whether their child has a personal digital device; the length of time their child uses digital devices on weekdays and weekends; the purposes of the use of digital devices; the attitude of the parents toward digital technologies; and the methods of mediation used by the parents to regulate their children’s interaction with digital devices.

Results

Use of Digital Devices by Children Ages 5–7

The study showed that 95.1% of children had the experience of active interaction with various digital devices. Even if their parents did not allow their children to actively interact with these technologies, the children had a positive attitude towards

Table 2

Types of personal digital devices of preschool children ages 5–7

Digital device	Number of responses	Percentage of responses
Smartphone	15	37
Tablet	14	34
Smart Watches	7	17
Mobile Phone	4	10
Laptop	1	2
Game console	1	2

them, but at the same time they had no idea about the rules for their safe use. Also, 68.3% of the children in the survey had their own digital devices (*Table 2*).

These older preschool children could not set the duration of the use of digital devices by themselves, which means they could not control it. According to the parents' answers, 61% of their children used digital technologies mostly between 1 and 3 hours a day on weekdays. On weekends, the duration of use of digital devices by this age group increased significantly (*Table 3*).

Table 3

Duration of use of digital devices by preschool children ages 5–7

Duration of use	Weekdays	Weekend
Less than an hour	13 (32%)	7 (17%)
1–3 hours	26 (63%)	25 (61%)
3–5 hours	3 (7%)	8 (20%)
5–8 hours	0	2 (5%)
Difficult to answer	1 (2%)	1 (2%)

The main purpose of using digital technologies by older preschool children was entertainment. The children could also use the technology for educational purposes, but usually not by their own choice, not regularly, and not often (*Table 4*).

Table 4

Ways of using digital devices by older preschool children

Way of use	Number of responses	Percentage of responses
Watching movies and cartoons	41	100
Playing video games	34	83
Watching videos	17	42
Taking photos	16	39
Communication	12	29
Drawing	9	22
Making videos	6	15
Listening to music and fairy tales	3	7

When asked about their favorite multimedia content, these older preschool children said they could watch cartoons, movies, and different video content available on platforms such as YouTube, TikTok, and Likee.

Knowledge, Skills and Motivation as Components of Digital Competence of Preschoolers

The knowledge of the digital world and technology which the majority of these older preschool children possessed can be described as fragmentary and unsystematic. More specifically, the majority of respondents had an idea of only a few areas of life and activity where digital devices could be used and could rarely list them on their own. Only in a few cases had the children developed a concept of what the Internet is, although they were active Internet users (*Table 5*).

Table 5
Older preschool children's ideas of the Internet

Child's definition	Number of responses	Percentage of responses
Electricity for digital devices	9	22
Something that turns on cartoons or games	9	22
Communication tool	3	7
Something that could be distributed by digital devices	3	7
App	2	5
Information storage and transmission system	2	5

These older preschoolers showed varying levels of confidence in interacting with digital devices. In most cases, the children succeeded in operations which required touch screen use (*Table 6*). Slightly more than half of the children could type a text using a touch keyboard, but only in isolated cases did the children demonstrate proficiency in specific skills, such as drawing or voice typing.

Table 6
Results of monitoring the use of touch screen digital devices by older preschool children

Operation with a digital device (iPad)	Number of responses	Percentage of responses
Choose the way to interact with the screen (press, swipe, etc.)	41	100
Use icons to select and get access to applications	39	95
Flip the page and access the content with a swipe from right to left or top to bottom	39	95
Resize content (increase, decrease)	36	88
Choose the icon to activate the application	35	85
Select and move content in the app	34	83
Swipe the screen to get access to additional pages with apps	33	81
Find and press the button to turn on the device	32	78
Swipe the screen to get access to apps and enter passcode if needed	30	73

More than half of the respondents — 53.7% (22) — believed that they had already fully learned how to use these devices; that is, they had low motivation to increase their digital competence. It can be assumed that older preschool children tend to perceive their level of interaction with digital devices as high, due to the fact that they independently use only a limited number of functions, even on their own digital devices. Analysis of the children's answers allowed us to identify the following groups of motives for increasing digital competence:

- Interest in the adult world. An emphasis on self-image as an adult: *"You need to study so that later, when you become an adult, you already know how to work"; "You need to learn to use. For example, you have an important conference of some kind, but you cannot hold on a push-button telephone or TV. And you have to learn."*
- Social motives. An emphasis on fear of taking a socially disapproving act, or harming yourself or others: *"You have to study, because if you press the wrong button, the money will be withdrawn there, or something else will happen. Or it will explode"; "When you press all the buttons in a row, it can deteriorate. And never work again. Therefore, you have to learn."*
- Communicative motives. An emphasis on mastering the communicative function of technology: *"I think it's important for people to learn this. You must have WhatsApp to be able to call another person."*
- Play motives. An emphasis on mastering the entertainment function of technology: *"You need to learn. For example, I asked my parents about what to press on the phone and where it was, and what games to download, how to download games"; "I saw in one video about games where they somehow turned on the joystick and played on the tablet. I would like that too."*

Safety of Children Ages 5–7 in the Digital World

Older preschool children often find it difficult to cite the family rules for using digital devices. Nevertheless, more than half of the surveyed respondents expressed their readiness to follow the rules set by their parents. Some of the children, however, admitted that they did not even comply with the clearly set rules. Some others reported that they did not agree with the rules and were reluctant to follow them.

More than 46 percent (46.3%) of the respondents gave a positive answer to whether a particular digital device could be dangerous. However, the children's answers were mainly related to the physical characteristics of these objects: *e.g.*, the device can break, or fall into the water and cause an electric shock to a person. The rest of the respondents could also recall some negative experiences of using digital devices and even facing online risks, but they did not speak about these situations as potentially dangerous. At the same time, when faced with various risks of the online environment, the children preferred not to inform their parents about them and tried to cope with the problems on their own. Most often this was due to the children's fear of being punished.

The Attitude of Parents Towards the Use of Digital Technologies by Their Children

The parents of these older preschool children perceived digital technologies in their children's lives primarily as a means of entertainment, relatively speaking, "toys." At the same time, a significant number of parents were aware of the potential of digital devices for their child's development, but this potential was rarely realized (*Table 7*).

Table 7

Advantages of using digital technologies for older preschool children according to parents

Advantage	Number of responses	Percentage of responses
Information	17	40
Development and learning	17	40
More effective learning technologies	3	7
Communication with parents	3	7
Communication	2	5
Unlimited possibilities	1	2

Moreover, the parents of the preschoolers tended to underestimate the risks of the online environment to their children (*Table 8*).

Table 8

The risks already faced by their children ages 5–7 in the online environment according to the parents

Online-risk	Number of responses	Percentage of responses
Confident that children did not face risks	24	56
Found it difficult to answer	8	19
Malware	5	12
Content containing scenes of violence, cruelty, murder	5	12
Insult, humiliation, harassment, or resentment	4	9
Promotion of alcohol, drugs, or tobacco	2	5
Become a victim of fraud or money theft	2	5
Theft of personal data	1	2

A significant number of parents also found it difficult to give specific answers to questions about ensuring their children's safe interaction with digital devices (*Table 9*).

Table 9

How parents regulate their child's interaction with various digital devices

Parental mediation method	Number of responses	Percentage of responses
Limiting the time of use	31	72
Supervision while using a digital device	27	63
Talking about digital devices	22	51
Monitoring the use of digital devices	22	51
Establishing rules for the use of digital devices	21	49
Co-using of digital devices with child	20	47
Teaching the child to use digital devices	17	40
Banning the use of a digital device	16	37
Telling the child about the use of digital devices and the Internet	13	30
Using special software for monitoring	10	23

Discussion

The data we obtained allows us to determine several features in the digital technology use by older preschool children. A significant percentage of children ages 5–7 periodically interacts with various digital devices. The most popular devices were the smartphone and tablet. These results are similar to those of other studies (Dardanaou et al., 2020; Papadakis et al., 2021). The duration of digital device use by the children exceeded the time recommended for this age group and generally ranged from 1 to 3 hours a day, a result which is consistent with data reported in other studies (Soldatova & Vishneva, 2019). Children could use their parents' digital devices, family digital devices at home, and their own digital devices. More than half of the children had personal gadgets. This number is higher in comparison with the studies previously conducted in Russia. It is also noteworthy that despite the presence of digital devices in kindergarten, during the study the children did not mention the experience of interacting with them.

Older preschoolers primarily used digital technologies to watch movies and cartoons and to play video games. Also, quite often children watched videos on video hosting and short videos on social media. Entertainment as the most preferred use of digital devices and apps by children has also been described in a number of other studies (Chaudron et al., 2018; Veraksa et al., 2020).

At the same time, the preferred game content differed according to the gender of the respondents. Boys were more likely to choose multi-level arcades, strategy, and online games with characters, where points must be collected, and opponents must be defeated. Girls were more likely to choose games without a plot where they had to take care of a computer character, or creative games such as drawing games, coloring books, character constructors, etc. Boys more often interacted with in-game content inappropriate for their age group (Brawl Stars, Among Us, Fortnite, War Thunder,

etc.). The games they named often contain elements of cartoon violence and involve acquisition of additional capabilities by characters for real money. One game which was mentioned by the respondents of both genders was Minecraft. This correlates with data from other studies, which explored differences in preferred activities with digital devices among boys and girls, as well as the content chosen (Brito & Dias, 2019; Veraksa et al., 2020). Girls were more communication-oriented: they were more likely to cite “connecting, communicating” as their favorite digital device activity, and chose drawing, music, educational activities, and watching cartoons with a digital device more often than boys (Veraksa et al., 2020).

When it comes to the specifics of digital device perception by older preschool children, it should be noted that their parents viewed digital technologies in their children’s lives primarily as a means of entertainment. Parents’ answers indicated that they rarely used digital technologies to stimulate their child’s learning and development, although they knew about such potential. This led to the children developing the same attitude. While the children were predominantly positive about the technology, they were rarely able to explain how digital devices are beneficial to them personally and to the society as a whole. Also, it can be assumed that their attitude was shaped by the mostly positive emotions (joy, fun, and interest) which they had experienced, since they used the gadgets to play and to watch entertainment.

The knowledge these older preschool children had about the digital world was limited mostly to the general idea of the spheres of application of digital devices, and the functions which the children had observed or used themselves. Respondents had the basic skills required to interact with a touch screen. Competence in tablet use by young children has also been shown in studies of various European nations (Chaudron et al., 2018). Also, according to our data, the older preschool children generally demonstrated low motivation for learning how to use digital devices, since they had a limited understanding of the functions of technologies which were available. The responses of motivated children allow us to suggest that when children are better informed about their opportunities in the digital world, their motivation could increase. Children of this age group were also virtually unaware of the possible dangers of the online environment, which gave them the false impression that they could cope with any problem if it arose. Although these older preschool children used various digital devices actively, most of them did not have any clear idea about how to use them safely and effectively in their everyday lives.

Moreover, the majority of the children in the study chose not to tell their parents about their negative experiences while interacting with digital devices, since they were afraid of subsequent punishment. The same problem has been shown in the UNICEF report. While attitudes vary by culture, children often turn first to their peers when they experience risks and harm online, making it harder for parents to protect their children (UNICEF, 2017). Moreover, the parents in our research tended to underestimate the risks of the online environment to their children. Most parental moderation strategies involved limiting the time of use of digital devices. Other studies also confirm this finding (Papadakis et al., 2021).

Parental supervision while using a digital device was also frequently mentioned by parents, but it is hardly possible all the time, considering the duration of their

children's use of digital devices. Co-usage of digital devices and lessons on how to use devices were effective but uncommon practices among parents. According to other Russian studies, preschool children often use digital devices every day with no supervision by their parents (Veraksa et al., 2020). Older preschoolers are an age group highly vulnerable to the risks of the digital environment. A significant number of parents try to establish family rules for the use of digital devices, but most children either cannot identify these rules, or do not know about their existence at all. Additionally, many parents of preschoolers do not know what strategies and means should be applied in situations where their child faces online risks.

Conclusion

Taking into account the current data on the use of digital devices by children (increasing duration, scope, and purpose of use), it is necessary to talk about establishing the foundations of digital competence of preschool children, and determining its content in accordance with the children's age characteristics.

Our study made an attempt to describe the content of the components of digital competence in older preschool children. We found that, despite the fact that the children in our study had basic skills in using digital devices such as smartphones and tablets, the majority had little or no knowledge of the application of these technologies in the life of society, and their impact on the environment and the community as a whole. The children successfully used digital technologies for entertainment purposes, which, together with limited knowledge, negatively affected their motivation to develop the skills to use them in other areas. Mastery of the digital world was gained by these older preschoolers mainly spontaneously, without proper support from adults; thus, the children were deprived of the opportunity to get the necessary ideas about safe behavior in the digital environment. Preschoolers actively explored the entertainment possibilities of digital devices, often going beyond child-appropriate content and age-appropriate environments. In the process, they often faced various online risks. However, due to the existing problems in mediating the children's use of digital devices, their parents may not have any idea of the difficulties or negative emotions their child experiences in the digital environment.

As we continue this study, we plan to increase the sample with representatives from different regions of the country. This will take into account the different ethnic, socio-economic, and other characteristics of the population. It is also necessary to compare the features of digital competence of preschoolers relative to the educational and economic status, and composition of the family — in particular, the presence of siblings. In our study, several respondents mentioned their siblings' role in familiarizing them with digital devices and moderating their use; thus, having siblings may be an important factor in the development of digital competence, but this study was not able to take this into account.

Limitations

This study had some limitations. Generalization of the results is limited by the small sample size. Socio-stratification characteristics of the families were not taken into

account. Mainly mothers of children participated in the survey. Interviewing both parents, whenever possible, can provide significantly more information about the digital environment and competence of a child.

Ethics Statement

The ethical aspects and results of the study were discussed and approved at a meeting of the Department of Developmental Psychology and Family Pedagogy, Institute of Childhood, Herzen State Pedagogical University of Russia (Protocol No. 12, 2021.03.10). The participation was voluntary, and the participants did not receive any incentives for their participation.

Informed Consent from the Participants' Legal Guardians

All participants and their legal guardians gave their consent for inclusion in the survey prior to the participation.

Author Contributions

Inna Kalabina and Tatyana Progackaya initiated the idea and developed the theory. Tatyana Progackaya examined the participants and performed the calculations. Inna Kalabina supervised the findings of this work. Both authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Adolescents on Social Media: Aggression and Cyberbullying

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Background. The aggressiveness of social networking is a significant component of the risk modern teenagers face during socialization, and cyberbullying is one of the most controversial forms of aggressive behavior on social media.

Objective. This paper deals with the study of secondary school students' behavior on social media. The parameters characterizing teenagers' usage of social media — their activity, intensity, motives, and self-presentation — are analyzed with respect to gender, age, and social psychological factors. The main focus is teenagers' personal experience dealing with aggressive situations on social media: their role in aggressive situations (as aggressor, victim, or witness); the form of aggression (public or private); the aggressor's characteristics (acquaintances or strangers, persons, or groups); and their views on what action victims should take (ignoring it, confronting it, or asking for help).

Design. This article is based on data obtained by researchers at the Center for Sociology of Education of the Institute of Education Management of the Russian Academy of Education in 2020–2021. Using a specially developed questionnaire, we collected responses from 40,575 students from grades 7–11 in 17 regions of Russian Federation through an anonymous online survey. Mathematical statistical methods were used for data processing, specifically, the chi-square test in the “Basic statistics-Difference tests” module of the “StatSoft Statistica 7.0” package.

Results. The data showed that the adolescents with high status among their classmates (“leaders”) used social media as an important educational resource, while those with low status (“loners”) used it to compensate for their poor real-life experience. Aggression on social media appears to be quite common among adolescents. The traditional differences between male and female subcultures appeared in the choice between private or public forms of aggression. The increase in aggressive interactions with strangers as the youth aged indicated that the realization of the teenage distinctive basic need for “expanding one's social environment” in online interaction comes with the risks of encountering unfriendly, aggressive reactions.

Keywords: Social media; adolescence; aggression; cyberbullying; motives for using social media; self-presentation, activity on social media; intensity of the use of social media; gender specifics; social status

Conclusion. Communication on social media reflects an adolescent's real-life interaction in school: those who have experienced psychological or physical bullying are more likely to become both victims and offenders in aggressive situations on social media. This transfer of group bullying from real life to the virtual can be seen as the main feature of adolescent cyberbullying.

Introduction

Digital technologies these days play a huge role in all areas of human life. A person learns to use computers and smartphones in early childhood (Sobkin & Skobel'tsina, 2014), and adolescents, due to modern mobile devices, almost "live on the Internet" (Koroleva, 2016; Sobkin & Fedotova, 2019c). Thus social media is the space where crucial processes of adolescent maturation take place: the development of self-awareness, the creation of identity and self-determination, and the phenomenon of "expanding one's social environment" (Bozhovich, 2008; El'konin, 1989; Vygotsky, 1984). Moreover, many modern researchers distinguish social networks as a special institution of socialization (Belinskaya, 2013; Koroleva, 2015; Martsinkovskaya, 2010; Sobkin & Fedotova, 2019b; Soldatova, 2018).

The popularity of social networks among adolescents is a matter of concern for the pedagogical and parental communities, and increased interest among researchers. Initially the networks were considered mainly from the point of view of their potential risks (Brenner, 1997; Karabanova & Molchanov, 2018; Marino, Gini, Vieno, & Spada, 2018; Shukhtueva, 2016; Soldatova & L'vova, 2018; Voiskounsky, 2010). After various crises (teenage suicides, shooting in educational institutions, etc.), some publications would always blame the influence of social networking (Korolenko, Dmitrieva, & Levina, 2014; Mursalieva, 2016; Soldatova & Iliukhina, 2021). Therefore, the study of teenage aggression on social networks is extremely valuable.

In speaking about adolescents and aggression on social media, we would like to clarify that we are facing two different phenomena. On the one hand, we are talking about the adolescent's perception of aggression that is not directly related to him; this is one kind of aggressive content on social networks, including socially acceptable forms (news, movies, sports events, etc.). On the other hand, there is the aggressive behavior of social network users, directed at other participants in the network interaction, in particular at the respondent himself (threats, insults, harassment, etc.). Cyberbullying, which today is the object of close attention of researchers, has a special place here (Beale & Hall, 2007; Bochaver & Khlokov, 2014; Fanti, Demetriou, & Hawa, 2012; Griesel, Finger, Bodkin-Andrews, Craven, & Yeung, 2012; Hinduja & Patchin, 2010; Kowalski & Limber, 2013; Li, 2010; Menesini & Salmivalli, 2017; Raskauskas & Stoltz, 2007; Smith, Mahdavi, Carvalho, Fisher, Russel, & Tippett, 2008; Song & Oh, 2018; Walrave & Heirman, 2011; Williams, Cheung, & Choi, 2000).

The present study originated in the early 2000s when we started our research on the characteristics of the information environment of schoolchildren (Sobkin & Evstigneeva, 2001). In our previous publications we have considered such aspects of

adolescents' interaction on social networks as the motivation and content of communication, the risks and consequences of using social networks, social network users' psychological well-being, and their attitudes toward aggression on social media (Sobkin & Fedotova, 2018a, 2018b, 2019a, 2019b, 2019c; Sobkin, 2016). In this paper we focus on the adolescents' personal experiences of participation in aggressive situations on the social network: their actual role in those situations (aggressor, victim, or witness); the forms of aggression (public or private); the bully's characteristics (acquaintances or strangers, persons or groups); and their views on how the victim should respond during the situation of cyberbullying (ignoring, confronting, or asking for help).

Methods

This article is based on data obtained during an anonymous electronic questionnaire survey, which was conducted in 2020-2021 by the research group of the Center for Sociology of Education of the Institute for Education Management of the Russian Academy of Education. The opinions of 40,575 schoolchildren (40.2% males, 59.8% females) in grades 7 (24.7%), 8 (23.3%), 9 (22.0%), 10 (16.0%), and 11 (14.0%) from 17 regions of the Russian Federation (19.6% from regional centers, 13.6% from district centers, 31.9% from small towns, 35.0% from rural areas) were received.

The special questionnaire was developed to study various aspects of adolescents' deviant behavior. It contained more than 150 open, closed, and scaled questions. The questionnaire featured questions concerning the teenagers' behavior on social media and their socio-demographic characteristics. The answers were processed by SPSS 21 and StatSoft Statistica 7.0. To compare the proportions observed in two independent samples and expressed as percentages, the chi-square test in the "Basic statistics — Difference tests" module of the StatSoft Statistica 7.0 package was used. All the differences indicated in the article are statistically significant at the 0.05 level.

When processing the empirical data, we paid special attention to the social and role aspects of the interaction in the aggressive situations, the forms of aggression, and the characteristics of the subjects of aggression, as well as the opinions of the adolescents about how a victim of aggression in social networks should respond. The data obtained were analyzed in relation to the influence of three groups of factors: demographics (gender, age); the particularities of their use of social networks (activity, intensity); and their social and psychological well-being (status among classmates, academic success, and real-life bullying experience).

Results and discussion

Our data are grouped into two sections. The first presents the characteristics of the adolescents' use of social networks (activity, intensity, motivation, and self-presentation). The second section examines the experience of a teenager's encounter with aggressive situations on social media: their role (aggressor, victim, or witness); the form of aggression; the characteristics of the subject of aggression; and possible reactions of the victim to the aggression.

1. Characteristics of adolescents' behavior on social networks

This section contains a general description of the adolescents' interaction on social networks. It examines how actively adolescents used social networks, the particularities of their motivation to use the network, and their self-presentation on the network.

Activity and intensity. In the course of the survey, only 2.3% of respondents indicated that they do not use social networks. Thus, online communication is already an everyday reality for modern schoolchildren. At the same time, questions arose about the activity and intensity of network communication.

The answer to the question about the teens' activity on social networks required the adolescents' self-assessment of their involvement on the social network (how much they monitor their account, make changes, etc.). Almost half of the respondents (48.6%) noted that they are "moderate users," indicating that they update their page from time to time and communicate with friends. About a third of adolescents (30.8%) identified themselves as "active users:" they constantly monitored their account, updated it, participated in active correspondence, and looked for new friends. A tenth (13.3%) noted that they used social networks "from time to time," rarely updated their pages, and only visited it as needed. And only a few (5.0%) indicated that they rarely used social networks and had never updated their page.

When analyzing the data, we paid particular attention to the connection between the activity of using social networks and the adolescent's self-assessment of his status among his or her classmates (*Figure 1*).

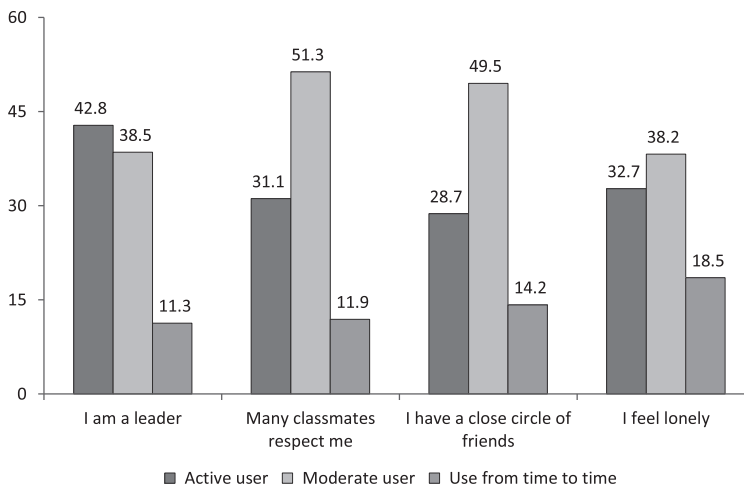


Figure 1. Adolescents' activity on social media depending on their social status among classmates (%)

As is shown in the figure, the highest proportion of active users was among those adolescents who considered themselves "leaders;" students with "average status" were more likely to identify themselves as moderate users; "loners" were more likely to indicate that they used social networks from time to time. These data show that network activity reflects the distribution of status in the adolescents' real interpersonal communication. In this respect, the online environment is a significant social space,

and teenage “leaders” aspire to take over this information field and establish themselves in it.

Responses on the *intensity* of using social networks (the time that adolescents devote to social networks during the day) showed that more than a third of students (35.2%) devoted 1-3 hours daily to this activity. About a quarter spent 5 or more hours (25.7%) and from 3 to 5 hours (25.6%) on social networks. Only 13.5% of respondents spent less than an hour a day on social networking. It is worth noting that the proportion of such answers was significantly higher among boys: 21.3% spent less than an hour on the networks, while among girls it was just 8.2%.

The share of schoolchildren who intensively communicated on social networks (from 3 to 5 hours or more) consistently increased during their time in secondary school: among seventh graders, the figure was 45.3%, and by the 9th grade, it was already 54.6%. However, by the end of school, the intensity of network communication was somewhat reduced (to 52.0%).

It should be specially noted that adolescents with low personal status among the classmates (feel “lonely”) were more likely than others to spend more than 5 hours on social networks (36.0%). The same tendency manifested itself among those schoolchildren who in real life participated in fights and were subjected to psychological and physical violence. This leads to the conclusion that communication on social networks performs a certain socio-compensatory function for a significant number of adolescents. In this regard, a large amount of time spent on network communication (more than 5 hours per day) is typical for those adolescents who assess their personal status in the class as low, as well as those participating in fights in real life and those subjected to psychological and physical violence (bullying).

Motivation. The impact of social networks was largely determined by the goals and motives which guided the adolescents in using them. During the survey, the respondents were asked about their motivation for the use of social networks. The distribution of answers is shown in *Table 1*.

Table 1
Motives for using social networks (%)

	Average	Male	Female
To have fun	47.5	51.8	44.6
To improve educational level	23.8	22.7	24.7
To master new skills	17.7	18.3	17.3
To receive the necessary information	44.5	42.1	46.6
Boredom	43.6	44.7	43.1
Conflicts and difficulties in real life	7.8	5.2	9.4
The possibility to freely express your point of view	11.9	10.8	12.6
To communicate	61.9	56.4	66.2
The opportunity to make money	7.1	8.6	6.1
To meet new people	24.1	20.6	26.4
The ability to do things that are not available in real life (online excursions, communication with foreigners, etc.)	9.4	7.6	10.8
To keep abreast of events	42.3	37.4	46.0

Comparative analysis of gender differences (see *Table 1*) showed that boys were more likely than girls to be guided by “the desire to have fun,” “the desire to master new skills,” and “opportunities to make money.” Girls, on the other hand, more often pointed to such motives as “the desire to communicate,” “to receive information,” and “the desire to keep abreast of events,” “to meet new people,” and “to escape conflicts in real life.”

It should be noted that, with age, the importance of the informational and educational motives increased, and the frequency of choosing such a motive as “boredom” decreased. This indicates that by the time of graduation, social networks more often appeared as information resources, and not just as a way to “kill time.”

As expected, the schoolchildren with high academic performance were more focused on educational motives, and the desire to communicate and realize what is not available in real life. Low-performing students were more likely to be driven by boredom, a desire to make new acquaintances, and a desire to earn money.

In the context of this article, the analysis of the influence of the adolescent’s assessment of his personal status in the class on his motivation for social networking was of particular interest. Thus, schoolchildren with a low social status (those who “feel lonely” and those whose “social circle is limited”) more often noted that they turned to social networks “out of boredom” (respectively: 53.5% and 51.5%) than their more popular peers did (37.7% among those who were “respected” and 33.5% among “leaders”).

Typically, it was conflicts in real life that became the reason for turning to social networks among those adolescents who felt lonely in their class: 23.6% gave that reason (among those whom “many respect,” the percentage was 4.8%; among the “leaders,” 5.8%). “Lonely” adolescents also more often used social networks for the opportunity to express their point of view: 18.2%, compared to 10.3% among the “respected,” and 10.8% among the “leaders.” In addition, “loners” were more interested in the possibilities of social networks that were associated with “realizing goals that are not available in real life:” 14.3%, compared with 10.6% among “leaders” and 9.0% among “respected.”

Finally, it should be noted that the adolescents who identified themselves as leaders were more likely to view social media as an educational resource. They were more often guided by “the desire to improve their educational level” — 31.4%, compared with 21.3% among adolescents with a lower social status — and the desire to master new skills — 21.3%, compared with 16.7% among “having a limited circle of friends.”

Thus, our data gave support for identifying two different orientations: 1) schoolchildren with a low self-esteem and personal status among classmates seeing social networks as a way to compensate for negative trends in real life and overcome the barriers to self-realization (overcoming boredom, avoiding conflicts, the ability to express their point of view); and 2) then socially successful schoolchildren using the capabilities of social networks as an educational resource.

Self-presentation. One of the important features of social networks is the relative freedom to choose a behavioral pattern and present oneself in the space of network

communication. In this regard, the adolescents were asked to characterize their page on the social network from the point of view of its perception by other users, choosing among several proposed options.

The overwhelming majority (82.8%) classified their page as “ordinary.”

At the same time, the additional characteristics used by the respondents were also important, since self-presentation on the network makes it possible to clarify the target of the adolescent’s communication. Thus, about a third (29.7%) noted that their page was “interesting only for friends,” and a quarter of the respondents (24.7%) described their page as “reserved.” Only 8.4% of the schoolchildren thought that their page might be of interest to strangers; 7.3% thought their page was “useful;” 5.3% considered their page to be “extraordinary;” 3.1%, “expansive;” and 1.7% “provocative.”

Note that the distribution of the answers was grouped around two contrasting orientations. One of them was “friends vs. strangers.” Here we can see that, in general, the schoolchildren had a predominant orientation toward maintaining communication with a close circle (“friends”). Moreover, this was typical for a third of the respondents. At the same time, almost one in five was clearly focused on contact with strangers, trying to “attract” or “interest” them. Here another tendency characteristic of adolescence was manifested — “the expansion of the social environment.” Another contrast concerned emotional manifestations: “reserved vs. expansive.” If every fourth teen was inclined to be quite reserved when communicating on the network, then every tenth, on the contrary, was focused on presenting himself in situations of network communication as “extraordinary,” “expansive,” or “provocative.”

A special analysis of our data on the activity and intensity of using the network showed that adolescents who considered themselves to be active users more often noted that their profile was attractive to both friends and strangers, and that it was “useful.” Moreover, active users more often, compared to those who pay less attention to social networks, classified their page as “extraordinary,” “expansive,” and “provocative.” The same tendencies were also characteristic of the intensity of Internet use: adolescents who spent more time on the social networks tended to classify their page as “expansive,” “extraordinary,” “provocative,” or “attractive to unfamiliar users.”

It is important to pay attention to the fact that adolescents with both high and low status among classmates, more often than adolescents with an average status, characterized their page as “expansive,” “extraordinary,” and “provocative.” At the same time, in contrast to students with a low status among classmates, leaders more often classified their page as “useful.” Of fundamental importance in the context of this article was the fact that adolescents who had been bullied in real life were much more likely to refer to their page as “expansive,” “extraordinary,” and “provocative.” This leads to the conclusion that the communication on social networks plays a compensatory role for a significant number of students subjected to school bullying.

2. *The experience of facing aggression and cyberbullying on social networks*

This section is devoted to the adolescents' experience of direct encounters with aggressive situations on social networks. Here we will consider the points related to the role of the teenager ("aggressor", "victim", or "witness") in such situations; the forms of aggression ("privacy vs. publicity"); the characteristics of the subject of the aggression ("familiar vs. unfamiliar"); and opinions on how a victim of aggression should behave on social networks (ignore aggression, confront it, or seek help).

Role in the aggressive situation. Slightly less than half of the surveyed schoolchildren (43.8%) indicated that they did not encounter interpersonal aggression on social networks. For the rest, aggression on social networks was a fairly widespread phenomenon: every fourth person (24.4%) faced "aggression towards themselves from other users;" almost the same number (26.6%) indicated that they "witnessed aggression against other users;" relatively few (5.2%) admitted that "they themselves acted as an aggressor against other users."

Analysis of gender specifics showed that network interaction among boys was more aggressive: they more often noted that they had had an experience of being both the aggressor (7.0% for boys vs. 4.0% for girls) and the victim (respectively: 26.6% for boys and 22.8% for girls). Girls more often indicated that they had not encountered interpersonal aggression on social networks (46.3% vs. 40.1% for boys).

The study of age dynamics showed an increase in the aggressiveness on social networks over the course of education in junior high school. This was evidenced by the decrease in the proportion of students who had never encountered aggression: 47.1% in the 7th grade and 41.4% in the 9th grade. This was mainly due to an increase in the proportion of "witnesses" of network aggression from the 7th to the 9th grade (respectively: 21.9% and 26.9%).

The academic success of a teenager also affected the level of aggressiveness of his network environment. Thus, among the "C-graders," the share of "victims" of aggression (26.9% vs. 21.2% for "A-graders") and "aggressors" (7.1% vs. 3.6% for "A-graders") was somewhat higher than among "A-graders." Thus, low academic success was generally associated with situations of increased aggressive behavior on social networks. This coheres with the results of Kowalski & Limber's research, which stated that adolescents in the cyber bully/victim group had the most negative scores on most measures of psychological health, physical health, and academic performance (Kowalski & Limber, 2013).

The most significant differences related to the adolescents' assessment of their status among classmates. Popular adolescents more often indicated that they had not had to deal with cases of aggression in social networks (46.9% among the "leaders," compared to 30.7% among the "loners"). Moreover, among the "loners," 38.6% noted that they had been objects of aggression from other network users, but among the "respected" students, this number was almost two times less — 20.7%.

These data give grounds for the assumption that adolescent aggression in real life is carried over to situations of network communication: the interpersonal status of a teenager in school also affected the attitude toward him or her in network communication. For this purpose, we carried out a special analysis to compare the

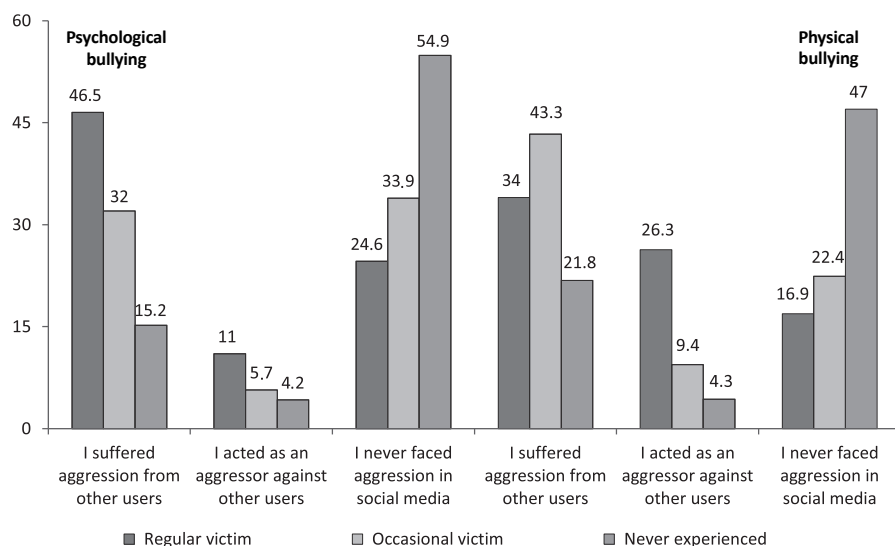


Figure 2. Adolescents' encounter with aggressive situations on social media depending on their real-life bullying experience (%)

frequency of experiencing psychological or physical violence (bullying) in real life and the role of the adolescent in network aggression (victim, aggressor, or witness) (see Figure 2).

The data presented in the figure show that teenager's experience of psychological or physical bullying increased the likelihood of his or her participation in situations of network aggression in the role of both the victim and the offender. In this regard, our results correspond with those of prior studies (Raskauskas & Stoltz, 2007; Smith, Mahdavi, Carvalho, Fisher, Russel, & Tippett, 2008; Fanti, Demetriou, & Hawa, 2012; Kowalski & Limber, 2013), which showed that the traditional victims and bullies are likely to retain their roles across the contexts of school and the cyber world. However, in those studies the possibility that adolescents who are victimized at school would become electronic bullies was not supported, whereas our data clearly shows the higher rates of cyber aggressors among those who had suffered from psychological and especially physical bullying at school.

Form of aggression. In order to clarify the features of network aggression, those adolescents who indicated that they were "victims" of aggression were asked to specify in what form it was expressed. The majority (55.0%) answered that they received personal messages containing insults, ridicule, harassment, threats, etc. More than a third of respondents (36.5%) indicated that the aggression consisted in public "show-downs" with other users ("holy wars," "flaming," "hating," "trolling," etc.); 8.5% noted that the aggression was expressed in public posts, containing insults, mockery, harassment, threats, etc.

Boys more often indicated that the aggression was expressed in public confrontations (41.9% compared to 32.2% for girls); girls, on the other hand, more often noted that the aggression was manifested in private messages (60.2% compared to 48.4% for boys). In our opinion, such results are a consequence of traditional differences in the

forms of aggressive behavior between the male and female subcultures: among boys we more often observe open public confrontations (“duels”), while for girls, individual-personal (“hidden”) aggression is more common.

It should be noted that the answers about the forms of manifestation of aggression in the network did not vary with the socio-demographic and sociocultural factors. At the same time, it is noteworthy that adolescents with low academic performance and low interpersonal status in the classroom more often noted that aggression expressed towards them came in the form of public posts; and those who had suffered psychological and physical bullying in real life more often indicated the public nature of the network aggression. In general, this allows us to conclude that the space of network communication turns out to be an important medium of very public pressure on the individual.

Subject of aggression. Another aspect of aggressive behavior on social media concerns the characteristics of the aggressor in relation to the parameter of his anonymity (more precisely: “familiar vs. unfamiliar”). Most of the adolescents who had been subjected to aggression indicated that the aggression came from unfamiliar users (63.7%); almost every fifth teen (17.8%) noted that it was someone from their real contacts; every tenth (11.9%) became a victim of aggression from a group of unfamiliar users; and 6.6% were subjected to aggression by a group of real acquaintances. Thus, three quarters of those subjected to aggression on the network indicated that it came from strangers.

Gender analysis showed that boys more often than girls faced aggression from unknown users (respectively: 69.7% and 59.1%) or a group of unknown users (respectively: 13.1% and 10.9%). Girls, on the other hand, more often pointed to aggression on social networks from their real acquaintances — 21.5% (it is 13.2% for boys) — or a group of real acquaintances (8.5% and 4.0%, respectively).

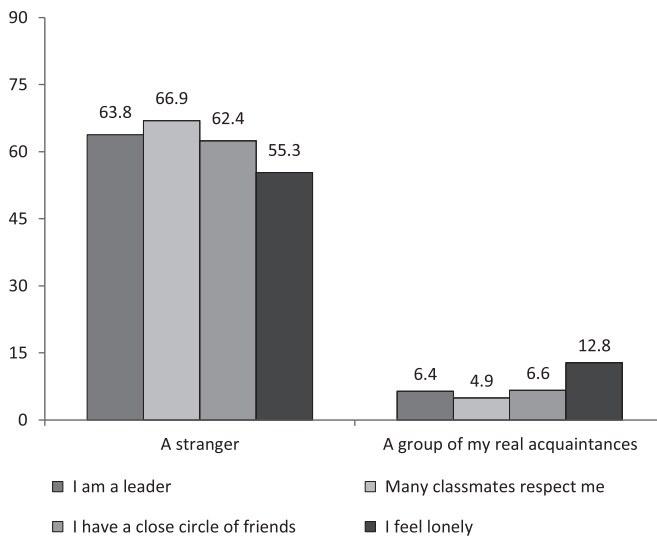


Figure 3. Aggressor's specifics depending on adolescents' social status among classmates (%)

The proportion of strangers among the aggressors increased with the students' age (from 63.4% in the 7th grade to 68.8% in the 11th grade), and the cases of aggression from real acquaintances decreased (respectively: 17.1% and 13.8%). In principle, our data indicated that the general age tendency associated with the "expansion of the social environment" of the adolescent, in situations of network communication, was often associated with the risk of aggression on the part of strangers.

In this regard, the manifestation of aggression on the network on the part of "acquaintances / strangers" in relation to the adolescents' different interpersonal status among their classmates is of particular interest (see *Figure 3*).

Students who "feel lonely," compared to their more popular peers, were less likely to indicate that they experienced aggression from strangers, but more often that they had been the victim of aggression from a group of real acquaintances. It can be assumed that in this case, we are dealing with cyberbullying, when bullying moves from the real to the virtual space, keeping the same roles for the parties to the conflict.

Victim reaction. An important aspect of behavior that relates specifically to adolescent cyberbullying is the definition of how a victim should behave in such a situation: ignore aggression, respond in the same way, or seek help.

About a third of respondents (31.3%) believed that aggression on social networks should be ignored. One fifth (20.6%) considered it necessary to complain to the administration of the social network; 16.1% pointed to the need to tell their parents about it; 12.9% believed that it was necessary to inform the police. One tenth of adolescents (8.2%) thought that this should be shared with friends; 6.3% believed that they should respond in kind; 4.7% believed that in such a situation, it was necessary to turn to teachers for help. Comparing these with the results of previous research (Smith, Mahdavi, Carvalho, Fisher, Russel, & Tippett, 2008), we can see that the most popular strategies pupils advocated for cyberbullying was still avoidance.

Boys more often than girls, answered that such aggression should be ignored (respectively: 59.5% and 49.1%) or be responded to in kind (respectively: 13.7% and 8.6%). Girls, in turn, more often tended to seek help from the network administration (respectively: 39.1% and 29.2%), their parents (respectively: 34.7% and 16.2%), or the police (respectively: 26.1% and 15.5%).

Throughout secondary school, the students were more often focused on responding to aggression on social networks in kind, or telling teachers about its manifestations. By the time they graduated from school, they were more likely to seek help from the network administration (40.6% in the 11th grade compared to 29.4% in the 7th grade) or from the police (25.6% and 19.9%, respectively).

Students with a lower level of academic performance were more likely to respond with aggression to aggression (12.9% among C students, 9.5% among B students, 8.8% among A students), while students who demonstrated a high level of academic performance were more focused on notifying the network administration (41.2% among excellent students, 37.9% among B students, and 29.3% among C students), parents (34.2%, 29.4%, and 22.2%, respectively), and friends (respectively: 16.3%, 14.5%, and 12.1%).

Teens who had participated in fights during the past two months were more likely to respond that aggression on social media should be ignored (54.7% versus 51.0%

among those who do not fight) or responded to in kind (respectively: 20.6% vs. 7.6%). Those who had never fought were inclined to resolve the situation of the aggression towards them in by involving their parents (32.3% compared to 18.4% among those who had participated in fights in the last two months), the network administration (respectively: 39.6 % vs. 25.8%), and the police (respectively: 24.9% vs. 16.5%).

Finally, victims of regular bullying were less likely to focus on turning to the police in case of network aggression than those who were bullied occasionally or never (19.0% of victims of regular psychological bullying versus 21.7% and 22.4%; 14.2% among victims of physical bullying, compared with 19.6% and 22.4%, respectively). Teens who experienced bullying were more likely to point out that they should respond in kind to online bullying. Those who had been regularly exposed to aggression were less focused on telling their parents about what happened or informing the police.

In general, the above data show that the choice of a method of responding to aggression in a situation of network interaction is largely determined both by the influence of gender and age factors, and by the experience of resolving conflict situations in situations of real interaction.

Conclusion

The analysis of our results showed that social networks play an important role in the daily life of a modern Russian teenager. Summarizing the results of the study, we highlight the following main conclusions:

1. The parameters characterizing the characteristics of adolescents' involvement in network communication (activity and intensity of use, motivation, self-presentation) are largely determined by gender and age, as well as socio-psychological factors (academic success and self-assessed status among classmates).
2. The activity and intensity of adolescents' behavior on social networks are correlated with their positions in the hierarchy of status in their real interpersonal communication. Moreover, there are two different orientations: when socially successful, schoolchildren use the possibilities of the social network as an important educational resource; but for schoolchildren with a low status in school, social networks perform an important compensatory function. This tendency is especially pronounced among a significant number of students who are subjected to school bullying.
3. The manifestation of aggression on social networks is quite common. At the same time, traditional differences in the forms of aggressive behavior in male and female subcultures are found here: if boys more often point to the public nature of network aggression, then girls tend to express aggression in the form of private messages. Of interest is the age-related dynamics of manifestations of network aggression in the context of general psychological ideas about the tendency of "expanding the social environment" in adolescence. The increase in aggressive manifestations on the part of unfamiliar network participants as the teens age indicates that the realization of the basic age-related need for "expanding the social environment" in situations of network communication is associated with the risks of encountering unfriendly, aggressive reactions.

4. The social status of a teenager among his or her classmates also significantly affects his or her encounters with aggression during network interaction. It has been established that manifestations of aggression in real life are carried over to situations of network communication, resulting in the same roles for the parties to the conflict. A teenager's experience of psychological or physical bullying increases the likelihood of his participation in situations of network aggression in the role of both victim and offender. In this regard, it is quite indicative that adolescents who "feel lonely among their classmates" more often report aggression towards themselves from a group of real acquaintances. These features characterize adolescent cyberbullying, when group bullying moves from real to virtual space, where it becomes public.

Limitations

The limitation of this research was the number of analyzed factors. We haven't yet explored the connection between adolescent aggression on social media and their deviant behavior, as well as value orientations. Furthermore, we didn't analyze the correlation between teenagers' aggression on social networks with their extremist attitudes. We expect aggressive behavior to be a part of a larger set of attitudes.

Based on the data we presented in this work, we feel that closer study of adolescents who are in the at-risk group — those with low status among classmates and those who have had bullying experience — would be extremely useful for predicting, and possibly preventing, teenage cyber aggression.

Also, an expansion of the age span of the sample would provide a more thorough study of the origin and development of teenager aggression on social media.

Ethics Statement

The ethical aspects of the study were discussed at a meeting of the Center for Sociology of Education of the "Institute of Education Management of the Russian Academy of Education" (March 2020) and approved by the Department of Children's Rights Protection of the Ministry of Education of the Russian Federation.

Informed Consent from the Participants' Legal Guardians (if the participants were minors)

The survey was conducted anonymously via electronic media. The participants and their legal guardians were informed by the school authorities about the purpose and the procedure of the study, and they gave their voluntary consent by participating in it.

Author Contributions

Both authors contributed equally to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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