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On the 120th anniversary of P.Ya. Galperin

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ON THE 120TH ANNIVERSARY OF P.YA. GALPERIN

The Scientific Biography of P.Ya. Galperin: Stages of Life and Creative Work

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Background. This article is dedicated to the 120th anniversary of the birth of Piotr Yakovlevich Galperin (1902–1988), an outstanding Soviet psychologist, the author of an original psychological concept and scientific school, and an organizer of psychological science.

Objective. To reconstruct the main stages of the scientific biography of Piotr Yakovlevich Galperin.

Results. The paper demonstrates the internal logic of P.Ya. Galperin's developing scientific views in creating the theory of stage-by-stage formation of mental actions and concepts, which analyzes the process of formation of the main components of mental activity and develops a system of conditions for transforming an objective action into a psychological phenomenon.

This biography is based on Galperin's publications and speeches, memoirs of associates and family members, and numerous archival materials.

All the periods of Galperin's life are presented, reflecting his participation, starting from the mid-1920s, in scientific and scientific-practical events. Particular attention is paid to Galperin's work at M.V. Lomonosov Moscow State University (MGU): 55 years of Galperin's professional and personal life (from 1943 until his death in 1988) were associated with the Philosophy Faculty, and then with the Psychology Faculty.

Conclusion. The importance of preserving P.Ya. Galperin's scientific legacy is shown and steps taken in this direction are indicated.

Keywords:

History of psychology, Lomonosov Moscow State University, MGU, scientific biography of P.Ya. Galperin, P.Ya. Galperin's theory of stage-by-stage formation of mental actions and concepts, general psychological theory of activity, non-classical psychology

*The greatest use of a life is to spend
it for something that outlasts it.*

W. James

This year, 2022, marks the 120-year jubilee of Piotr Yakovlevich Galperin (October 2, 1902 — March 25, 1988) and the 70th anniversary of the first official mention of a new psychological approach, the orienting function of the psyche as a subject of psychological research. These anniversaries are a worthy occasion to look at Galperin's scientific legacy, to recognize his philosophical and psychological ideas and their subsequent influence on science and practice, as well as the facts of his scientific biography, which reflects milestones in the development of Soviet psychological thought.

On the 90th anniversary of Galperin's birth, V.P. Zinchenko wrote an article in the journal *Voprosy psikhologii* [Questions of Psychology] titled "A word about a Teacher": he acknowledged with regret that a scientific biography of P.Ya. Galperin had not yet been written. Zinchenko noted: "I cannot claim to describe it, since I was not his direct student, although I consider him my teacher" (Zinchenko, 1993, p. 89). Three decades later, on the 120th anniversary of Galperin's birth, we are only approaching a solution to this difficult task, and the compilation of a complete scientific biography of Galperin, encompassing all periods of his life equally, is still a matter for the future. Not all the archives have yet been sorted out, and not all the research performed under Galperin's direction has been carefully analyzed.

A brief essay about Galperin, titled "A teacher from the galaxy of sages," was written by L.F. Obukhova for the book *Outstanding psychologists of Moscow* (Obukhova, 2007), which has gone through two editions. Information about the stages of Galperin's creative work can be found in articles by L.I. Aidarova (2002), A.N. Zhdan (2007, 2017, 2018), V.P. Zinchenko (1993, 2021; *Stil' myshleniia...*, 2011), N.N. Nechaev (2003, 2012), A.I. Podolskii (2002, 2007, 2017), A.N. Sidneva (2019), M.A. Stepanova (2012, 2016, 2020), and others.

We should note that a scientific biography is inseparable from a personal one, and this is true not only for Galperin. An example is the recently published biography of N.A. Bernshtein by I.E. Sirotkina (2021). A.R. Luria, in his scientific autobiography *Stages of the road traveled*, wrote that "in this book there is no hero with exceptional abilities; there is neither specific talent nor tragedy. But there is an atmosphere of real life..." (Luria, 1982, p. 181). Biographers of A.N. Leontiev quote him as saying: "A scientific autobiography cannot, it seems to me, be limited to the official list of completed works. Personally, I have always been more interested in *subjective aspects* of the descriptions of scientists' lives: *how the scientist came to science*; the inner motives of his scientific life; how *he himself perceived* its events and what subjectively acted upon him — at one stage or another — as a 'discovery' made by him" (emphasis added — M.S.) (Leontiev et al., 2005, p. 8). The outstanding Russian thinker D. Merezhkovskii (2007) called attention to the importance of a subjective view of a writer's life, a point which is also true of a scientist.

It is this approach that seems the most productive, and it formed the basis of P.Ya. Galperin's scientific biography.

Family and Education

P.Ya. Galperin was born on October 2 (new style), 1902 in Tambov. His father, Iakov Abramovich Galperin, was a district doctor at that time, and later became a well-known neurosurgeon and otolaryngologist. In 1911, the family moved to Kharkov, where his father taught at the Medical Institute and in 1930 became a professor in the Ear, Nose, and Throat Department; he died in 1937 (according to some sources, in 1938). P.Ya. Galperin's daughter Sof'ia Petrovna wrote in her memoirs that Piotr Yakovlevich tried all his life to imitate his father, and for years developed the habit of restraining himself and making compromises.

His mother, Sof'ia Moiseevna Galperina (née Margulis), was a housewife; she died in 1917. After their mother's death, there were three children left in the family: two sons (Piotr Yakovlevich, born in 1902; Teodor Yakovlevich, born in 1904) and a daughter (Polina Iakovlevna, born in 1908). Anna Ivanovna, an employee of Ia.A. Galperin, became their stepmother; she treated the children as if they were her own, but herself bore no children. Anna Ivanovna outlived her husband and died in 1961; she was buried in Kharkov next to Iakov Abramovich Galperin.

P.Ya. Galperin attended the classical gymnasium of the Society of Working Women in Kharkov, at which boys and girls were taught together. One of Galperin's classmates was Tamara Izrailevna Meerzon, who later became his wife. He dedicated to her his only book published during his lifetime, *Introduction to psychology*: "To my dear friend, my wife, Tamara Izrailevna Meerzon." In the gymnasium there were various groups for the study of socio-political and social sciences. Galperin attended a philosophical group led by Professor Stolpner, a translator of Hegel's works into Russian. We can assume that this had an impact on the formation of the professional views and attitudes of the future psychologist.

In his youth, Galperin read books on philosophy and psychology that were in his father's library, which even then aroused in him a desire to search for a method of objective study of human thinking. An attempt to implement this idea subsequently resulted in the study of optical illusions, on which Galperin prepared a short article for the German psychological journal *Zeitschrift für Psychologie* (Galperin, 1931). Later Galperin recognized the scientific limitations of that first study, but he did not abandon the search for an objective approach to mental life.

On the emphatic recommendation of his father, who advised him not to choose philosophy or psychology for his profession, P.Ya. Galperin followed his father's example and from 1921 to 1926 studied at the Kharkov Medical Institute, specializing in psychoneurology. In 1924, while a student, he began scientific work at the Department of Nervous Diseases. Under the influence of Professor K.I. Platonov, who used hypnosis to treat neuroses and instead of anesthesia during operations, Galperin began to study the effect of hypnosis on digestive leukocytes. The results of the study formed the basis of Galperin's first scientific publication (with P.P. Istomin) in 1926 in the Ukrainian *Bulletin of Reflexology* (in Ukrainian). These studies were not continued, but they contributed to the development of his interest in experimental research.

The Beginning of a Professional Path

After graduating from the Institute in 1926, Galperin began a medical practice in an evening outpatient clinic and treatment center for drug addicts, treating mainly alcoholics, as well as morphine addicts, cocaine addicts, and others. Galperin suggested that a metabolic disorder is the basis of drug addiction. He translated from German the book *Treatment of drug addictions* and wrote a preface to it, "Outpatient treatment of alcoholics," which described the organic aspect of drug addiction (Galperin, 1930).

In 1928, Galperin was invited to work in the psychoneurological laboratory, which, like the addiction clinic, was part of the Ukrainian Psychoneurological Institute in Kharkov. Galperin's publications during those years indicate that he was actively engaged in medical practice, and the results he achieved were the subject of subsequent analysis.

In 1932, the Ukrainian Psychoneurological Academy was formed, as a result of the merger of the Ukrainian Psychoneurological Institute with the Ukrainian Institute of Psychiatry and Psychohygiene, and the creation of a number of new institutions. Around the same time, the People's Commissariat of Health of Ukraine decided to organize at the Ukrainian Psychoneurological Institute, and then in 1932 at the Psychoneurological Academy, a Division of Psychology, headed by A.N. Leontiev. The researchers in the psychological division of the Academy were A.R. Luria, A.N. Leontiev, P.Ya. Galperin, A.V. Zaporozhets, L.I. Bozhovich, M.S. Lebedinskii, F.A. Khazina, F.V. Bassin, V.I. Asnin, P.I. Zinchenko, V.S. Stepanova, L.P. Odarich, E.I. Artyukh, and G.D. Lukov.¹ Galperin headed the Section on the General Theory of Psychology, the task of which was to work on the main theoretical problems. In 1934, he wrote, "At present, these tasks are being implemented by defining the subject matter of psychology and, even more precisely, addressing the relationship between the subject matter of psychology and physiology" (Galperin, 1934, p. 35). Galperin already saw the problem of determining the subject matter of psychology as extremely important.

According to Galperin's recollections, he worked at first with A.R. Luria (Luria soon returned to Moscow), and then joined the Leontiev group. The Kharkov psychologists and graduate students of the Pedagogical Institute and the Research Institute of Pedagogy began to group around Leontiev, and thus the famous Kharkov School of Psychology emerged, with Leontiev as its leader. According to V.P. Zinchenko, there were no ordinary students in this school, and each of the psychologists had their own role to play: A.N. Leontiev — the leader, A.V. Zaporozhets — the conscience, A.R. Luria — the genius, D.B. El'konin — a scientific temperament, P.Ya. Galperin — the teacher. V.P. Zinchenko recalls that people went to Galperin to ask for advice in difficult situations: "Piotr Yakovlevich was ... recognized as a teacher. L.I. Bozhovich, A.V. Zaporozhets, P.I. Zinchenko, D.B. El'konin, and many others ... said that it was necessary to go consult with the teacher.... The next generations also went to him. ... It is hardly necessary to say that Piotr Yakovlevich did not always approve of what he heard. But he was an excellent listener. When, after his sometimes harsh, but kindly

¹ The data are taken from the personal archive of P.Ya. Galperin.

and ironically expressed criticism, I went to my immediate teacher A.V. Zaporozhets, discouraged; he consoled me with a smile, saying that he also rarely got to hear compliments from Piotr Yakovlevich” (Zinchenko, 1993, p. 90).

In Galperin’s personal papers there is a document indicating that, at least until February 1936, he remained an associate professor of psychology at the Kharkov Pedagogical Institute. After 1936, Galperin recalls, the Psychology Department was significantly cut back, and he had to transfer to the psychiatric clinic at the Department of Chronic Diseases. From the middle of 1936 until the war began, Galperin was mainly engaged in psychiatry, that is, he worked in his acquired specialty.

Galperin was also actively engaged in teaching in those years. In his autobiography, he writes that his teaching career is officially counted from January 1933, when he began teaching dialectical and historical materialism at the Personnel Institute of the Psychoneurological Academy. He recalls that throughout his life, he paid great attention to teaching, since communication with students contributed to the formation of his own scientific worldview.

On the Role of Practical Action

In the mid-'30s. Galperin began writing his candidate dissertation on the difference between tools used by humans and animals, and defended it on December 9, 1936 before the Medical Scientific Council of the Psychoneurological Institute. This research was performed under the instruction of the Psychology Department of the Ukrainian Psychoneurological Academy to study “the development of thinking, speech, and practical activity in their interconnection and relationship to other psychological functions at different developmental levels...” (Galperin, 1934, p. 34).

Preserved in Galperin’s personal archive is a version of the dissertation entitled “The difference between human tools and auxiliary aids of animals (experimental psychological research)”; the work is 87 printed pages with illustrations. The title page says: Ukrainian Psychoneurological Academy — President Prof. L.L. Rokhlin, Institute of Experimental Psychoneurology — Directorate: Dr. Z.Yu. Svetnik and Dr. M.O. Kleiman, Section of the General Theory of Psychology — head associate professor P.Ya. Galperin. Later Galperin included the dissertation on the list of his scientific works under a different title, “On the psychological difference between human tools and auxiliary aids of animals.” The official opponents were Professor T.I. Iudin² and Professor M.S. Lebedinskii.³

The degree of Candidate of Medical Sciences was awarded by the Higher Attestation Commission only in 1938, since the subject of research chosen by the author was far from medical science. Nevertheless, in 1940 Galperin was confirmed in the academic rank of associate professor in the Department of Pedagogy.

Galperin performed an experimental study of the use of tools by humans and auxiliary aids by animals with the objective, first, to determine the difference between manual operations and tool use, and, second, to clarify the sequence and reasons for

² Tikhon Ivanovich Iudin (1879–1949) — Russian psychiatrist and historian of Russian psychiatry.

³ Mark Samuilovich Lebedinskii (1894/or1895–1980) — Soviet psychotherapist, in those years a researcher in the psychology sector.

the development and change of operations. The use of certain objects by animals, Galperin notes, does credit to their mental abilities and shows that their behavior demonstrates reason. “But this is reason about manual operations; it does not encompass the social usage of objects; it subordinates things to the logic of manual action. It is an instinctive reason ... which is limited to discerning the possibility of a mere extension of the arm” (Galperin, 1998, p. 56). The replacement of manual operations by tools leads to a transition of thinking from the path of its biological development, limited by a direct relationship to nature, to a path of development that is “social, mediated by labor and speech and unlimited in its perspective, just as practical human activity is not limited in its perspective and is based on the development of tools” (Galperin, 1998, p. 93). It is not reason that causes a transition from manual operations to tool-based ones, but the opposite: the replacement of manual operations by tools restructures thinking.

Unfortunately, it must be recognized that this work has not yet received its due appreciation, although an abridged form was included in collections of P.Ya. Galperin’s posthumously published works. According to V.P. Zinchenko, “this is the first, without exaggeration, cornerstone of activity theory” (Zinchenko, 2002, p. 122), which “can be confidently called a prolegomenon to psychological activity theory and a test of strength in its experimental substantiation. It convincingly shows the birth of thinking out of practical action and its tasks” (Zinchenko, 2002, p. 121). What V.P. Zinchenko said in the year of Galperin’s 100th jubilee prompts us to turn to one of the first of Galperin’s studies and to work out the internal logic of his scientific views.

The War Years: Studies on the Restoration of Movement

V.P. Zinchenko asserts that Galperin’s aforementioned studies of children’s tool-mediated activity played an important role in the practical activities of psychologists to restore the movement of those wounded during the Great Patriotic War.

During the war, the Kharkov (Ukrainian) Psychoneurological Institute was turned into a psychoneurological hospital and was evacuated to Tiumen, where Galperin worked as an intern in the neurosurgical department of the hospital from September 1941 through February 1943. Then Galperin moved to the town of Kaurovka, in Sverdlovsk Oblast, where A.N. Leontiev had created a rehabilitation center for restoring movement after injuries. According to Leontiev’s biographers, those working with him also included A.V. Zaporozhets, S.Ia. Rubinstein, T.O. Ginevskaia, Ia.Z. Neverovich, A.G. Komm, V.S. Merlin, among others. Galperin became the head of the medical unit of the rehabilitation hospital. Leontiev’s biography says that he returned from evacuation in the summer of 1943, and Galperin a little later, in October of the same year.

From then on, from the end of February 1943 until the end of his life, Galperin was on the staff of Moscow University. His first scientific research at the university was devoted to psychological problems of restoring motor functions after injury.

On February 14–16, 1943, the joint 11th Session of the Ukrainian Psychoneurological Institute and the Second Conference of Neurosurgeons, Neuropathologists,

and Psychiatrists of the Ural Military District was held in Tiumen, on the 25th anniversary of the Red Army and the Navy. Galperin gave a report on “The experience of constructing a system of meaningful movements in remedial physical therapy.” He noted that the movement of an affected limb toward an objective target is much more effective than movements performed without any purpose.

Subsequently, in June 1944, the MGU Psychology Department, together with the Institute of Psychology of the Academy of Psychological Sciences and the Clinic of Nervous Diseases of the All-Union Institute of Experimental Medicine, held a special conference on psychophysiological problems of restoring function — motor, sensory, vocal — after military trauma. Galperin, in an article written with T.O. Ginevskaia titled “Dependence of the amount of movement on the psychological nature of the task,” showed that there is a “sharp and unexpected increase in the productivity of movement, crossing boundaries that had seemed insurmountable, due to a change in *the psychological structure of the task*” (Galperin & Ginevskaia, 1947, p. 79).

Although that 1947 publication gives a fairly complete picture of the content of Galperin’s research in evacuation hospitals, it would be unfair not to mention his other printed documents of that time. In 1945, *Uchenye zapiski MGU im. M.V. Lomonosova* published a volume titled “Movement and activity” (a collection of research from the Department of Psychology, edited by S.L. Rubinstein). This volume included an article by A.N. Leontiev, “Psychological study of movement after hand injury,” which describes the results of work in evacuation hospitals. Leontiev stated that “the phenomenon of changing the amount of mobility of the affected parts of the hand, depending on the task being performed, *was first published by us, by P.Ya. Galperin*” (emphasis added — M.S.) (Dvizhenie..., 1945, p. 92). He also referred to the Proceedings of the Ukrainian Psychoneurological Institute of 1943, which included Galperin’s work “Psychological factors in remedial physical therapy.”

Also in 1945, Leontiev and A.V. Zaporozhets published the book *Restoration of movement. A psychophysiological study of the restoration of hand functions after injury* (Leontiev & Zaporozhets, 1945), which laid out the results of the work at evacuation hospitals, including by Galperin and Ginevskaia. This study by Galperin and Ginevskaia was used as a textbook, shedding light, among other things, on fundamental issues such as the emergence and development of the activity approach in psychology.

Moving to Moscow

The Psychology Department within the MGU Philosophy Faculty⁴ was established on October 1, 1942 by S.L. Rubinstein. Until the autumn of 1943, part of the Psychology Department was in evacuation, and A.N. Leontiev was the head of that part of the department. In 1951, Leontiev was named head of the Psychology Department, remaining at this post until 1966, when the Psychology Department was separated from the Philosophy Faculty and became an independent Faculty.

⁴ A faculty in Russian universities can include several departments (*kafedry*) with a more specific competence — Translator’s note.

In October 1943, Galperin was approved as an associate professor in the Department of Psychology within the Philosophy Faculty, “for research without a teaching load”; the academic title of associate professor was awarded him in 1946.

Galperin’s theory of the stage-by-stage formation of mental actions and concepts, according to the author himself, developed in the late ’40s to early ’50s as a theoretical solution to a practical school-teaching task: to teach students how to perform arithmetic and grammatical operations, historical and aesthetic analysis, in their minds. However, it can be assumed that the *origin* of some *fundamental* ideas, the formation of a *psychological outlook*, had occurred even earlier. In particular, in 1931, there was a “Discussion on the situation on the psychological front” in Khar’kov. Galperin participated and noted the following in his speech: “We must seek *the subject matter of psychology* in the content of such psychological phenomena *as human activity*, and it is with the product of labor (in the broad sense), of human activity, as psychological content, that psychological research should begin (emphasis added –M.S.) (Diskussiia..., 1931, p. 33). Galperin asks about ways to study the content of mental phenomena and explains that since “the psyche *orients* us in fire, water, etc., then the content of mental life must be considered, first of all, in relation to the external world” (emphasis added — M.S.) (Diskussiia..., 1931, p. 33). Thus, the question of the origin and further development of psychology as a science of the orienting nature and function of the psyche is still awaiting comprehensive study.

Galperin presented his theory for the first time in July 1952 at the All-Union Conference on Psychology convened by the Presidium of the RSFSR Academy of Psychological Sciences (a conference on the restructuring of psychological science based on Stalin’s work on linguistics and in light of the decisions of the joint session of the USSR Academy of Sciences and the USSR Academy of Medical Sciences). Galperin was not scheduled to give a report, but he spoke during the debate and set forth a fundamentally different understanding of certain issues of psychology. In his view, there are two lines in psychology: one was that proposed by the author of those remarks with a small number of supporters, and the other was that of the Institute of Psychology of the Academy of Psychological Sciences, with a huge number of supporters. “But ... questions of truth are not decided by voting. Truth reflects objective reality, and reality will show itself and be able to stand up for itself” (Materialy..., 1953, p. 99).

A year later, in July 1953, Galperin delivered a report on “The experience of studying the formation of mental actions in schoolchildren” at a Conference on Questions of Psychology. This was the first detailed and comprehensive presentation by Galperin of his approach to psychology; the report was republished not long ago (Galperin, 2017). In 1955, Galperin took part in two events: the jubilee scientific session in May commemorating the 200th anniversary of the university, and a July conference on psychology.

In 1959, the First Congress of the USSR Society of Psychologists was held in Moscow, at which Galperin gave a report on “The main types of teaching.” The publication in 1959, in the first volume of the academic publication *Psikhologicheskaiia nauka v SSSR*, of his foundational article “Development of research on the formation of mental actions” (Galperin, 1959), may be considered a result of the maturing of his theory

of the formation of mental actions. This article was the first substantiated presentation of the main theses of the hypothesis (that is how the author describes the system of his ideas) of the formation of mental actions, with a detailed description of the stages of formation and the main parameters of action. By that time, under the leadership of Galperin, experimental research had already begun on the initial formation of the motor skill of writing (N.S. Pantina), geometric concepts (N.F. Tal'zina), the concept of number (V.V. Davydov), grammatical concepts (A.N. Dubrovina, M.Ia. Mikulinskaia), elementary mathematical concepts (L.S. Georgiev), and others. All these studies confirmed Galperin's assumptions.

Whereas in 1952 Galperin spoke of the small number of psychologists who shared his view on the origin and nature of human consciousness, a few years later ardent opponents emerged, culminating in a discussion that took place in the late '50s and early '60s in the pages of the journal *Voprosy psikhologii*. The discussion began with an article in the journal by Galperin, "Mental action as the basis for formation of ideas and images" (Galperin, 1957), which argues that mental action is a psychological phenomenon, while its subject matter is not. In a concluding article in 1960, Galperin "answers" Iu.A. Samarin, A.A. Lyublinskaia, N.A. Menchinskaia, and E.N. Kabanova-Meller, and comes to the conclusion "that various phenomena that are cited to refute the hypothesis actually serve as further confirmation of it" (Galperin, 1960, p. 146).

In the first half of the '60s, Galperin conducted new research on the theory of the formation of mental actions. In 1962, he headed a group (later a laboratory) on programmed learning, and at MGU, by order of the Ministry of Higher Education of the RSFSR, an interdepartmental group was created to work on issues of programmed learning.

During those years, Galperin took an active part in meetings of Soviet and foreign psychologists: in 1963 at the Second Congress of the USSR Society of Psychologists held in Leningrad ("The experimental formation of attention," with A.N. Zhdan), in 1964 at the 15th International Congress on Applied Psychology (in Yugoslavia, as part of a delegation), etc.

Research on the Formation of Mental Actions and Concepts at the Moscow University Psychology Faculty

V.P. Zinchenko drew attention to the fact that Galperin, the last of the brilliant galaxy of L.S. Vygotsky's school, became a doctor of science and a full professor.

The Academic Council of the Philosophy Faculty of M.V. Lomonosov MGU appealed to the Higher Attestation Commission to allow a defense for the degree of Doctor of Pedagogical Sciences in Psychology based on the set of published works united by the theme "Formation of mental actions and concepts,"⁵ by Associate Professor Galperin Piotr Yakovlevich. Permission was granted.

The defense took place on May 28, 1965 at the MGU Philosophy Faculty, and according to the recollections of psychologists and philosophers who were present, it became an "event" in the scientific life of the university.

⁵ The defense procedure is described in detail by M.A. Stepanova in "The historical significance of the general psychological theory of P.Ya. Galperin" (Stepanova, 2016).

Galperin treated the defense with a certain irony, and called the “report ... a bureaucratic work, unsuitable for reading, not covering the actual state of affairs and ideas” (from a letter to F.I. Fradkina), and asked “not to place greater demands on it than it deserves” (from a letter to R.G. Natadze) (Galperin, archive).

The transcript of the meeting of the Academic Council on May 28, 1965 (Protocol ...) is preserved in the MGU archive, which makes it possible to reconstruct the procedure of his defense.

In his brief speech, Galperin took up three questions: the psychological structure of human action, psychological mechanisms and laws themselves, and the main method of psychological research.

External comments on Galperin’s published work were prepared by the Psychology Department of Zhdanov Leningrad State University (LGU) and signed by the head of the department, B.G. Anan’ev. Then came the remarks of the first official opponent, B.M. Teplov, and the second official opponent, A.A. Smirnov. The last comments were by G.S. Kostyuk, who, like the two previous speakers, had no fundamental criticisms. The main “criticism” was a complaint that the defense was so late. As V.P. Zinchenko wrote later: “He was coaxed, shamed, and scolded for a long time by friends and students” (Zinchenko, 1993, p. 91). It should be noted that all the speakers emphasized Galperin’s contribution to the development of both general psychology and the psychology of learning.

In conclusion, it should be said that the results of the secret voting were that out of 16 members of the Academic Council present at the meeting, 12 voted “for,” three “against,” and one ballot was invalid.

Galperin’s defense occurred on a memorable day, as Chairman of the Academic Council V.S. Molodtsov said in his speech. It was the same day that the Board of the Ministry of Higher Education decided to create a special Psychology Faculty to replace the Moscow University Psychology Department. Galperin reacted to this event philosophically: on the one hand, he assessed it as very positive, but on the other, with some sadness, since he had assigned a special role to philosophy in the emergence of psychology. Galperin emphasized that he always guided himself by general philosophical methodological problems in psychology, which oriented his work. It should be noted that this idea runs through all of Galperin’s works.

The academic degree of Doctor of Pedagogical⁶ Sciences (MPD Diploma No. 000076) was awarded to P.Ya. Galperin by Decision of the Higher Attestation Commission of January 22, 1966.

After the formation of the Psychology Faculty in 1966, Doctor of Pedagogical Sciences Galperin was appointed associate professor in the Department of General and Applied Psychology.⁷ In February 1967, he was transferred from the position of associate professor to that of professor in the same department. By the Decision of

⁶ Only in October 1968 was the Decree of the Council of Ministers of the USSR issued “On the inclusion of psychology in the list of branches of science in which academic degrees are awarded.”

⁷ The structure of the faculty included three departments: general and applied psychology, psychophysiology and neuropsychology, pedagogy and educational psychology; scientific laboratories: psychophysiology of sensations, engineering psychology, neuropsychology, genetic psychology, programmed (guided) learning.

the Higher Attestation Commission of July 12, 1967, P.Ya. Galperin was approved as a professor in the Department of General and Applied Psychology.

In 1966, the 18th International Psychological Congress was held in Moscow, at which Galperin not only delivered a report, "Method, facts and theories in the psychology of the formation of mental actions and concepts," but was also a co-organizer from the Soviet side, together with J. Piaget and B. Inelder, of the 24th Symposium on "The psychology of concept formation and mental actions" (the symposium's chairman was J. Bruner). The only discussion between J. Piaget and P.Ya. Galperin took place at this symposium. The difference between the scientific approaches of Piaget and Galperin was not only the basis for the discussion, but also a source that contributed to the development of psychological science. It was Piaget who said at the 18th International Psychological Congress, "We should not be afraid of differences, which encourage us to take the only way to broaden our positions" (cit. by Obukhova, 1995, p. 311).

In 1968, Galperin participated in the Third Congress of the Society of Psychologists of the USSR, which was held in Kiev ("On the characteristics of Type III learning").

Galperin attended the 19th International Psychological Congress in London in 1969, giving a report on "Learning and mental development (from age 5 to 8)." He gave a report on the same topic to the Fourth All-Union Congress of Soviet Psychologists in Tbilisi.

In November 1970 in Kharkov, on the initiative of the Society of Psychologists of the USSR, the first All-Union Symposium on the Psychology of Memory was held, on "Psychological mechanisms of memory and its patterns in the learning process." Galperin's report, "Brief remarks on voluntary and involuntary memory" — following P.I. Zinchenko (1903-1969), to whom he dedicated his speech — drew attention to the role of involuntary memorization in life and learning.

Starting in September 1970, Galperin was the head of the Child Psychology Department; in March 1971 he was elected officially to the post of head of the department.

In 1971–72, there was a discussion about the subject matter of psychology in the pages of the journal *Voprosy psikhologii*. Galperin did not directly participate in the discussion, but archival records have been preserved that shed light on its content.

"Introduction to Psychology"

Galperin's principal work, *Introduction to psychology*, was published in 1976 (Galperin, 1976). Archival materials allow us to reliably state that this little book was in preparation for at least 15 years, but was conceived much earlier.

The *Introduction* was written at the beginning of the 1970s — a copy of the manuscript dated 12/27/71 is stored in the archive — but the path to its recognition in the psychological community turned out to be a thorny one. In 1972, the author received a critique from A.N. Leontiev, eight typewritten pages, entitled "Remarks on P.Ya. Galperin's *Introduction to psychology*." According to Leontiev, "Much in it remains inarticulated and unclear, and some fundamental methodological problems

are *overlooked*” (Galperin, archive). A little over ten years before, Galperin’s hypothesis of stage-by-stage formation of mental actions had been criticized, and now his main work suffered the same fate; one has to wonder at and admire the author’s professional courage: neither then, nor years later, did he abandon his ideas.

A.A. Leontiev and D.A. Leontiev report that A.N. Leontiev and Galperin had a thorough, frank conversation after the *Introduction* was published, since that version had received a great deal of criticism from A.N. Leontiev. “Notes” were written especially for this conversation, page-by-page comments that were included in the volume of A.N. Leontiev’s scientific legacy, *Filosofia psikhologii* [The philosophy of psychology]. In comments to this volume, A.A. Leontiev and D.A. Leontiev sum it up: “P.Ya. Galperin’s theory of stage-by-stage formation, relying in a number of essential provisions on A.N. Leontiev’s activity approach, in fact was a *reduced version* of it, which has proven its practical effectiveness in a number of applied fields, but is hardly suitable for the role of a *general psychological theory*” (emphasis added — M.S.) (Leontiev, 1994).

It should be noted that this view is not shared by all researchers. N.N. Nechaev writes: “I think, however, that here we have something quite the opposite: P.Ya. Galperin’s approach was not a reduction but, on the contrary, a concretization of the activity approach to which de facto, judging from a number of Leontiev’s statements ‘scattered’ through his individual manuscripts and published works, Leontiev was approaching, but which he did not reach” (Nechaev, 2003, p. 59). Nechaev calls Galperin’s approach a concept with an “undisclosed, unexplicated methodological potential” (Nechaev, 2012, p. 37). He urges us to “think about the role that *the theory of stage-by-stage formation of mental actions and concepts* may and should play in the development of the activity approach” (Nechaev, 2012, p. 23). He insists on the possibility of revising the concepts of the activity approach from the standpoint of Galperin’s theory. The author summarizes: this theory “should be considered as a theory of the method of psychological research aimed at reproducing psychological phenomena. This is the essence of the theory of stage-by-stage formation of mental actions, as a modern interpretation of the activity approach. ... And we must start from the main point: to begin revising traditional approaches to defining the subject matter of psychology, on the basis of the method of stage-by-stage formation” (Nechaev, 2012, p. 38).

N.F. Tal’zina (2002, 2013) and I.M. Arievidh (2002) point to the activity-oriented nature of Galperin’s conception. According to Arievidh, “the version of activity theory created by P.Ya. Galperin can serve as a means of understanding many fundamental problems of modern psychology” (Arievidh, 2002, p. 50). The author of the present article also conducted a study aimed at finding commonalities and differences in the approaches of A.N. Leontiev and P.Ya. Galperin (Stepanova, 2017). The following conclusion was drawn: there is every reason to consider the theories of A.N. Leontiev and P.Ya. Galperin as *complementary*: they reflect various aspects of the study of activity, its motivational and operational sides, respectively, but neither of them can claim to be a comprehensive analysis of activity.

A comparative analysis of the scientific views of these scientists who worked simultaneously at the Psychology Faculty is the subject of an ongoing special study,

so one should not rush to final conclusions. That said, special attention should be paid to those statements by Galperin that are directly related to the issue under discussion.

For many years, the book *Introduction to psychology* was difficult to access: its circulation was only 28,000 copies — which at that time was considered very modest — until it was reprinted as part of Galperin's *Izbrannyye psikhologicheskie trudy* [Selected psychological works] (Galperin, 1998). In subsequent years, *Introduction to psychology* went through several more editions. However, it should be added that this small volume requires a lot of work from the reader to comprehend its content.

In 1976, immediately after the publication of *Introduction to psychology*, a review by E.A. Klimov, “A positive development in difficult and acute questions of theory” (Klimov, 1976), appeared in the journal *Voprosy psikhologii*. Publication in the leading and at that time only psychological journal in the Soviet Union serves as proof of the recognition of the significance of Galperin's book.

P.Ya. Galperin and L.S. Vygotsky

In 1976, Galperin took an active part in the celebration of the 80-year jubilee of L.S. Vygotsky, on the occasion of which leading Soviet psychologists gave lectures. The period of Vygotsky's return to psychology had begun. On December 9, 1976 Galperin gave a lecture on “The meaning of L.S. Vygotsky for us today.” It should be added that Galperin considered Vygotsky to be a genius, “a ray of light in the confusion of the psychological crisis” (Galperin, 1981, p. 46).

In 1981, the All-Union Conference took place on “The scientific work of L.S. Vygotsky and the tasks of psychology today,” where Galperin made a presentation on “L.S. Vygotsky's ideas and the tasks of psychology today.” The main task, in his view, is “... to understand that there is ... actually something called mental activity and what in it constitutes the subject matter of psychology” (Galperin, 1981, p. 50). Galperin ended his speech with the following words: “... without overcoming the so-called experimental foundations of classical psychology, it is impossible to build psychology systematically as an objective science. The systematic development of Vygotsky's ideas is impossible. Because Vygotsky's ideas are the beginning of a new, non-classical psychology” (Galperin, 1981, p. 50). The use of this quotation is not by chance. I would like to restore historical justice: usually D.B. El'konin is called the discoverer of this reading of L.S. Vygotsky, which does not contradict the actual situation. For example, V.V. Davydov writes, in his “Preface” to El'konin's *Selected psychological works*, “... D.B. El'konin came to the conclusion that the basic law of human mental development, formulated by Lev Semenovich, ... is *the beginning of non-classical psychology*” (El'konin, 1989, p. 21). However, a careful reading of the conference materials (which, unfortunately, have become a bibliographic rarity) shows convincingly that L.S. Vygotsky was simultaneously called the creator of non-classical psychology by both Galperin and El'konin: they were unanimous in their assessment of the cultural-historical psychology created by Vygotsky, which once again shows the unity of the worldview of our leading scientists.

P.Ya. Galperin's Scientific School

In 1977, the Fifth All-Union Congress of the Society of Psychologists of the USSR was held in Moscow, at which Galperin gave a lecture on “The problem of activity in Soviet psychology.” The lecture appeared in printed form in 1977, but the materials for it had been prepared long before, since the time that discussion took place about the development of Soviet psychology. In particular, the 1969 so-called “domestic” discussion became well known, and later became the subject of our research (Stepanova, 2017).

The 1960s–70s turned out to be very productive for Galperin: the hypothesis of the formation of mental actions turned into a developed theory of the origin of specific mental processes and phenomena, confirmed by numerous experimental studies (L.I. Aidarova, G.A. Butkin, M.B. Volovich, I.A. Volodarskaia, L.S. Georgiev, P. Golu, M.M. Gokhlerner, A.N. Zhdan, O.Ia. Kabanova, S.L. Kabylnitskaia, I.P. Kaloshina, A.F. Karpova, S.N. Karpova, G. I. Lerner, V.I. Lefevre, N.N. Nechaev, L.F. Obukhova, N.S. Pantina, A.I. Podolskii, Z.A. Reshetova, N.G. Salmina, N.N. Sachko, V.P. Sokhina, N.F. Tal'zina, H.M. Teplenkaia, and others).

In June 1975, the All-Union Conference on “Theoretical problems of managing human cognitive activity” took place in Moscow. The discussion was based on reports in a collection published specially for the beginning of the conference. Galperin prepared an article titled “Management of cognitive activity in terms of perception.”

In 1977, on the initiative of the dean of the Psychology Faculty, A.N. Leontiev, the journal *Vestnik Moskovskogo universiteta. Psikhologiya. Serii 14* [Bulletin of Moscow University. Psychology. Series 14 (now *Vestnik Moskovskogo universiteta. Serii 14. Psikhologia*)] began appearing. A.N. Leontiev was the editor-in-chief of the journal and P.Ya. Galperin was a member of the editorial board. During Galperin's lifetime, only one of his articles, “The current state of the theory of the stage-by-stage formation of mental actions” (co-authored with N.F. Tal'zina), was published in the journal (Galperin & Tal'zina, 1979).

In 1979, on Galperin's 75th birthday, MGU presented him with the title of “Honored Scientific Worker of the RSFSR.”

At the Sixth All-Union Congress of the Society of Psychologists, held in Moscow in 1983, Galperin gave a lecture on “The formation of cognitive processes,” which summarized many years of research.

On October 2, 1982, Galperin turned 80 years old. On this occasion, the Rector of Moscow University, Academician A.A. Logunov, issued an order congratulating Galperin on his birthday and expressing gratitude to him. The staff of the Psychology Faculty at Moscow University wrote beautiful words in their congratulatory address: *Your wonderful human qualities, your incomparable charm and captivating wisdom, attract to you people of all ages and professions, because communication with you is a real pleasure. We are proud of being able to work alongside you and to learn from you.*

Galperin remained the head of the department of child psychology (in some documents it is called developmental psychology) until September 1983.

V.P. Zinchenko wrote in his memoirs, “Piotr Yakovlevich ... by nature kept away from leadership, avoided leading positions, ... never tried to qualify for membership

in the Academy of Pedagogical Sciences” (Zinchenko, 1993, p. 91). This probably also explains the fact that Galperin did not celebrate anniversaries or birthdays. According to L.F. Obukhova’s memoirs, on his 75th birthday Galperin came together with a small circle of colleagues; photographs have been preserved that help to reproduce the special atmosphere of this almost domestic celebration. The only larger event was the celebration of his 80th birthday and the 55th anniversary of his scientific and pedagogical activity. On September 30, 1982, a meeting of the Academic Council of the Psychology Faculty was held on this occasion. The next day, October 1, a conference was held on “The significance of P.Ya. Galperin’s theory of the stage-by-stage formation of mental actions for the development of psychological science and the improvement of teaching practice.” It was a conference with a large number of participants, which the Psychology Faculty could not accommodate, which is why they held it in a building on the Lenin Hills.

For many years, Galperin had been preparing for publication a work on the relationship between learning and mental development. It was published only in 1985 (Galperin, 1985). A succinct presentation of one of the main problems that was the subject of Galperin’s experimental and theoretical research allows us to identify this edition as having great scientific significance. This brochure was Galperin’s last publication during his lifetime, not counting a short interview with the journal *Voprosy psikhologii* in 1987 on the occasion of his 85th birthday.

P.Ya. Galperin died on March 25, 1988, at the age of 86; his wife, Tamara Izrailevna Meerzon, died six months later. They were buried in Vostriakovskii Cemetery.

Teaching Psychology

Galperin lectured throughout all his years at Moscow University. He gave a course on general psychology to future philosophers from the beginning of the 1950s to the beginning of the ’80s — more than one generation of psychologists attended these lectures with pleasure and obvious benefit to themselves. True, once — in the 1970/71 academic year — he gave a course in general psychology to psychology students.

Galperin also held seminars on general psychology for psychologists when the lectures were given by A.N. Leontiev, and as V.P. Zinchenko recalled, “we were ensured pluralism and dialogue” (Zinchenko, 1993, p. 91).

For many years, Galperin also taught a year-long course in the history of psychology, which was presented as “a drama of ideas and a drama of people.” In the 1968/69 academic year, Galperin handed over this course to A.N. Zhdan.

Galperin prepared a special course on “The formation of cognitive processes” for students and graduate students of the Psychology Faculty, but did not give it every year.

P.Ya. Galperin: A Psychologist of the 21st Century

It is commonly known that a person is alive as long as memory of him is alive. The words of V.P. Zinchenko ring true: “It has even become a certainty that psychologists have a memory that is not the weakest of their mental powers. They understand that

as long as we remember our teachers, not only they, but also we ourselves, are alive” (Zinchenko, 2021, p. 61).

Among the events of recent years associated with the name of P.Ya. Galperin, the following are particularly worthy of note.

First there was the award of the President of the Russian Federation in the field of education for 1997,⁸ for the creation of the psychological and pedagogical complex known as “Theory and practice of the formation of mental activity,” given to P.Ya. Galperin (posthumously), N.F. Tal’zina, L.I. Aidarova, I.A. Volodarskaia, I.I. Iliasov, L.F. Obukhova, A.I. Podolskii, Z.A. Reshetova, N.G. Salmina, and N.N. Nechaev.

Second, an International Scientific Conference dedicated to the 100th anniversary of the birth of P.Ya. Galperin was held in 2002 at the Psychology Faculty of MGU. The conference, a notable event in scientific life, was attended not only by Galperin’s students and followers from different corners of Russia, but also by foreign colleagues. Similar conferences were timed to coincide with subsequent anniversaries: on the 110th and 115th anniversaries of Galperin’s birth, and a conference is scheduled this year to mark his 120-year jubilee.

Third, the P.Ya. Galperin Lecture Hall was opened at Moscow State University of Psychology and Education (MGPPU) in 2008, on the initiative of L.F. Obukhova, a devoted student and successor in the work of her Teacher. On the 110th anniversary of Galperin’s birth, a lecture hall named after him was also opened at the Psychology Faculty. On the board was written: “Lecture hall named after Piotr Yakovlevich Galperin (1902-1988), an outstanding Soviet psychologist, professor at Moscow University.”

And, finally, Galperin’s works are being republished, and research is continuing on the theory of stage-by-stage formation of mental actions and concepts.

It is now an urgent task to comprehend P.Ya. Galperin’s legacy, which, without any doubt, is not an achievement of the bygone 20th century, but will be one of the present 21st century.

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⁸ Decree of the President of the Russian Federation of October 6, 1998, No. 1200, *Poisk*, No. 41, p. 8.

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On Several Problems with the Application of P.Ya. Galperin's Classical Theory

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Background. The theoretical and applied works of Piotr Ya. Galperin have attracted the attention of scholars for more than 70 years. But what about the contemporary situation? Does the Galperin's "System of Psychology" have only historical significance, or does it deal with crucial problems of contemporary psychology?

Objective. This article explores several opportunities for applying Galperin's System of Psychology and his theory of planned stage-by-stage formation of mental actions (PSFMA) as part of the System, in current conditions.

Design. There are three main areas where the concepts of P.Ya. Galperin's System of Psychology can be applied. The first is the application of the method of planned stage-by-stage formation to studying the formation and development of human mental activity. The second is the study of the theoretical and actual process of planned stage-by-stage formation as a psychological reality. The third area is the use of the provisions of the theory in the practice of teaching.

Results. We argue that the efficacy of the provisions of the main components of Galperin's System, and especially the PSFMA, is closely related to the solution of a number of purely theoretical issues today.

Conclusion. The condition for the successful application of PSFMA principles is a harmonious combination of the basic psychological foundations of this process, taking into account the specifics of both the activity being formed, and of those socio-economic and technological parameters that create the space where such formation is carried out.

Keywords:

Planned stage-by-stage formation of mental actions (PSFMA), System of Psychology, practical application of the theory of planned stage-by-stage formation of mental actions

Introduction

As we celebrate the 120th birthday of the outstanding Russian scientist P. Ya. Galperin, and pay tribute to his contributions to general, genetic, and educational psychology, it is necessary to highlight his method. His approach to the essence of mental phenomena and processes, and the mechanisms of their formation and development, was unique in its internal integrity and consistency. The doctrine of the subject of psychology, the objective necessity of the psyche, the main patterns of its development in phylo-, anthropo- and ontogenesis, and the patterns of formation of the elements of mental activity are the main components of Galperin's psychological conception (Galperin, 2002).

The great heuristic potential contained in the works of P.Ya. Galperin is based primarily on the genuine internal integrity of his entire System of Psychology. Familiarity with any section of the System implies at least a general idea of the System as a whole. Unfortunately, the relatively small number of comprehensive publications written by Galperin during his lifetime, and his extremely concise writing style, have often led to the emergence of a number of misunderstandings and superficial interpretations over the more than 60-year history of this doctrine. Let us point out as an example the frequent confusion between the extended interpretation of Galperin's theory (what we referred to as Galperin's System of Psychology before), and the conception (theory) of the stage-by-stage (planned, planned stage-by-stage) formation of mental actions and concepts, which is, although crucial, only a part of this System, which significantly loses its status and heuristic potential if taken out of the context of the System as a whole (Arievitch & Haenen, 2003; Galperin, 2002; Podolskiy, 2010).

Today, there are at least three main areas where knowledge produced by P.Ya. Galperin's System of Psychology can be applied.

The *first* is the use of the method of planned stage-by-stage formation to study the formation and development of human mental activity. (Arievitch, 2003; Hedegaard & Lompscher, 1999; Podolskiy, 2012; Stetsenko, 2017). The method of planned stage-by-stage formation (of course, to the extent that it can be implemented in accordance with the theory) becomes a touchstone by which various theoretical-psychological perceptions about the origin, structure, and functioning of various fragments of mental (primarily cognitive) activity can be tested for effectiveness and operationalizability.

The *second* is the study of the theoretical and actual process of planned stage-by-stage formation as a psychological reality. (Galperin, 1969). Having singled out a number of areas in which the formation of specific mental actions takes place (transfer to an ideal plan, generalization, reduction, etc.), Galperin built a meaningful model of the functional-genetic process and indicated the main way to study it — the planned stage-by-stage formation of actions with specified indicators. At the same time, the discrepancy between the experimenter's supposed and the actual course of the formation of the cognitive action was the stimulus to deepen the formulations by using the strategy of planned stage-by-stage formation.

Many years ago N.N. Nechaev (1975) developed what is figuratively called the tool, the use of which can allow the researcher to constantly control the nature of the

relationship between the system of conditions which they have a priori described and constructed on the basis of the original theoretical model, and real experimental conditions; it is called “managing the process of controlled formation.” He added this most important point to the process of controlling the formation of cognitive actions which P.Ya. Galperin described. It is clear that this connection will be directly dependent on the completeness (always relative) of the initial model, and the depth of its reflection of the psychological mechanisms underlying the acquisition of its characteristics that are becoming cognitive actions. Considering that the features of the regulatory and controlling orientation of this action serve as such mechanisms, we can say that the path to a more complete study of the patterns of formation of cognitive actions goes through a comparison of the theoretical and real mechanisms of orientation of the formed cognitive activity, i.e., the hypothetical and real trigger conditions for these mechanisms.

And, finally, the *third* area for the application of the Galperin’s System of Psychology is the use of the provisions of the theory of planned stage-by-stage formation in the practice of teaching. Based on this theory and under his direct supervision, P.Ya. Galperin’s students and followers carried out several hundred projects aimed at improving the content, forms, and methods of education on all levels. These included preschool, primary school, secondary general education and vocational schools, higher education, training workers and specialists in production, advanced training and retraining of managers and specialists from various sectors of the national economy, and military and sports training.¹ Over the last 15–20 years, there has been a significant expansion of Galperin’s approach in new areas, applying it to evaluation the moral competence of children and adolescents (Brugman et al., 2001), promotion of the psychological well-being of people at different stages of ontogenesis (Idobaeva, 2011), the development of professional consciousness (Nechaev, 2014), and other areas.

The main result of the theory’s application to the aforementioned areas was the following: learning time was reduced, while the quality of acquiring the relevant material was improved; successful learning for the vast majority of students was ensured; a significant increase in their interest in learning was observed; and differentiated learning while maintaining a single structure of theoretical knowledge became possible.

Results

The more than 60-year history of Galperin’s approach gives every reason to assert that its competent use allows us to quite successfully solve many practical problems, providing both researchers and practitioners with a most powerful “intellectual tool” (Podolskiy, 1997; Engeness, I. & Edwards A., 2017). We will focus precisely on this area in this article. Although we will do this not only (and, perhaps, not so much) because the modern trends in the socio-economic life of society — “digitalization” of

¹ In 1999, P.Ya. Galperin (posthumously) and a group of his students and followers were awarded the Russian Federation President Award in the field of education for the development and practical implementation of the provisions of this theory.

the economy, the need for training, or rather retraining (sometimes multiple times) throughout life, requirements ensuring the formation of the so-called “Competences of the 21st century” among the vast masses of the population, etc. — with all their acuteness put forward new challenges to the Galperin’s System (Seel, N. et al., 2017). Another reason for such an emphasis, which is more significant in our opinion, is that successful practical (truly practical!) training — especially in its mass version — requires, paradoxical as it may sound, notions about the mechanisms of formation of human mental activity that are much deeper and more extensive than arbitrarily “pure” academic laboratory research.

The key question that arises in this regard is: what is the reason for the relatively limited application of Galperin’s theory in the practice of training? It is this question that prompts the ongoing debate in national and international psychology and pedagogy about the real possibilities of using the conception in training practice (Engeness, I. & Lund, A., 2020; Podolskiy, 2020; Talyzina, 2020; Reshetova, 1989). From our point of view, the key to solving this issue is a correct understanding of the scientific status of the conception itself.

Despite the outward “similarity” of the core of the conception — the formation of mental actions and concepts — to the main goal of almost any training, the theory of planned stage-by-stage formation of mental actions itself is not and never was a theory of training. The works of P.Ya. Galperin’s students and followers (N.F. Talyzina, 2020; Z.A. Reshetova, 1989; N.N. Nechaev, 2014; A.I. Podolskiy, 2010) and others) describe the additional, intermediate work that should be carried out by psychologists and teachers in order to move from the general psychological knowledge contained in Galperin’s basic conception, to the construction of the actual learning process — the actual content carried out in the interaction of a real teacher and real students.

Moreover, as has been repeatedly shown in the experiments of the last decade, fragments of the planned stage-by-stage formation procedure are not absolute and, in this sense, are external to the subject. They receive their psychological certainty only in a specific situation. The main condition for the effective practical application of the conception is not the aspiration to literally reproduce some abstract general procedure, but to have a creative psychological modeling of a specific situation (learning, information retrieval, interaction, etc.). If this requirement is met, the practical application of this approach indeed provides excellent results, as has been repeatedly demonstrated in relation to various components of school and university vocational training. Otherwise, if one tries to implement the theory in teaching as if it were a kind of universal knowledge, almost a philosopher’s stone, the result will as a rule be deplorable.

There is an interesting paradox: the more universal knowledge is (and Galperin’s System, from our point of view, contains highly universal knowledge), the more specific must be the auxiliary means by which this universal knowledge can be applied to specific cases. The less universal the knowledge, the less such specifications are required, because such knowledge is specific in itself. Indeed, in a general sense, it can be said that a person’s mastery of any knowledge, skill, or any new competence always presupposes some more or less complete orientation to the task, in the sense of what

is happening, in the specific circumstances and conditions for achieving the accepted goal. In this respect notions formulated by P.Ya. Galperin about the structure of the orienting basis of action and the ways of its formation are indeed universal (Galperin, 2002; Engeness & Lund, 2018).

However, the way the process of forming an orientation to a particular subject area should be designed is another matter. It must be adjusted for the age-psychological characteristics of the students, taking into account the individual characteristics of quite specific children, adolescents, and adults, as well as individual psychological characteristics and pedagogical capabilities of the teacher, university professor, or vocational training instructor. How should one move from the most generalized scientific theoretical knowledge to technological, methodological knowledge, which, in fact, is required to be used in practice? Or, in other words, what prevents wide and full-fledged practical implementation of Galperin's approach in practice?

Certainly, almost in the first place, the inhibitory factors are the same as those for the introduction of other psychological developments. However, there are a number of circumstances specific to Galperin's conception. The first circumstance is rather external to the substantive side of the case. There is a huge distance between the non-psychologist's preconceived notion of the simplicity of obtaining spectacular results with the help of PSFMA (theory of planned stage-by-stage formation of mental actions) tools and the true complexity of this process, which involves long painstaking work both in designing and in implementing training. Awareness of the need for a thorough subject analysis, building a psychological model of the forming activity, and the formation process itself, its specification in relation to the features of the material, the age and individual characteristics of the trainees, and many other components that make up the procedure of planned stage-by-stage formation, often, as our experience shows, turn out to be serious, if not decisive, obstacles in the way of the introduction of PSFMA.

More meaningful and, therefore deserving of serious analysis, are the circumstances related to the assessment of specialists in general, university, vocational, and other education, regarding the practical possibilities of PSFMA. Assertions about the limitations of these possibilities are not uncommon. As justification, the following reasons are given: 1) The use of PSFMA is associated with a radical breakdown of established methodological and organizational forms, which gives rise to practically insurmountable difficulties of an objective and subjective order; 2) The possibilities of PSFMA are limited by the formation of separate fairly simple actions, and since almost any activity in modern production is a complex hierarchy in which an action is only a particular element, is it worth spending effort, time, and money to take this step (even assuming that it produces results of a somewhat higher quality) without affecting the rest of the structure of professional activity; and 3) The application of the provisions of the PSFMA allows for the formation of only high-quality skills, while a student's broader creative activity, the share of which in modern production is increasing, remains unaffected. Some other critical considerations are also given, but these are perhaps the main ones.

These considerations cannot be instantly dismissed by simply pointing out that their authors misunderstand the true meaning of the conception. The true task of a

psychological researcher interested in the practical implementation of the scientific achievements of the PSFMA should be an objective analysis of the current situation and explanation to practitioners of the ways of applying the provisions of the conception, taking into account the current and future requirements of professional training.

Many difficulties in the practical implementation of the provisions of the PSFMA today are closely related to the solution of a number of purely theoretical issues. Historically, impressive pedagogical results of applying the theory of the controlled formation of action came to the fore in a significant part of the psychological research carried out in line with the conception of P.Ya. Galperin. Interest in truly extraordinary (in comparison with traditional methods) indicators of assimilation led in a certain period to the extensive development of research and the application of methods of planned formation to an ever-wider range of human actions. The reverse side of this generally positive process was the fairly common belittling of the status of the conception, relegating it to the level of a kind of methodological guideline, a practical manual regarding the organization of training.

If we recall the history of the emergence of Galperin's theory and the first stages of its development, it is clear that initially it was about discovering the conditions for the formation of a separate action on a certain subject in a person's mental plan. After these conditions were identified, it became possible to construct a generalized scheme of its stage-by-stage formation (later this term was replaced by the author with "planned" and "planned stage-by-stage"). Later, the main efforts of P.Ya. Galperin were aimed at clarifying the composition of these conditions, their systematization, and the application of the system to the formation of various types of cognitive actions and images. At the same time, the formation itself, no matter how detailed its development, still remained a means of implementing the research strategy, subordinated to the goals and objectives of a psychological research project. This presupposed, first of all, the acceptance of certain abstractions necessary for any scientific research. In this case, such abstractions were the assumptions about the isolated formation of a separate mental action, about the novelty of the formed action for the subject, the limitation of the ongoing psychological transformations to the zone controlled by the experimenter, etc.

Discussion

It is easy to understand that the direct use of research methods in practical training has a number of fundamental limitations. Highly successful results in practical training cannot be expected to be maintained if circumstances which were deliberately put aside in a psychological experiment, come to the fore in a real training situation. This is precisely what happens most often. Hence the explicable discrepancy between the possibilities of experimental techniques and the real efficiency of their practical application. Such a direct transfer gives satisfactory results only in those cases, which are not too frequent, when the psychological content of the object of experimental formation completely (or, at least, mainly) exhausts the corresponding content of the object of real learning, and the other aspects of the latter are organized in such a way that they do not have a practical effect on this content.

We need to consider the fact that in order to fill the gap between research methods and training practice, it is necessary to carry out a whole range of developments involving a number of stages of the reality of training. It can be said that we need a special science that raises such an approach from the empirical level to the theoretical one. It is the needs of the practical use of the method of planned formation that lead to the need for additional reflection of its essential characteristics, and the separation of the internal patterns of acquiring a new activity from the specific forms of this acquisition described in numerous studies by the followers of P.Ya. Galperin. Unfortunately, these studies often confuse two different languages: 1) the language of the *conditions* for organizing orientation and execution of an action, and 2) the language of the *mechanisms* for the formation of orientation structures, the subject's acceptance of these conditions, and their active reflection. This is another source of misunderstanding the true possibilities of the method by practitioners.

Focusing on an external procedure, reproducing it according to a certain general template without taking into account specific circumstances, and missing significant points or distorting their meaning — this is an incomplete list of the defects common to the practical application of planned formation methods. In our opinion, this is not the fault, but the misfortune of practitioners. Given all the attractiveness and seeming simplicity of obtaining effective results, behind each of them there is a thorough psychological and pedagogical process, which, unfortunately, has not yet been fully brought to the level of a technology

Meanwhile, P.Ya. Galperin strongly emphasized the need to distinguish between the external form of the method, which depends on the conditions of its application, and its actual content. The main and constant content of the method is the **set of steps** that must be carried out in order to obtain an action, representation, or concept with the desired given properties as a result of formation (Galperin, 2002). It should be noted that the concept of a set of steps includes not so much a description of external conditions as a description of the content and form of the subject's own activity, its controlled changes through the creation of a controlled system of conditions. Then it becomes necessary to carefully analyze the psychological content of both the activity planned for formation and the process of formation itself.

Features of the tasks being worked on, the specifics of the activity (both in terms of its content and in terms of its place in the overall structure of production), age-psychological characteristics of the perception of the training situation, and other factors most significantly affect the layout of the procedure. In a number of cases, such familiar attributes of planned formation as the sequence of stages and the method of setting and assimilating the scheme of the complete orienting basis of the action, may vary. For example, for some professional activities it is not at all necessary to achieve a mental (ideal) form of performing their main components. Moreover, there are a number of professions in which regulations require the use of external support. There, the procedure for planned formation also takes on a form that is very far from the paradigmatic one. The same can be said about cases of retraining and mastering related professions, in which many of the psychological steps which P.Ya. Galperin describes have already been mastered by trainees earlier, and the point is not the formation of new psychological structures, but their actualization.

Finally, in the overwhelming majority of cases, practical (primarily vocational) training involves the formation of not one action, nor even a simple series of actions, but a most complex hierarchized system of actions. The development of even a laboratory version of the scheme for the formation of such a system is a rather difficult task.

From what has been said, it is clear that the productive application of the principles of planned formation presupposes carrying out diverse steps regarding the optimal “docking” of psychological requirements and specific features of the training situation. Skipping these steps and ignoring the psychological mechanisms behind them, leads to emasculation of the conception and a decrease in its practical potential.

Thus, the direct application of the procedure of planned formation in the practice of training should be preceded by a preparatory period. Primary and definitive here is the psychological analysis of the activity planned for acquisition, the structure of the process of its formation, and the training situation itself. The result of such an analysis should be the construction of a *psychological model* of a specific case of vocational training (Podolskiy, 2008). We, following P.Ya. Galperin, presuppose a quite definite understanding of the concept of the psychological. It is used to describe the patterns of formation, development, and functioning of the active orientation of the subject in a training situation; the content of the forms of orientation necessary for the implementation of a full-fledged professional activity in all its parts; the actions and images necessary to reveal this content at different stages of assimilation; the content of these stages; and special characteristics (for example, the objectively or subjectively intense nature of the professional activity itself or the process of mastering it) (Galperin, 2002).

To date, the PSFMA has accumulated a lot of data on the patterns of description and presentation of the content of the elements of human activity — individual actions and images, and the ways of their purposeful, controlled formation. However, no less important is the disclosure of the principle by which individual actions and images are formed into an integral structure of real activity. We place special emphasis on this point, since any modern, primarily professional activity is a more or less complex hierarchically organized system of actions that are diverse not only in their subject matter, but also in their psychological content, *i.e.*, the place occupied by these actions in the hierarchical structure of a person's orientation in those relationships, circumstances, and characteristics that are essential for mastering and implementing high-quality professional activity.

It seems to us that the development of classifications of the types of such hierarchical models for the main groups of professions should be undertaken in the near future, which would greatly simplify the process of introducing the achievements of the PSFMA into practice. To date, we have several samples of the implementation of such contributions in constructing optimization options for training a number of workers and professionals. For example, the hierarchical structure of orientation was most notably presented in our development of the psychological foundations for the training of operators of nuclear power plants (Podolskij, 2010).

The next step would be to develop a system of conditions that ensured the construction of this complex activity. As is known, P.Ya. Galperin identifies a number

of subsystems of psychological conditions that ensure the formation of activities with specified indicators (Galperin, 2002; Engeness & Lund, 2018). Since the orientation of each of the levels is a very complex activity with its own structure, it seems appropriate to build three relatively autonomous groups of these conditions for each level: 1) the formation of appropriate orientation bases; 2) the preparation of training and control tasks; and 3) the organization of controlled acquisition. At the same stage of development, indicators for the formation of individual components of the orientation at each level are outlined, and the development of specific methods for the formation of these components is planned; *i.e.*, along with the development of a general macro-scheme of formation, the necessary number of micro-plans of a kind is outlined, which are aimed at formation of individual actions and images.

An important point which must be taken into account at this stage is the age-psychological characteristics of the trainees. Ignoring these features (especially in relation to adolescence and early maturity) can lead to the trainees' psychological devaluation of vocational training. To prevent this from happening, training should not only form high-quality knowledge and skills, but also ensure a conscious identification of a real connection between the characteristics of an activity (reflecting the success of the training that precedes it) and the parameters of its social and personal significance (economic, social, socio-psychological, moral).

Taking into account the age-psychological aspect is also significant for older ages. For example, the current widespread method of vocational training in the workplace, as schools for the dissemination of advanced techniques and methods of work, is not very effective. This is largely due to the fact that the "frontal" psychological procedure implies the insufficient professional competence of the participants, which, in turn, evokes various forms of psychological defense mechanisms in workers with a long job tenure. What is natural and positive for children — the counter-position of the bearer of knowledge (trainer) and the person lacking knowledge (trainee) — is not suitable for people at the age when they are especially sensitive to the assessment of their capabilities, in particular professional ones.

The solution is to change the procedure for organizing training schools: setting a certain standard, but encouraging all school participants to conduct a joint analysis, which leads to the identification of features of the activities of a successful specialist. In this case, all participants subjectively become, as it were, "co-authors" of the technique found. There is a rearrangement of psychological emphasis: not "they are better, I am worse," but "we found it together; why are they doing it better?" In this approach, only one element of planned formation is subjected to age-psychological concretization — the objective conditions for the successful performance of the action for the subject.

It is easy to show that each component of the system of planned formation can't be considered in isolation from the laws of human ontogenetic development, but, on the contrary, must be seen through the prism of such development. It is clear that this circumstance significantly affects the construction of a psychological model. Thus, the psychological model of training must include a description of the macro- and

microstructure of orientation. However, this model is by no means a model of real learning; at the moment we are just talking about its framework.

The next stage is the construction of a **psychological pedagogical model**. Its main function is the projection of the psychological model on specific conditions: the organizational forms of the training, available technical training tools, its desired dynamics, etc.

The application of the conception of planned formation to the practice of training can pursue two goals: either the development of a new optimal training option, or the modernization of existing training methods. In the second case, the psychological pedagogical model will be built selectively, prescribing a partial revision of the content or form of training, and retaining empirically based successful moments. Bearing in mind that each phase of the existing training in this case will be considered through the prism of the psychological pedagogical task at which it is directed, advantageous opportunities open up for the purposeful use of pedagogical experience accumulated in the field.

The construction of a psychological pedagogical model ensures the imposition of a psychological model on selected *forms* of training, taking into account the specific situation. In this way the general form of the training process, and the sequence and content of its main fragments, are determined. The construction of a psychological pedagogical model creates real opportunities for extrapolating the practical effect of introducing a planned formation procedure.

The final stage of development is the construction of a **methodological (technological) training model**. This model includes a detailed description of the course of training; it fixes the place and time of each lesson, and establishes the success criteria for both each lesson and the course of study as a whole.

Even a brief description of these models indicates the complexity of the full-fledged, evidence-based implementation of the provisions of the PSFMA in training. However, the results obtained indeed show a meaningful return on investment. Furthermore, taking into account the acuteness of the issue of improving personnel in the modern economy, it can be confidently stated that the theory of planned formation in its modern form is one of the serious ways of solving this problem, operationally and long-term.

At the same time, the key to success is a deep, meaningful approach to both planning and ensuring implementation, an approach that no longer considers planned formation a purely scientific abstraction, but a reality that is influenced not only by the initial theoretical premises, but by the whole complex set of economic, production-related, and socio-psychological circumstances that determine the course and content of training specialists in production.

To date, the conception of planned formation has accumulated a lot of data on the methods of describing and presenting subject content in the purposeful formation of individual actions and images. However, any real human, not to mention professional, activity is a complex hierarchy of actions, diverse not only in its subject matter, but primarily in its psychological nature and place in the structure of a person's orientation in those relations and circumstances that are essential for mastering and best performing any actual activity.

Conclusion

In creating a theory and developing a method of planned formation, P.Ya. Galperin quite justifiably had to put aside a number of psychological characteristics of human activity. This allowed him to create a coherent theoretical structure and to work out the most effective method of psychological research on the formation of mental (more broadly, cognitive) activity. At present, from the theoretical, experimental, and applied sides, there is a need to take the next step in the development of scientific thought: to construct a psychological model of the process of formation of a specific cognitive action, which would include a description of the reflection by the subject on the most complete set of both subject-object and subject-subject relations implicitly contained in the situation of planned formation. The more complete and multi-layered the perceptions that are included in this model, the more intensive and productive our movement from potential to real explanatory and practical possibilities of the method of planned formation will be.

This is exactly what is demanded by the current challenges of the 21st century. National and international scientists and practitioners continue to carry out work in a number of areas. There are special requirements for human mental activity, the formation of which involves an increasingly large-scale deployment of the digital economy (Engeness & Morch, 2016), and a new stage of large-scale deployment of the Instructional Design movement, which has by no means lost its relevance, and quite favorably reacted to the connection of the Galperin direction to its developments (Seel, N. et al., 2017). An interesting challenge is to use the fundamental and concrete possibilities of Galperin's approach to such a movement as the Partnership for 21st Century Skills (Partnership..., 2018). Laboratory research conducted by us and our colleagues becomes achievable when the psychological model of this process includes ideas about the genesis of the *multicomponent structure of the orientation* of the emerging cognitive action (Podolskiy, 1997; 2010).

Here work needs to be done on all the levels of the theory, including in relation to phenomena that have not previously been analyzed in terms of planned formation. Thus, we deem it productive to consider the category of "properties (parameters) of an action," not only as some characteristic of the objective state of a given action, but also from the point of view of their representation in the mind of the subject.

For example, the "level of action" parameter is not only an indication of how (with or without support from external means or speech) an action can be carried out. It inherently contains an indication of the social significance of this property: an action performed with the support of a given plan and means from outside will have a social valuation that differs sharply from the assessment of an action with the same content, but performed without such external mediation. Certainly, the "internal-external" ("material/materialized-ideal") axis is not identical to the opposition of "bad-good." In a number of cases, it is not the ideal, but the materialized implementation of an action (for example, the performance of regulated professional actions in an extreme situation) that will have a higher social significance.

Other properties of action, both primary and secondary, can be considered in a similar way. It is clear how much more complex the psychological model should become, taking into account not only the purposeful movement of the emerging action

towards the intended indicators, but also the person's subjective refraction of both these indicators in their social and personal meaning, and the functional genetic process itself.

In the future, a detailed analysis of this type can be carried out in relation to all components of the systems of planned formation. Thus, the subsystem of the formation of a complete orienting basis of an action requires consideration of the entire hierarchical structure of orientation; the internalization subsystem (transferring an action into an ideal plan), requires consideration of nonlinear changes in psychologically heterogeneous, albeit interconnected components of the structure of action regulation. The trend towards the convergence of the subjective and objective characteristics of the human psyche, and its motivational and operational components, is very typical for many areas of modern psychology (in particular, for the Partnership for 21st Century Skills movement). However, a truly meaningful solution to this issue can only be achieved on a clear methodological basis. "That which was separated from the very beginning cannot further be connected, except in an external way, but the bare declaration of their unity (*as in cognition and relation, objective and subjective content* — A.P.), like any bare declaration in general, does not in fact change anything" (Leontiev, 1975, pp. 284–285).

In other words, the general methodological requirements for a holistic, systematic consideration of the aforementioned aspects of human mental activity have been outlined. Now it is up to specific theoretical and experimental developments to truly show the psychological integrity of the genesis of the components of human cognition, and the contradictory unity of its objective and subjective content, which we deeply believe is especially relevant in our stormy and incredibly dynamic times.

* * *

In the present publication, we dwelled only on some general issues of connection between the fundamental principles of the System of Psychology of P.Ya. Galperin and the possibilities of their application in 21st century practice. It is crucial to understand that the condition for the successful application of these principles is a harmonious combination of the basic psychological foundations of this process, taking into account the specifics of both the activity being formed, and those socio-economic and technological parameters that create the space where such formation is carried out.

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Orienting Activity of the Subject as a Mechanism for Instruction, Learning and Development

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Background. The 120th anniversary was celebrated in 2022 of the birth of the outstanding Soviet scientist P.Ya. Galperin (1902–1988), who made a significant contribution to the development of Russian psychology.

Objective. To analyze the significance of P.Ya. Galperin's concept of "orienting activity" for the study of processes of mental development, learning and instruction.

Design. The concept of "the zone of proximal development" (L.S. Vygotsky) is interpreted in light of the doctrine of orienting activity, presenting three examples from different areas of research, where the concept of orienting activity is used to analyze the phenomena of mental development in children and adults.

Results. 1. The concept of orienting activity makes it possible to substantially concretize the psychological content and mechanisms of "the zone of proximal development." 2. The subject's orienting activity plays a key role, which is implicitly present in the method of "cognitive learning" developed in the Geneva psychological school and reproducing (according to the followers of J. Piaget) "an autonomous process of constructing new operational structures". 3. The study examines the organization of orienting activity in the process of children's mastery of the concepts of combinatorial thinking in a learning experiment based on Galperin's method of stage-by-stage formation of mental actions and concepts. 4. The role of a client's orienting activity is explicated, and its special organization by the psychologist who is counseling parents on the mental development and upbringing of children and adolescents.

Conclusion. P.Ya. Galperin's discovery regarding the structure of human activity and introduction of the concept of "orientation," and the creation of a method for studying the orienting component of action as distinct from the executive component, lead to a much deeper understanding of the central problem posed by L.S. Vygotsky: the interrelation and mechanisms of connection between the processes of learning, instruction (teaching) and development.

Keywords:

Orienting activity of the subject, P.Ya. Galperin's theory of the stage-by-stage formation of mental actions and concepts, zone of proximal development, types of orientation and types of learning, mental development in ontogenesis, cognitive learning method, Piagetian phenomena, combinatorial thinking, psychological counseling

Introduction

The 120th anniversary of the birth of P.Ya. Galperin is a good occasion to look at the scientific heritage of this classic figure in Soviet psychology and to comprehend from a modern standpoint his contribution to science, as well as the potential of his ideas. The publication in the 1960s–1980s of Galperin’s works on the stage-by-stage formation of mental actions and concepts shook the very foundations of Soviet psychology, affecting ideas about its subject, research method, the role of object-oriented actions, the process of internalization, and other basic questions (Galperin, 1968; 1969; 1992; 1998). Galperin’s research opened up a new approach to classical problems and made it possible to see many previously known phenomena in a different, somewhat unexpected light.

For more than half a century, attitudes in Russian science towards Galperin’s ideas have evolved significantly. If at first they were perceived as very controversial and even revolutionary, today they fit naturally into the system of fundamental ideas accepted in Russian psychology (which, however, does not mean they have been deeply understood). Despite the significant difficulties in translating Galperin’s works, there has been interest in them outside the country, including in connection with the ideas of L.S. Vygotsky, whose theory is much better known (Engeness, 2021; Engeness & Lund, 2020; Haenen, 1996; Stetsenko, 2017).

Galperin’s scientific contribution is primarily associated with the theory of planned stage-by-stage formation of mental actions and concepts, as well as the introduction into psychology of the concept of the *orienting activity of the subject*. According to Galperin, orienting activity is an integral and important aspect of any purposeful activity by a subject. He considers orienting activity as the principal *mental function* and the genuine *subject of psychology*, its central category. In order to understand, form, or improve human activity, we must discover the particular characteristics of its orienting basis. Let us briefly recall Galperin’s main theses regarding the concept of orienting activity.

First: The orienting activity of a subject occurs where and when it is necessary to act in *new or changing conditions*; on the other hand, in stable conditions, a learned and automatic action is sufficient, and orientation is not needed.

Second: In the structure of any human action (more broadly, any human activity that is *not* performed automatically) it is necessary to distinguish between two mandatory components — the orienting and the executive parts of the action.

Third: The subject’s orienting activity performs several functions: 1) constructing an image of a problem situation or an action being performed; 2) determining significant elements of this field of action from standpoint of the subject’s needs; 3) constructing a plan to solve the problem; 4) monitoring and correcting implementation of the plan. The success of an action in a problem situation depends crucially on the quality of the subject’s orientation — its completeness, generality, and other properties. Being a mandatory (and in this sense universal) mechanism for implementing any action that is *new* for the subject, orienting activity becomes key in situations that require going beyond what has been previously mastered, what is known — i.e., in the course of the subject’s mastering of any new actions, concepts, and competencies. This applies both to attempts at independent learning and the subject’s participation in various forms of purposeful and organized instruction.

Let us consider further, using the example of a number of specific studies, how the application of Galperin's concept of the subject's orienting activity leads to a deeper understanding of the classical problem of the interrelation between the processes of instruction, learning, and development.

Orienting Activity as a Means of Analyzing the Connections among Instruction, Development, and the Zone of Proximal Development

L.S. Vygotsky, the originator of cultural-historical theory, confidently asserted the leading role of instruction in development, but emphasized that this does not apply to all forms of instruction, which can be qualitatively different: one type of instruction (and the learning associated with it) directs processes of development, while another conveys only particular knowledge and narrowly practical skills — that is, it relies on the achievements of development, but does not itself lead to qualitative changes (Vygotsky, 1978, 1984). It is no secret that, for all its great attractiveness and heuristic value, Vygotsky's position remained largely declarative for a long time. In particular, it lacked a substantive differentiation of the types of instruction that are related in different ways to developmental processes. No hypotheses about possible psychological criteria that distinguish instruction that “promotes” development, from instruction that is not connected with it, appear in Vygotsky's works. This left Vygotsky's position abstract and vulnerable to criticism, and most importantly, left open the question of a psychological model of instruction, which is highly sought-after in practice, a model that can not only provide knowledge, but also develop students, prepare the way for ontogenetic changes in their thinking.

P.Ya. Galperin's introduction of the concept of orienting activity may be viewed as an important step in solving the problem posed by Vygotsky. Galperin showed in numerous works that orienting activity is a defining aspect of the subject's activity, and that the process of instruction and its effectiveness depend decisively on the content and methods used to orient students, primarily on the completeness of their orientation to the essential conditions of the problem situation or task (Galperin, 1967; 1969). The result of this line of research was Galperin's concept of *three types of orientation* and the *types of teaching and learning* that correspond to them, which have different developmental effects (1989). Thus, Vygotsky's thesis about qualitatively *different* types of instruction was fleshed out for the first time.

According to Galperin, traditional instruction is *the first* type of teaching and related learning (Type I), based on an incomplete system of points of orientation and the use of trial and error. Because of this, its success depends on the level of development of the student, rather than affecting that development. The *second* type of teaching and learning (Type II) is based on a full orienting basis of action; the process of mastery proceeds in stages and requires a special organization (by the method of planned and stage-by-stage formation). This type of teaching provides for the formation of full concepts and, although it does not have a strict cause-and-effect relationship with development, nevertheless creates important prerequisites for it. Finally, the *third* type of teaching and learning (Type III) is based on the child's mastery of a certain *method* of analysis and setting points of orientation in a given

subject area. With this type of teaching, the child does not master specific actions or concepts, but *methods of orientation* that enable the student to independently analyze any subject area and solve problems, which ensures advancement in *the development* of thinking (or other processes). Developed by Galperin on the basis of the concept of orienting activity, the conception of three types of teaching and related learning was convincingly demonstrated experimentally and practically by various empirical studies (Obukhova, 2001; Podolskiy, 2012; 2017 et al.).

Similarly, the concept of orienting activity also makes it possible to understand much more clearly the mechanisms of “the zone of proximal development” (ZPD) discovered by L.S. Vygotsky (1984). The idea of the ZPD as a model of the interrelation between instruction and development has been firmly established in psychology, and recognition of the leading role of instruction in the mental development of the child is based on it. However, numerous attempts to further specify its psychological content have not been very successful. We recall that Vygotsky described the ZPD as the discrepancy between the actual and potential levels of a child’s development, as the presence of “immature but maturing processes” (Vygotsky, 1984, p. 267). The difference between a child’s achievements in independent activity and those in cooperation with and under the guidance of an adult points at the ZPD. In connection with the ZPD, Vygotsky emphasized that although each subsequent step in development depends on the level of development already achieved, it is still accomplished through collaboration with an adult.

In such a description, the existence of “the zone of proximal development” is an indisputable fact, but the mechanisms that link processes of instruction and development in it remain undiscovered. As P.Ya. Galperin rightly noted, the existence of a “zone” does not say anything about *how* the child learns and how, as a result, the development of thinking takes place (if it does) (1967). In other words, the main question is *what* a child and an adult do in the course of joint activity, as a result of which “immature processes” are transformed and the child achieves a higher level of development.

This question can be significantly clarified by the distinction between the orienting and executive components of activity proposed by Galperin: it is not the *interaction* of a child with an adult, in itself, that opens up the ZPD for the child, but the *orientation* in their joint activity (for example, a problem to be solved), which the adult transfers to the child in a clear verbal formulation or an example of an action, either purposefully or spontaneously and practically, whether deliberately or unwittingly, *de facto*. In collaborative activity, it is the adult who directs the child’s actions (leaving aside the question of whether this is done worse or better, effectively or not very well), and the child constructs his “zone of proximal development” to the extent that he grasps points of orientation that are new to him. By directing the child’s actions, the adult essentially *finishes constructing* the child’s incomplete image of the problem situation or required action, identifies significant conditions that the child does not consider (“an immature process”) or, preferably, arms the child with the means to independently identify the points of orientation that he lacked to solve the problem.

Among the points of orientation for the problem situation that the subject of the action must consider must be included its semantic components: *why* and *for what*

purpose the action is performed. This is well shown in the study by L.F. Obukhova and I.A. Korepanova (2005), where Vygotsky's conception of the zone of proximal development is considered from the standpoint of orienting activity. In other words, the orientation necessary to advance the child's initial (current) level should include not only the subject matter of the tasks to be solved, but also the semantic aspect of the adult's actions, since in joint activities with the child it is the adult who conveys the meanings and methods of performing the action.

Thus, the transformation of the *orienting* basis of an action also forms a genuine psychological *mechanism of cooperation* — figuratively speaking, its “main nerve” and “point of contact” of the child and the adult as two subjects of the interaction process, whether educational or purely practical (Burmenskaya, 2012, 2019). We stress that explaining the connection between instruction and development in the ZPD on the basis of Galperin's concept of orienting activity is not a replacement of one metaphor (“maturing processes”) for another (change of the orienting basis of an action). The direct or indirect transfer to a child by an adult of the points of orientation that the child lacks for successful completion of a task is a fully objective process, which changes the effectiveness of learning/teaching activity. It can be organized in different ways (the three types of teaching, according to Galperin), and it can be directed, supervised with respect to content and form. Organization of teaching Type III, the stage-by-stage formation of mental actions and concepts on the basis of complete orienting activity in the subject, may be considered as an optimal model of the process of interaction between child and adult taking place in the ZPD, and at the same time as instruction leading to development, in Vygotsky's words.

Analysis of the Method of “Cognitive Learning” in Light of P.Ya. Galperin's Theory of Stage-by-Stage Formation of Mental Actions and Concepts

Jean Piaget — the creator of the operational theory of intellectual development in ontogeny and the famous opponent of L.S. Vygotsky — argued for many years that “learning is subordinated to development, and not vice versa” (Piaget, 1972; 1974). There is no doubt, however, that this position on the issue of the relationship between mental development and instruction was largely influenced by the fact that Piaget considered only traditional forms of instruction. With regard to the latter, Piaget quite reasonably denied the possibility of influencing the development of the operational structures of the intellect. It is indicative, however, that over time, the study of mechanisms of intellectual development led representatives of the Geneva school to attempt to create their own version of instruction related to intellectual development. The method, called “cognitive learning” by B. Inhelder and other collaborators of Piaget, creates, in their view, the conditions in which the intellectual structures existing in children are transformed into structures of a higher order (Inhelder et al., 1974). So what are the mechanisms by which the method of cognitive learning produces new operational structures?

To answer this question, we performed a special series of experiments (Burmenskaya & Kurbatova, 1983) to reproduce the procedure for cognitive learning by pre-

schoolers of the concept of conservation of quantity, which is described in detail by B. Inhelder and her colleagues (Inhelder et al., 1974). The picture and the results of cognitive learning almost completely coincided with the results of experiments by the Geneva authors, but at the same time clearly showed that they can be described and interpreted quite differently if we approach the analysis of cognitive learning by taking into account the role that orienting activity plays in it.

Let us consider the fundamental thesis of the Genevan method of cognitive learning, that children have to *independently* discover the conservation of quantity. To achieve such independence, according to those authors, there must be a problematic presentation of the material that provokes a cognitive conflict with respect to the task and the child's attempts to coordinate different ways of reasoning (schemas of action). Along with the experience of solving problems, all this leads children to the gradual development of new, more advanced structures of thinking.

However, the picture of the process of cognitive learning that we reproduced by us, and even the protocols of the experiments of the Geneva authors themselves, showed that in reality the children were not completely independent (Inhelder et al., 1974). The experimenter interacted with the children and, to use Galperin's terms, actually tried to expand their orientation to the material of the task, to draw their attention to those aspects of the task that they were not taking into account. In other words, the authors of the cognitive learning concept wanted the child to more fully consider the essential features (points of orientation) of the task. This was achieved, for example, by skillful selection of material, as free as possible from the variety of properties of natural objects, in order to make it easier for children to isolate the essential parameters. Another way of directing the child to the desired parameter of an object was quite traditional: while solving the problem, the experimenter asked the child questions that directed their attention to those elements or relationships that were significant for solving the problem.

Thus, the role of orienting activity was obvious and crucial, but the authors of cognitive learning theory did not differentiate it from the general activity of the child and did not recognize it as one of the main conditions for cognitive progress, due to the lack of a distinction between the orienting and executive components of activity in Piaget's theory.

Nevertheless, comparison of the theories of Galperin and Piaget (in this context) shows their potential complementarity. Despite fundamental differences, these very different approaches to understanding developmental instruction and learning process have in common object-oriented actions, recognition of the significance of cognitive conflict, rejection of the communication of knowledge in a finished form and of the direct guidance of students' actions. At the same time, Piaget's theory is insensitive to the obvious manifestations of children's living, orienting activity, which plays a decisive role in their intellectual progress. However, research shows that it is the concept of orienting activity that allows us to understand more deeply the real psychological mechanisms of "cognitive learning" and, figuratively speaking, to look inside the developmental process, which Piaget considered "an autonomous process of constructing new operational structures," but which in reality is based on orienting activity and requires the skillful organizing participation of an adult.

Orienting Activity in the Acquisition of New Concepts: An Example of Formation of the Foundations of Combinatorial Thinking

The formation of combinatorial concepts in children of primary school age and adolescence (Burmenskaya & Evdokimova, 2007) can serve as an example of a specific application of Galperin's theory to the study of mental development. It is well known that children do not master the elements of combinatorial thinking before the stage of formal operations in adolescence (Inhelder, 1976; Inhelder & Piaget, 1958). At the same time, the teaching of combinatorial mathematics in secondary school encounters very significant difficulties, so that the topic of combinatorial mathematics is often excluded from the compulsory mathematics curriculum in secondary school. Unsuccessful attempts by the majority of schoolchildren to master the basic combinatorial configurations (placement, permutation, combination) are usually attributed to the "unpreparedness" of children's thinking to master these difficult concepts.

Our analysis of the problem from the standpoint of Galperin's theory of stage-by-stage formation has shown that children's difficulties are largely due to their insufficient initial *orientation* to the material of combinatorial problems (Burmenskaya & Evdokimova, 2007). To master combinatorial concepts, pupils must confidently identify the basic properties in sets — volume (size), composition, order and repetition of elements in the set — and also clearly relate the set to its parts (groups or subsets). But in the process of their independent spontaneous and practical mastery of the objective world, children usually do not gain sufficient experience in compiling sets, and are therefore poorly oriented to their properties. Methods of school instruction also do not assume any special familiarization of children with the properties of sets; instead, combinatorial concepts are explained in mathematics curricula using the example of individual tasks and are often introduced immediately in the form of tables, diagrams, or even formulas.

The necessary orientation to combinatorial material can be successfully shaped by Galperin's method. The basis for construction of such an orientation is the children's mastery of a special *action to compile a variety of sets* from different elements. This refers to the three main types of combinatorial configurations — placements, combinations, and permutations. At first, the children put them together from various material objects and elements, *focusing on differences in the configurations*, and then they write them down using the appropriate notation. Thus, development of the logical prerequisites of combinatorial thinking begins with special *propaedeutics* (before the introduction of tables and formulas), during which the children themselves make up sets of different types, acquiring real, practical experience of operating with sets. Only after this is the schema of the complete orienting basis of action for compiling combinatorial configurations introduced, in which four kinds of conditions are taken into account: 1) the properties of the initial *set* of elements, its qualitative composition and number of elements; 2) the properties of the formed *groups* (subsets): their qualitative composition and the number of elements included in them; 3) the possibility of *repeating elements* in the compiled sets; and 4) the significance of the *order of elements* in the groups (Fig. 1).

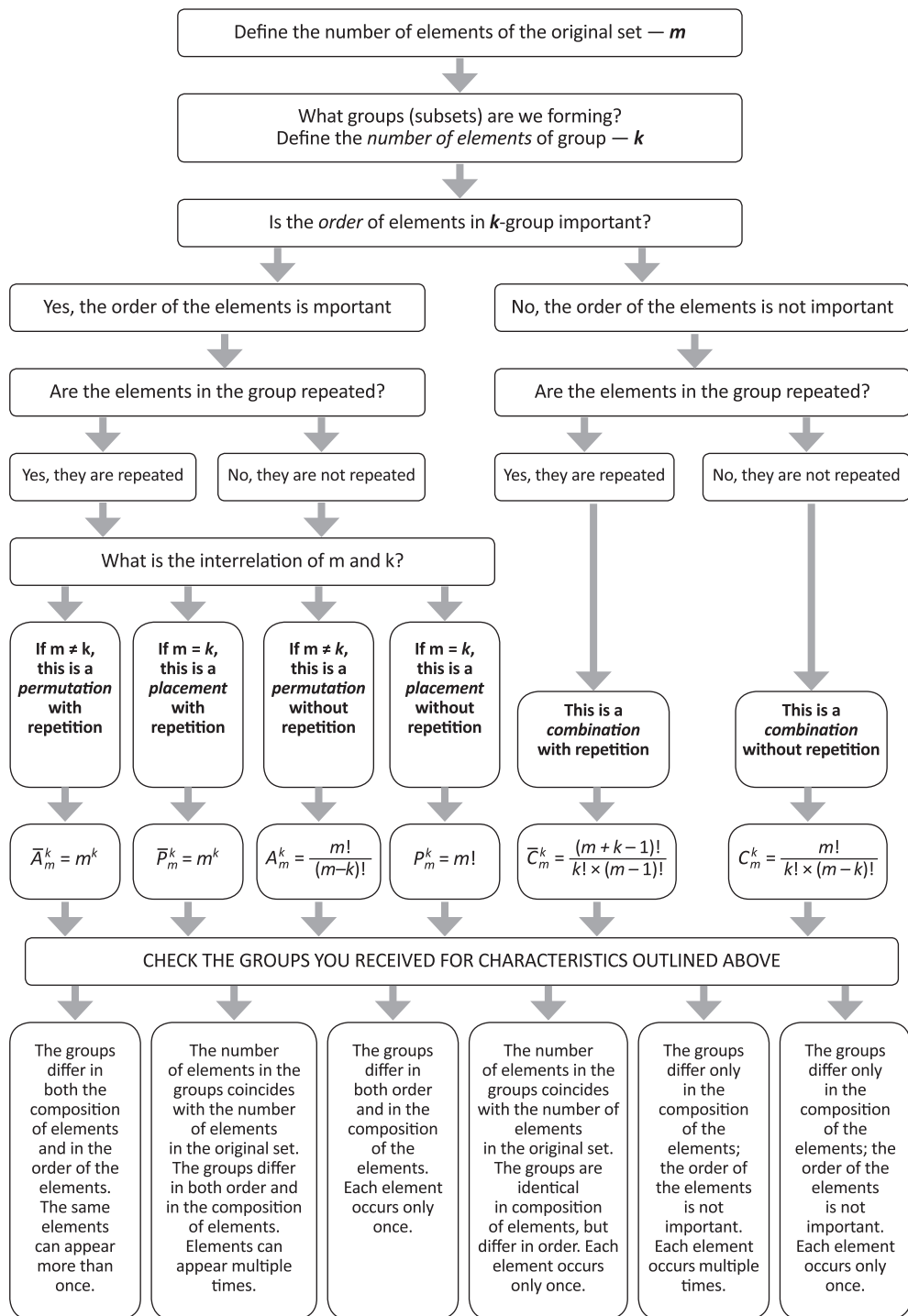


Figure 1. Schema of a complete orienting basis of action of combinatorial configuration analysis (the formulas were introduced only in the version of the methodology for adolescents)

Thus, in contrast to traditional teaching, where it is erroneously assumed that children independently become sufficiently oriented to the properties of sets to start the instruction process, in the experimental set-up following Galperin's method, that orientation was specially organized by preliminary propaedeutics. It is important that the orientation to combinatorial concepts was then graphically presented in a single schema with a clear indication of similar and distinctive features of all three types of combinatorial configurations. The children's assimilation of them occurred in the process of solving problems of various types based on the complete schema for the orienting basis, without first memorizing it (the second type of teaching). Using this schema of orienting activity, the students were able to independently analyze and solve combinatorial problems, thereby learning *a generalized* method for solving combinatorial tasks of various types. This method was successfully applied in the instruction of 4th- and 8th-grade students at a general school, with the difference that adolescents' mathematical training allowed them to use the combinatorial formulas. As a result, the stage-by-stage formation of the action of compiling groups from sets (together with the previous propaedeutics) ensured the students' full assimilation of the concepts of mathematical combination, which, as was shown, for example, in the works of B. Inhelder (1976), are very complex and often simply inaccessible by other methods.

A delayed test (three months later) of the quality of the learned combinatorial concepts confirmed their strength and their generalized character. Moreover, there was a tangible positive effect of the children's participation in the formative experiment solving J. Piaget's tasks and J. Raven's test. What could explain the children's cognitive progress? We believe that the generalized character of the methods of orientation learned by the children allowed them to freely transfer to new material the ability to clearly separate out and combine its characteristics — that is, to take into account several features at the same time. During the formative experiment, the children mastered *orientation in a system of signs*, which made an area of combinatorial mathematics that was new and difficult for them accessible, not only in adolescence, but also at primary school age.

Organization of the Orientation Process as a Condition for Effective Psychological Counseling

Since any new action or an action in changed conditions requires active orienting activity from the subject, its role should be analyzed not only in the traditional context associated with instruction, with mastering new mental actions and concepts, but, in fact, wherever the subject confronts *a lack of his accustomed methods* of response and the need to go beyond them (Galperin, 1998). We suggest that this is also true of those complex processes that occur during the interaction of a psychologist and a client during psychological counseling. We consider this using the example of counseling parents about problems in the development and upbringing of children and adolescents (Burmenskaya, 2017).

Parents usually resort to psychological counseling when they have exhausted their own abilities to solve a problem — for example, to improve their relationship

with the child, to understand the reasons for the teenager's undesirable behavior, or to eliminate family conflicts. Regardless of the significant variety of children's problems and parental difficulties, psychological help is almost always associated with the need to change the notions that parents have when they come to a psychologist. These notions may involve the essence and causes of the current situation, the parents' own role in it, or those characteristics of the child that, for example, prevent him or her from being successful at school, having harmonious relationships with relatives or peers, etc. The common task for all these cases is to help the parents to better understand the problematic situation, to understand more deeply the motivations and meaning of the child's actions and emotional experiences, the nature of the relationship, etc. In a word, the parents need a different, more complete and correct image of the problem situation as an *orienting* basis for its appropriate transformation, for change. In Galperin's terms, what is necessary is a *reorientation* of the parent, which the clinical psychologist should encourage.

In clinical practice, it is well known that this problem cannot be solved by simply *providing information* to the parents: all the correct explanations and recommendations that are offered to them in "ready-made" form are most often understood formally, as external, and remain alien until they become the result of the parents' own analysis and comprehension, the product of their own activities. But how can that be organized? How can a clinical psychologist help a parent to better understand the problem situation and how to resolve it, while avoiding two unacceptable extremes: attempting to directly transfer knowledge in a finished form (advice) and relying on a parent's spontaneous insight that has no foundation?

This problem can be solved by using a special form of organization of clients' activity in the process of interaction with the psychologist. Of course, we are not talking about a literal reproduction of Galperin's method of stage-by-stage formation for guidance of client-parents' activity, but about implicit methods *to direct their orientation* to significant circumstances or conditions, to expand the orienting basis of their behavior in the problem situation.

To achieve this, the psychological content of the consultative process is constructed so as to single out and *objectify* for the parents the significance of circumstances or the child's psychological characteristics that the parents are not sufficiently considering (the missing points of orientation). The consultative interaction takes the form of a special *collaborative discussion and analysis of the problem situation* by the psychologist and parents. The subject for discussion is specially selected fragments of materials for a comprehensive diagnosis of the child and parents, including the results of studies of child-parent relationships and other data. The materials (results of questionnaires, individual statements and reactions of the child, the child's drawings, emotional and behavioral manifestations, etc.) are presented not in oral retelling by the psychologist, but in a graphic, text or audio format, presenting to parents a kind of materialized projection of the child's inner world. The parents are invited not only to familiarize themselves with these materials, but also to comment on them, to give their own interpretation, to express their understanding, emotional attitude, etc. Active conceptualization of a problem situation in dialogue with the counselor helps parents to see the situation from a new angle, including looking at themselves

and their style of upbringing “through the eyes of the child.” In other words, working through diagnostic materials together helps parents to see essential aspects of the problem situation that had not previously been clear to them, and contributes to the formation of a more complete and accurate orientation to the nature and causes of the problem.

This practice, of course, has its limitations: the success of counseling remains dependent on the difficulty of the problem, the motivation and sensitivity of the parents, their ability to reflect, and many other things. It is beyond dispute, however, that the psychologist’s purposeful consideration of *orienting processes implicitly occurring* during counseling, and conscious efforts to *create conditions for a more complete and appropriate orientation* by parents in a problem situation, almost always contribute to a successful outcome.

Conclusion

P.Ya. Galperin is credited with discovering the subject’s orienting activity as a principal function of the psyche and a subject of psychology. Today, this concept is part of the conceptual core of Russian psychology and has been recognized as a fundamental category, without which modern ideas about the nature and development of the psyche are inconceivable (Podolskiy, 2017). The studies presented in this article show that the orienting activity of the subject can also be considered as *a mechanism* of processes of the teaching/learning activity, and development. Orientation necessarily participates in the development of any actions, concepts or competencies that are *new* to the subject, and it gradually prepares the way for ontogenetic changes. Orientation processes take place during the child’s cooperation with an adult (“the zone of proximal development”); they actively unfold in the consultative interaction of the psychologist and the parents; they are present in the method of “cognitive learning” and are given an extremely explicit and clear form in specially organized planned stage-by-stage formations (for example, the formation of combinatorial concepts). Orientation processes are not just connected to instruction in the broadest sense of that word, but play a leading role in it.

Galperin was critical of traditional observational psychological research, because he believed that attempts to study *already-formed* and largely automatic processes were limited in principle (1998). He ironically called such attempts “peeking” and, as an alternative, worked out the method of planned stage-by-stage *formation* of mental actions and concepts, which was the basis for the main results of his research. Thus, the concept of the subject’s orienting activity was firmly connected with the formative type of experiment, the only method that makes it possible to openly trace the subject’s orienting activity in the process of formation of new mental actions and concepts.

However, given the absolute dominance in our time of observational research and the laboriousness of formative and instructional experiments, we would like to emphasize that even *beyond* a strategy of formation, the concept of *orienting activity* retains its constructive value. Experience in applying Galperin’s theory demonstrates the productivity of analyzing any human activity for the content of its orienting basis,

as well as the effectiveness of not only direct, but also indirect *organization* of the subject's orientation.

Galperin's methodology, stressing the crucial significance of organizing the orienting aspect of the subject's activity, works successfully in scientific research, education, and many areas of applied practice. However, the potential of this approach is far from being fully realized. To move in this direction, analysis of the content of the subject's orientation and the possibilities of its optimal organization should become a priority of researchers and practitioners.

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The Action “Wanted!”: The Concept of Valency during the Early Steps of Mastering Chemistry

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Background. We apply the theory of step-by-step concept formation (Galperin) and the theory of learning activity (Davydov) to the practice of education and teacher training.

Objective. This paper describes a feasible way to teach the basics of Galperin’s theory to students studying pedagogical psychology, by involving them in an exemplary educational module on combining chemical formulas according to the elements’ valency values.

Design. We suggested that our students participate in an educational module which was designed as an example of how to materialize orientation components of action as the basis of concept formation. The “practical” action for mastering the valency concept was to combine the correct formula for a pair of elements, whose valency was provided, and correct the formulas made by someone else. However, the core “orientation” required an extended procedure of building a “molecule” structure with a special construction kit. The key challenge for the students was to coordinate their calculation of the number of bonds needed for the molecule, and name the exact total before they would receive their atom-tokens for constructing the model.

Results. Our workshop participants took on the role of students facing their first encounter with chemistry, and embarked on the formation sequence. At the same time they analyzed the mistakes they had made by ignoring some procedural steps. Considered through the lens of Galperin’s theory, these “adult” mistakes proved how vital his theoretical principles are for educational design.

Conclusion. Our workshop thus illustrated that the search for the proper action for concept formation within Galperin’s theory framework is a challenging task. The difficulties that our participants experienced while they worked as pupils revealed the divergence of didactic approaches. The effectiveness of the concept formation approach, even within our small exemplary educational module, once again confirmed the practical value of pedagogical psychology in general, and Galperin’s theory in particular.

Keywords:
Step-by-step
concept
formation,
Activity
approach,
materialized
form of action,
interiorization,
orientation

Introduction

The activity-based reconsideration of the development of psychological processes which Galperin conducted, brought about a fundamental shift in how to teach children to think conceptually. This course of action was supported by a number of pedagogical and psychological studies conducted within the Activity approach framework (Galperin & Talyzina 1957; Obukhova, 1968; Nikola, & Talyzina, 1972; Galperin, & Georgiev, 1969; Aidarova, 1978). Unfortunately, modern studies which rely on Galperin's theory as their framework are rare (worth mentioning: Burmenskaya, & Evdokimova, 2007; Vysotskaya, & Rekhtman, 2012; Proyanenkova, 2014; Maksymenko, 2018). Meanwhile, current popular studies in education and the psychology for teaching are following and introducing methods based on misconceptions which were already overturned by Galperin (see the analysis in Arieviditch, 2020). It is thus an urgent problem to transfer the means and meanings of Galperin's theory to students, specifically future specialists in pedagogical psychology (Shabelnikov, 2017; Engeness, 2021).

In this paper we use our educational module on the valency concept, which was developed based on Galperin's theory, in order to illustrate the major challenge of delivering concepts through students' own actions; that challenge is the choice of a proper action.

At the core of assimilating concepts at school, according to Galperin (1957), are special activities and their intrinsic actions, which must include the concepts' content as their absorbed "orientation" part, which are then turned into mental actions. In order to master the whole system of "landmarks" and operations which a concept bears and transmits over generations, one has to perform the actions according to the concept's functionality. The materialized, external form of the action which "lies behind" the concept is thus placed (by Galperin) at the center of studies on the formation of concepts at school.

One of the first "projects" to examine the actions' components and content, was a study on the formation of basic geometrical concepts through their defining characteristics (Galperin & Talyzina, 1957). The concepts' definitions, which are usually provided in school, were revised to become the actual means of the students' work. In this study the assimilation of the "action-mediated" way of orientation was introduced, as opposed to the "trial and error" search for one's own way of handling some matter, a method which often leaves students ignorant about "what were all these definitions about." The definitions of concepts were presented to students in their functional and operational aspects, so that the characteristics of geometrical objects from the definitions would "serve primarily to identify whether the given phenomenon belongs to the domain of the concept of interest, or not" within the special action of "recognition" (Galperin & Talyzina, 1957, p. 30). The concept-mediated action of recognition of geometrical figures was internalized and allowed students to "see" the objects in their "conceptual" aspect, while they dealt with them in school math problems.

Careful analysis of the actions of students who were making mistakes, led to closer examination of the deficiency of relying on the traditional object-oriented

school definitions (Obukhova, 1968; Nikola, & Talyzina, 1972; Galperin, & Georgiev, 1969). The examination of the process of problem-solving highlighted the concepts’ “instrumental” role and the necessity for a special modelling space to support the materialized form of the desired action. These studies showed that the characteristics provided by the definitions were not sufficient for the orientation process required for the solution. Not only the objects which the concept can be applied to, but also the characteristics of the situation which demands a person act “conceptually,” vary from one problem to another.

Galperin wrote: “If a separate object is the bearer of the concept, the recognition by the characteristics goes smoothly; but if a set of objects appear to bear the concept, then the distinguishing features cannot point out how many of them there should be and why only together they present the object the concept is applied to” (Galperin, 1998, p. 305). The “concept-action” bond and the orientation functions of a concept within the process of concept formation thus demanded further examination within Galperin’s tradition of research (Davydov, 2008; Davydov’s modern followers — see Coles, 2021).

The special features of the “conceptual” form of action were described by Davydov (1960); the modelling scaffolds a shift from routine manipulation with objects towards the content of the concept: the product and means of theoretical thinking. Here the educational and pure cognitive meanings are opposed to the common-sense ones: modelling is aimed at purposes other than getting immediate pragmatic results.

In her experimental teaching of Russian morphology, Aidarova presented the qualitative leap from the object’s natural characteristics towards the conceptual meanings achieved through modelling (Aidarova, 1978). In this example the lexical meanings of the words interfered with their grammatical features, and the special modelling means, which reflected the morpheme structure of words, were introduced to separate and bind them conceptually. The work of building up the message, which required word-modification, repeatedly made students appeal to these artificial models. Further studies showed that special investigation of the components of the “materialized” form of action and the development of the proper models are necessary each time we need to scaffold the desired concept formation through appropriate action.

Educational module on valency

In this paper we present an example of introducing special modelling means to support the materialized form of action. Our analysis of students’ and teachers’ difficulties also showed that without an adequate educational design, the traditional way of teaching appeals to formal procedures, which allow students to acquire the solution directly without “bothersome” modelling.

The concept of valency which we built our example upon, is introduced in the very beginning of learning chemistry, as students first encounter different formulas of substances. Students are to compose some compound formulas themselves based on the valency values of a given pair of elements, so that their formulas would match

those written in the chemical books. Another task is to identify the valency of one element by its compound formula with another element, whose valency is provided.

What “landmarks” can the student refer to when he is performing the corresponding action?

The formulas themselves (elements’ symbols and indices) imply and demonstrate some regularity in the numbers placed near the symbols. A usual method used by teachers to explain how students should compose formulas themselves, is the “transposition” of the valency values to the indices of the elements in a “crisscross” manner (Winston, 1921). The action dictated by this instruction has some “conceptual” limitations, however: such operations may or may not lead to the right answer. Mistakes which children make when they try to combine the formulas themselves and confuse indices and valency values, are well-known. Those students who are good at math manage to overcome the mismatch with the formulas in the books by reducing the indices by common denominator, which is also how the majority of chemistry teachers instruct students to correct such mistakes.

We question the ability of the valency definitions contained in the textbooks to guide students’ own actions to compose a formula. Most descriptions in the basic chemistry textbooks are more or less like the following: valency is the capacity of an element’s atoms to combine with a certain number of other atoms. Valency is then usually illustrated through binding atoms of the element in question with univalent atoms (hydrogen, for example). Students successfully identify elements’ valency from these examples and combine formulas, but fail to deal with pairs of elements whose valency is other than one. The number of bonds of each atom in a compound is often used to illustrate valency: one can derive the valency values from a ready-made graphical representation of atoms with bars in between, but the number of bonds is not used by students to compose formulas according to the elements’ valency.

Counting the least common multiple of two valency values may help only in cases where students have mastered the ways to find the least common multiple as their active mental tool, which they can use fluently. When that is not the case, many students substitute finding the least common multiple by simple multiplication or even addition. As students proceed through the chemistry course, they adopt “roundabout” ways to deal with valency (the “crisscross method”), and diligent, hard-working students try to remember the most relevant formulas.

As we consider the ability to assimilate the valency concept as a psychological problem, and search for psychological tools to help overcome or even prevent students’ difficulties in such problem-solving, we have to elaborate the matter of their orientation in detail. The research questions here are 1) what are the components, means, and content of the action(s) at the core of assimilating the valency concept, and how is the formation of the orientation part of action to be scaffolded; and 2) what are the materialized forms of action at the early steps of concept formation and the procedure to develop it into the corresponding mental form, which will allow students to write the correct formula directly by the valency of the elements and recognize the valency “behind” new formulas.

“Logical-genetical” analysis (Davydov, 2008) aims to reconstruct the essential “conceptual” relationship of the matter of interest within an external form; it cor-

responds to Galperin’s call for the materialized form of action. However, the external form of action should not be understood as manipulating objects in order to motivate students and/or to grant them the right answers; and the modelling means of these actions does not serve as vivid illustrations to the ready-made formulas. In this respect, studies which suggest, for example, using Lego bricks to explain valency (Ruddick & Parrill, 2012), or the modern kits for chemistry classes with molecule models, do not represent an example of “materialized” form of action corresponding to concept formation. According to our analysis, the special action (orientational in its meaning, external and modelling in its form, and theoretical in its content) appropriate for valency concept acquisition demands the explication of the magnitude, which corresponds to the elements’ valences and makes tangible the meaning of the common multiple — the total number of bonds in a molecule. Students are to identify its value, which is disguised in a premade formula, and use it to assemble a “molecule” of the compound.

For such an educational design we needed to operationalize the definition of valency and find an appropriate model material to support the procedure, which would place the substantial relationship of the objects at the center of students’ consideration as they searched for the landmarks of their own action. The operationalized definition of valency should be one which implies and refers to the action of a student working with the compound’s formula. A formula contains element symbols and indices; where is the valency then? What do we do with the valency value in order to acquire the correct formula? Thus, we have chosen the following available definition, which is sufficient for building up the model (pen-and-paper) prototype of a substance formula:

Valency of an element signifies the number of bonds, through which each atom of an element is combined with atoms of another element¹.

The special challenge was to make the students’ work with the model material purposeful and meaningful: to choose a problem which would develop into their own inquiry. Thus, we chose the construction kit with atom-units and bonds to fasten them, to be our model material (a “ball-and-stick model”). The kit’s “terms of use” demand that 1) students work together in pairs (each in charge for his own element units) and that 2) partners coordinate their calculations in order to acquire the exact total number of bonds needed to build the entire molecule prototype; then the teacher will hand out the fastening pieces (sticks). Only after that can the students have their atom-tokens.

Each bond has to be used to connect two atoms of different elements (*Fig. 1*), while each partner is maintaining the proper valency of his own tokens. The preliminary calculation and selection of the number of fastening bonds, which has to be coordinated by both students in a pair, sets the learning task in our experimental teaching. The thoughtless manipulation of construction kit pieces (in case they are handed out simultaneously), without adjusting “partial” actions between partners will not allow students to properly build up the correct structures.

¹ We do not go in detail of the modern notion of different types of bonds (covalent, ionic, metall) here, as it is more object-related and cannot scaffold students’ actions at the very first encounter with chemical formulas (Nelson, 2002; Brown, 2013; Sindhu, 2021 and other modern descriptions of the nature of chemical bonding for teachers and students).



Figure 1. The construction kit: fastening two atoms together by the bonding “stick”

The search for the least common number of bonds in the compound of two elements for which the valency is given, thus comprises the content of the valency concept, and allows the student to develop the action towards building more complicated compounds later on.

Results

We conducted a special teaching workshop to involve students of the pedagogical psychology department in the educational design of school subjects based on Galperin’s theoretical principles. We used materials from this workshop to illustrate the desired progression of the valency concept formation and the possible difficulties along the way: students’ common mistaken strategies, and teachers’ and educational designers’ prejudices.

There were 20 participants at our workshop — 15 students from Moscow State University and 5 guest students from other universities’ psychological departments. The students’ ages varied from 19 to 27 years; there was only one male student and 19 females (this gender ratio is typical for psychology departments).

Our workshop participants took on three roles at the same time: that of an educational designer, a would-be teacher, and a school student. After a short introduction on the basic idea and principles of Galperin’s theory, a “lesson” was conducted so that the participants would undertake the same steps of forming the valency concept themselves.

First, a short oral test was given to assess the students’ understanding (*Fig. 2*). For school students the “prelude” would be, for example, to look through the textbook and see for themselves that there is an abundance of formulas consisting of symbols and indices. To understand them and compose the right ones themselves is what they should set out to learn.

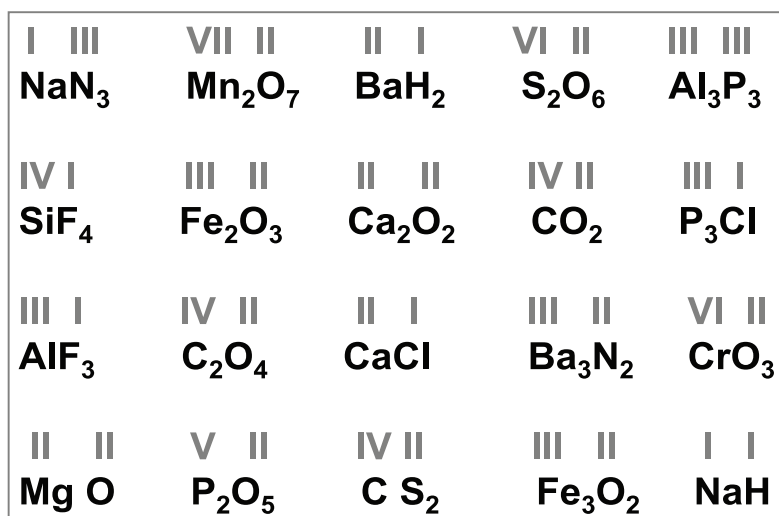


Figure 2. Introductory test. Check out the formulas, written by some students according to the elements' valency (roman numerals above elements' symbols)

After the definition of valency was introduced, we checked whether the students grasped what the valency value signified in terms of bonds; students were to match the representations of "molecules" and the formulas (both correct and incorrect with respect to the elements' valency) (Fig. 3).

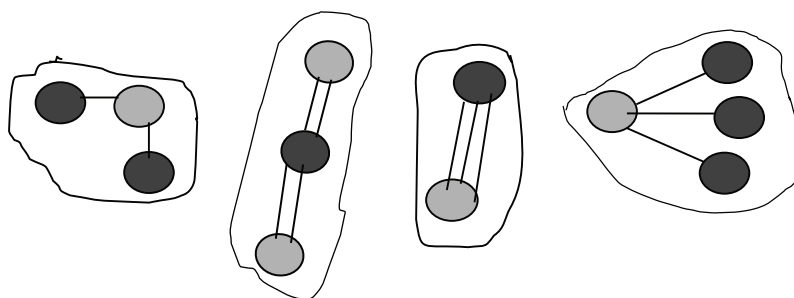
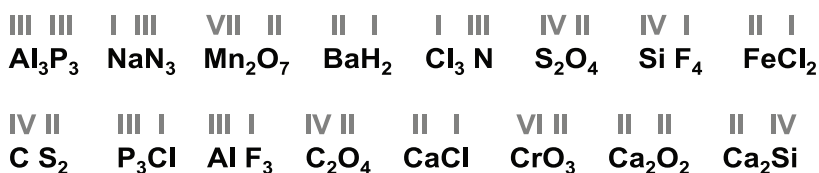


Figure 3. Note the formulas in the list which match the representations of "molecules." Some incorrect formulas were presented on purpose to prompt a discussion

After that, the teacher showed the students the construction kit and set the basic rule: the "bonds" were to be received before the "atoms": students were to work together to choose the exact number of the bonds needed, and only then would the teacher hand them the "sticks."

An example of coordinated work was then provided for a pair of elements; the students discussed the exact number of bonds needed for the phosphorus (P — III) and sulphur (S — II) compound, following the template provided:

“P” — student: In this substance there are three-valent atoms of phosphorus. Each atom of phosphorus makes three bonds. In a molecule with these atoms there can be three bonds, if there is one atom of phosphorus; six bonds, if there are two atoms; nine bonds, if there are three atoms; etc.

“S” — student: In this substance there are two-valent atoms of sulphur. Each atom of sulphur makes two bonds. In a molecule with these atoms there can be two bonds, if there is one atom of sulphur; four bonds, if there are two atoms; six bonds, if there are three atoms; etc.

Then the key question was raised: “How many bonds do we take for this molecule? On what number will we agree? What number of bonds is the least to suit both partners?”

In the example provided it was six bonds.

Our participants now received a pair of elements and were to identify the number of bonds they would take from the teacher for their own molecule. The teacher handed out the bonds, after each pair repeated their argumentation following the template.

Then, each student in each pair was to decide how many atoms of his own elements make up this “molecule.” In the example with phosphorus (III) and sulphur (II), the reasoning went as follows:

“P” — student: Since the total number of bonds is six, I will need two atoms of phosphorus, because each token will have to be fastened with three bonds.

“S” — student: As the total number of bonds is six, I will need three atoms of sulphur, because each token will have to be fastened with two bonds.

Students took the tokens — each of his own element — and built the “molecule” (Fig. 4).

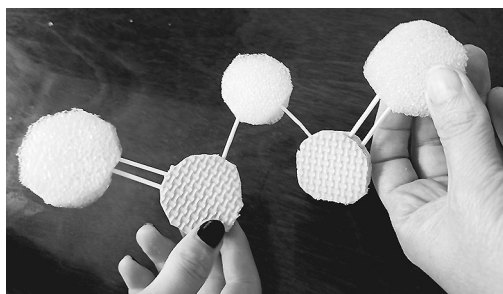


Figure 4. The P_2S_3 “molecule” model

Finally, the formula of the compound was to be written: P_2S_3 in the example.

Then we laid out a series of tasks which scaffold the transition of students’ action through external articulated form, then “speaking to oneself,” and finally to the mental form of action (Galperin, 1998). Students composed the formulas for a pair of elements without using the construction pieces, but following the same template

of oral reasoning: they were to coordinate their possible sets of bonds and come up with the proper total number of bonds for the compound, to identify the number of atoms for each element, and then to compose the formula.

The tasks of the last stages of interiorization were: 1) to write down the number of bonds and compose the formula; 2) to find the wrong formulas among the list and correct them; and 3) to fill in the indices for the formulas.

Discussion

Our workshop was held as a demonstration rather than a real “full size” formation experiment. Nevertheless, we observed the typical mistakes that our previous experience showed that pupils make, as well as observed some interesting “grown-up” mistakes. These gave us a hint about the difficulties that psychology students experience when learning Galperin’s theory.

The common mistakes which students make derive from the empirical “criss-cross” strategy which they often come up with, since the indices do coincide with the valency values of the opposite symbols in some formulas. To reveal this kind of mistake, we placed a number of pitfalls in the introductory test, which demanded that students check out whether the formulas were composed according to the elements’ valency or not:

- wrong formulas which look right, because the indices coincide with the valency value above the symbols ($\overset{III}{Ba}_3\overset{II}{N}_2$)
- wrong formulas which look right, because the indices coincide with the valency value above the symbol across ($\overset{VI}{S}_2\overset{II}{O}_6$)
- correct formulas that look wrong, because their indices do not coincide with the valency values ($\overset{IV}{C}\overset{II}{O}_2$; $\overset{II}{Mg}\overset{II}{O}$)

The results showed that the majority of the students fell into two of the three pitfalls: they pointed to formulas such as C_2O_4 as correct ones, and MgO they considered to be wrong, since their indices did not coincide with the valency values above. The discussion showed that students stuck with the “crisscross” strategy. They confessed their confusion with the CO_2 formula, since they knew it was correct, but the numbers did not match.

Those participants who followed the formation procedure with the construction kit step-by-step successfully combined the molecule and wrote down the formula (Fig. 5). There were some pairs of students who ignored the instruction and proceeded to fasten the molecule as soon as they received the bonding sticks (Fig. 6). They could not make a proper molecule: the valency values of their atoms were wrong, or the structure had “loose ends.” These mistakes are typical of school students when they start to make or draw graphic representations of molecule structures later on in a regular chemistry curriculum.

In the sequence of tasks that followed, many students tried to skip the “bothersome” extended step-by-step procedure of choosing the number of bonds, and then the number of each elements’ atoms corresponding to the total number of bonds.



Figure 5. Building a proper model after each partner has chosen his atom-tokens corresponding to the total number of bonds chosen. Writing down the correct formula

Eventually, they made mistakes. Most typically, they did not choose the smallest common number of bonds: for example, for Sulphur (VI) and Oxygen (II) they chose 12 bonds. Then the lecturer asked them to follow the template: to repeat what number of bonds there could be for each element and name the suitable total number of bonds. When the students, though reluctantly, performed the detailed procedure, they corrected their mistakes themselves.

Some students also failed to write the proper formula, since they did not articulate the choice of the number of atoms for each element in pairs, corresponding to the number of bonds. For example, after having chosen 12 bonds for Aluminum (III) and Carbon (IV), students wrote down the formula: Al_3C_4 . Presumably, they skipped articulating that each atom of aluminum has three bonds and thus for 12 bonds, one needs four atoms of aluminum, three bonds each (and vice versa for carbon). Again, when asked to follow the procedure precisely, students could correct themselves.

The latter mistakes are of a special kind: they happen due to taking “shortcuts” in procedure and are corrected by including the missing steps. Students, especially adult ones who are used to performing operations mentally and individually, try to optimize the “cumbersome” procedure and miss the essential “coordination” steps, which are of the utmost importance here. The essential content of the valency concept is exactly the way the valency values of the two elements are to be coordinated through the total number of bonds. If the substantial basis for this coordination is not assimilated by students, then within their individual formulas composition they will have to conduct some “roundabout” ways to produce the indices.

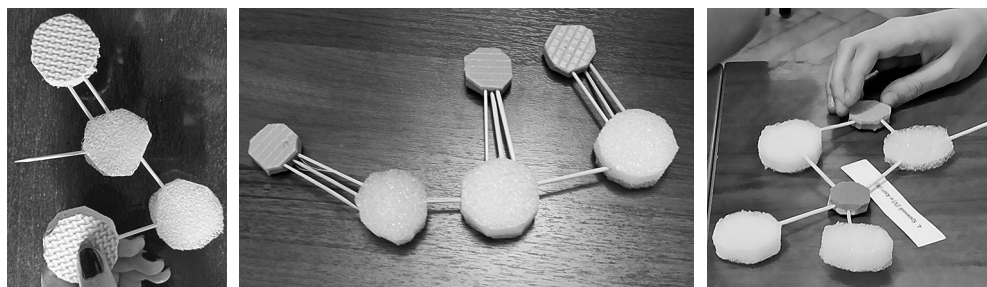


Figure 6. Building invalid constructions with the bonds and atoms

These mistakes do not happen outside the formation procedure, and they are an important indicator that students do not accept the necessity of doing the task in the required way, which they find cumbersome and excessively extended, although it assuredly leads to correct formulas. Thus, students ignore the orientation functions of the means provided and miss their opportunity to acquire the concept. A feasible explanation of the origin of these mistakes is the discrepancy between the new step-by-step formation procedure and the students' own learning experience within the traditional paradigm. However, the usual way of explaining the topic with simplistic demonstrations shows only the execution part of action and keeps the orientation part out of sight.

The analyses of the origin of these mistakes through the lens of Galperin's theory allowed the workshop participants to understand the difference between the naïve and conceptual comprehension of students' difficulties, and the meaning of the fundamental elaboration of the orientation procedure, which mediates the correct executive part of action.

Conclusion

Our major result was the design of a feasible way of introducing students to Galperin's theory through their participation in real concept-formation, where each component of the step-by-step formation procedure can be observed. Here the materialized form of action deserves the utmost attention, as it may be mistaken for mere visual illustrations and hands-on manipulations by those who are not familiar with Galperin's theory. Thus, with this article we tried to clarify the difference and the originality of his activity approach to formation of a concept.

The central content of the valency concept is the substantial coordination of students' partial actions within shared choice of the total number of bonds, which is at the core of the orientation process. The transition from the joint form of action to the individual one comprises the most important part of the interiorization and has to be scaffolded with the appropriate procedure.

As students considered their mistakes through the lens of “orientation development,” the basic principles of Galperin's theory proved to be vital. It was an opportunity to direct students' attention to the content of the action “behind” a concept, especially its orientation part, as its quality defines the flawless performance of a practical action on the first try. The simple demonstrations of visual “aids” whose role is limited to the illustrative, deprives students of the conceptual basis for their own orientation. The choice of the proper action and the design of its materialized form are thus still a challenge, for which Galperin's theory provides essential guidelines for school education innovations.

Limitations

The purposes of our research demand from our future teaching series a more detailed collection and description of the students' actions for each step of the learning trajectory for a broader sample. This might allow its statistical processing and the definition of the factors leading to successful or poor performance of the critical tasks.

Ethics Statement

All study participants were informed about the purpose of the study. The study followed the ethical guidelines of the institutional ethics review board, and no special ethical approval was required, since the procedure had no more than minimal risk. Participation in the study was entirely voluntary.

Author Contributions

Elena Vysotskaya conceived of the idea. All authors participated in the experimental design. Anastasia Lobanova and Mariya Yanishevskaya performed the procedure. 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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Effectiveness of Different Teaching Resources for Forming the Concept of Magnitude in Older Preschoolers with Varied Levels of Executive Functions

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Background. Studies have shown the great importance of early mathematical development as a predictor of subsequent success, which poses the question of how to organize preschool mathematical education with a view to the children's age characteristics, including their cognitive development. In other words, mathematical concepts and actions should be formed with the help of teaching resources appropriate to the child's development.

Objective. To determine the effectiveness of three teaching resources (examples, models, and symbols) in formation of the concept of magnitude in older preschoolers (ages 6–7) with different levels of executive function.

Design. Four training programs (with 15 twenty-minute lessons each) were developed and conducted in a formative experiment for older preschoolers with different levels of development of executive functions. The lessons addressed the concept of magnitude (length, area, volume), using different types of teaching resources: exemplars (in traditional and game variants), models, and symbols. The total sample of 116 subjects (44% boys) was divided into 4 groups for each of the programs, plus a control group in which no sessions were conducted. The groups were equalized according to the initial level of development of concepts of magnitude and the level of development of executive functions.

Results. There was a statistically significant increase in the quality of mastery of the concept of magnitude in three experimental groups (“symbolic,” “traditional,” and “traditional with imaginary characters”) compared with the control group. The formative effect of the “model-building” program showed no significant differences from the effect of the child's natural development (the control group). We also showed that children with a low level of regulation learned mathematical concepts more

Keywords:

Teaching resources, regulatory functions, executive functions, symbol, elementary mathematical conceptions, older preschool age

effectively with the “symbolic” program; children with a medium level of regulation with the “symbolic” and any variant of the “traditional” program; and children with a high level of regulation with the “symbolic” and “model-building” programs.

Conclusion. The findings underline the importance of both the type of teaching resources used and the level of development of voluntary regulation, when teaching mathematics to preschoolers.

Introduction

Research in psychological and pedagogical science has demonstrated a significant influence of early mathematical skills on subsequent academic and social success, both in school and in adulthood (Jordan et al., 2009; Tikhomirova, 2021; Watts et al., 2018). The great importance of preschool mathematics teaching for subsequent development (Ritchie & Bates, 2013; Watts et al., 2014) indicates the need for organization of effective education at this age based on the specifics of child development in the preschool period. This is extremely important given the nature of modern preschool childhood: increasing demands on children’s intellectual development, and the discrepancy between children’s age requirements and characteristics and some models of education, leisure activities, and children’s products (Smirnova, 2019).

Following the cultural-historical and activity approaches, studies have shown (Aleksandrova, 2013; Davydov et al., 1996; Davydov & El’konin, 1966; Obukhova, 1972; Shinelis & Sidneva, 2020) that it is advisable to start introducing children to mathematical reality by mastering an elementary mathematical concept such as magnitude. Magnitude itself is usually determined using three comparison relations ($a = b$, $a > b$, $a < b$); examples of magnitudes that preschoolers constantly confront include length, area, volume, and quantity. The concept of magnitude is essentially a system-forming concept that underlies the concepts of number, function, and figure, and, accordingly, links three domains of mathematics: arithmetic, algebra, and geometry (Davydov, 1962).

According to P.Ia. Galperin’s theory of planned stage-by-stage formation of mental actions and concepts, any concepts new to the child should be learned as reference points for relevant actions, revealing the cultural and historical conditions for the origin of these concepts (Gal’perin, 1975). In studies conducted according to the theory of developmental learning and the theory of planned stage-by-stage formation of mental actions and concepts, it has been shown that from the psychological and logical/subject-related standpoints, the most complete and appropriate idea of magnitude is formed when learning actions of comparison (establishing the correspondence or non-correspondence of magnitudes) and measuring quantities using a conditional measure (how many times the measuring instrument fits into the given magnitude) to establish relationships between them (Davydov, 1962; El’konin, 1963; Frolova, 1963; Gal’perin & Georgiev, 1960). The use of a conditional measure makes it possible, first, to compare objects that cannot be directly placed upon each other, and second, to concretize the relationship between magnitudes and understand how much one magnitude is larger or smaller than another. When teaching is organized

this way, the concept of “magnitude” is mastered as a necessary reference-point for a specific object-oriented action — the action of comparison and measurement (Gal’perin, 1976) — which allows us to say whether children have understood its essential features. However, even when the children perform the same actions, the organization of specific cognitive situations and tasks can be provided by various teaching methods. This raises the issue of the effectiveness of such methods.

Teaching Resources and Age Characteristics of Preschoolers

Teaching resources are defined as anything that facilitates the transfer of knowledge in the instructional process (Salmina, 1988). This may include materials and study aids used in the classroom, the teacher’s narrative, etc. They may differ in form and content. However, the key point in achieving developmental effects is the difference among teaching resources according to their function in children’s action (Salmina, 1988). From this point of view, it is essential to consider teaching resources that:

1. Establish a meaningful purpose for the child’s action;
2. Provide a way for that action to be performed.

In this context, the term “resource” is used here in the sense of an instructional approach. However, the teaching resources used in the functions mentioned above may also be considered as psychological methods that allow one to master new types of activity (Vygotsky, 2004). Mastering the cultural system underlying one’s own cognitive activity is an important aspect of the cognitive development of a preschool child (El’konin, 1989; Karabanova, 2005; Venger, 1986). Accordingly, the child’s success in mastering mathematical content will depend on the appropriateness of the instructional approaches that are selected.

These instructional approaches and resources must first of all be consistent with the logic of amplification (Zaporozhets, 1986). In other words, the tools should “grow out of” children’s natural activities, in which zones of proximal development (ZPD) are also created. Based on the features of children’s activities described in various studies (El’konin, 1978; Sarama & Clements, 2009; Shapovalenko, 2004; Shiiian et al., 2021; Solovieva et al., 2021; Venger & Kholmovskaia, 1978), we have identified three possible types of teaching resources for this age group:

1. Exemplars (instructions or rules that are accepted by general agreement of the players), most actively used in games that have rules;
2. Models (diagrams, maps, plans, and other objects that allow the child to display the essential relationships between objects) encountered in children’s productive activities (model-building, construction, drawing, etc.);
3. Symbols (a magic wand, an imaginary letter, etc., in which the child singles out and maintains significant relationships through an emotional attitude to the situation being created), which are an essential part of the content of plot role-play.

In order to test the effectiveness of each type of teaching resource, we developed four different approaches to designing a curriculum to teach the concept of magnitude to older preschoolers:

1. Traditional approach with imaginary characters (the key teaching tool here is the exemplars introduced through imaginary characters);
2. Traditional approach (the key teaching tool is exemplars);
3. Model-building approach (the key teaching tool is models);
4. Symbolic approach (the key teaching tool is the symbol);

Although the teaching resources identified here have analogues in the free activity of most preschoolers, we believe that such tools can play different roles, depending on the particular characteristics of the child's development. Voluntary self-regulation plays a key role in this development. Thus, for example, orientation to exemplars and rules appears significantly later than symbolization and model-building (these are the essence of mastering the substitutive function of game objects); such an orientation, closely related to voluntary regulation, appears only at the stage of already rather developed plot role-play (El'konin, 1978; Veraksa & Veraksa, 2016). Therefore, it seems to us fundamentally important to consider the effectiveness of various means of forming mathematical representations in the context of the development of voluntary self-regulation in preschoolers.

Mathematical Development and Voluntary Self-Regulation at Preschool Age

When we speak of self-regulation in this paper, we rely on the concept of regulatory or executive functions (EFs) as developed by A. Miyake and colleagues (Miyake, 2000). According to this concept, EFs are a group of cognitive processes that provide for purposeful problem solving and adaptive behavior in new situations (Diamond, 2012); that is, they are metacognitive capabilities (Morosanova et al., 2021). Executive functions comprise three components: 1) working memory (visual and verbal); 2) cognitive flexibility (focusing attention and/or switching attention under changing conditions); 3) inhibitory control (the ability to suppress an impulsive reaction).

Research shows that EFs predict the future performance of preschoolers (Duncan et al., 2007) and are correlated with mathematical ability (Bull & Scerif, 2001; Clements et al., 2016; Jarvis, 2003). Thus, for example, inhibitory control and cognitive flexibility in preschool children are predictors of mathematical ability at an older age (Best et al., 2011; Espy et al., 2004). A low level of EF is associated with difficulties in mastering mathematical concepts (Ribner, 2020; Swanson, 2001). These results raise the question of the particular ways that mathematical education should be organized for children with different levels of development of executive functions.

Research Hypotheses

We have suggested that symbolic representations are most appropriate in the preschool period, as these are more natural from the standpoint of preschoolers' play activity, and contribute to self-expression (Veraksa & Veraksa, 2016). Techniques using exemplars are more specific to traditional schools, where the teacher serves as a conveyor of cultural models and most often passes them on to students in a directive form. Modeling tools may be difficult to master in that situation. On this basis, we advanced the following empirical hypotheses:

1. Children with a low level of development of EFs will learn mathematical concepts and skills more successfully when using symbolic representations. This hypothesis is based on the fact that symbolization at an early age greatly facilitates perception of the conditions of tasks (Veraksa et al., 2014; Veraksa et al., 2020) and will be the most effective means of their formation due to the symbolic nature of mathematical representations (Salmina, 1988).

2. Preschoolers with a high level of EF development will show the best results from the model-building approach. This is because visual models are more conducive to the cognitive development of children with a pronounced cognitive orientation (Venger, 1995).

Methods

Participants

The sample comprised 150 children aged 6–7 (mean age 6.9) attending kindergarten preparatory groups, of whom 65 were boys (43%) and 85 were girls (57%). The study was conducted in the 2021–2022 academic year. All participants attended a Moscow educational complex where the program “From Birth to School” was used as the base program. The study was approved by the Ethics Committee of the Faculty of Psychology of Lomonosov Moscow State University.

Questionnaires

Methods for Mastering the Concept of Magnitude

A diagnostic toolkit was developed for use with preschool children to assess the quality and stability of their formation of elementary mathematical representations of magnitudes and their relationships.

This diagnostic technique included four types of tasks for each magnitude: length, area, volume. The children were given two tasks to solve for each magnitude, about the ability to compare objects; they were asked to select an object the same size as another one — for example, to find the rectangle with the same length as that shown in a drawing. Two tasks each for the ability to use a measuring instrument correctly (“who measured correctly?”): to apply it so that there is no empty space between measurements, to use equal measuring instruments, etc. Two tasks each for actually measuring a magnitude with a conditional measuring instrument and recording the result with labels or a number (“how many times does the measuring instrument fit in this magnitude?”). Two tasks each to understand how the number depends on the measuring instrument used (the larger the measuring instrument, the fewer times it fits into the magnitude). Two more assignments were included for making sets (“what would be left over if such and such sets were used?”). The ability to put together complete sets was not specifically targeted in this study during the lessons, so we considered these tasks to be within the children’s zone of proximal development (ZPD). The tasks for making sets were assessed depending on the amount of assistance provided to the child by the tester and the correctness of the answer: the preschooler received 2 points for correctly solving the task independently, 1 point for

solving the task correctly with the help of the tester's prompts; 0 points if the task is not solved or is solved incorrectly even with the help of an adult. The formation of concepts of length and area was assessed from 0 to 10 points; of volume from 0 to 7 points; and for tasks in the ZPD from 0 to 4. The total possible score was 31 points. Diagnosis of mathematical concepts and skills was performed individually with each child.

Methods for Assessing the Development of Executive Functions

Recent studies show that the level of executive functions is significantly associated with children's success in mastering mathematical content (Clements et al., 2016; Veraksa et al., 2020); therefore, we used the level of development of executive functions as the criterion for dividing the children into groups. To measure students' EF, we used the NEPSY-II subtests (Korkman et al., 2007) for visual memory (Memory for Designs) and auditory working memory (Sentence Repetition), inhibition and switching (Naming and Inhibition, Statue), and also cognitive flexibility (The Dimensional Change Card Sort) and visual-spatial memory (Schematization). This allowed us to measure various components of preschoolers' cognitive processes. The diagnosis of EFs was performed with children on an individual basis during two meetings with each child.

The NEPSY-II Memory for Designs subtest was used to assess working visual memory. This test includes the following final scores: content scores are awarded for correctly remembering picture details (maximum 46 points); spatial scores reflect how correctly the child remembers the configuration of a picture (maximum 24 points); and bonus scores are awarded to the child for correctly remembering and looking at both dimensions simultaneously (maximum 46 points). The three indicators are summed up in the final score (maximum 116 points).

Verbal working memory was assessed using the NEPSY-II "Sentence Repetition" subtest, which consists of 17 sentences that gradually become more difficult to remember due to their length and grammatical structure. Children receive 2 points for each sentence they repeat correctly; one point if they make one or two mistakes in the repetition by skipping, replacing or adding words, or changing the order of words; and if the child makes three or more mistakes or does not answer, no points are awarded. The assignment is terminated if the child receives 0 points four times in a row.

The NEPSY-II "Naming and Inhibition" subtest assesses information-processing speed and inhibition of impulsive reactions. It consists of two blocks: a series of white and black circles and squares and a series of white and black arrows showing different directions (up and down). Two tasks were performed with each series of pictures: a task to identify the form (in this case, the child simply had to quickly name the forms that he saw) and an inhibition task. In the latter case, the child had to do everything contrariwise: for example, if he saw a square, he was supposed to say "circle" and so on. For each task, the researchers recorded the number of mistakes the child made and corrected or could not correct, as well as the time it took to complete the task.

"The Dimensional Change Card Sort" test (Zelazo, 2006) was used to assess cognitive flexibility. This technique consists of three tasks for sorting cards. First,

the children must arrange the cards by color, shape, and then follow a complex rule: if the card has a frame, they must sort it by color, and if there is no frame, they must sort it by shape. For each correctly sorted card, the child receives 1 point; at the end, the number of points for each series is calculated (maximum 6, 6, and 12 points, respectively), and then the total score for all tasks is calculated (maximum 24 points).

We used the “Statue” subtest (NEPSY-II, Korkman et al., 2007) to assess “hot” self-regulation and physical inhibitory control. In this test, the child is instructed to remain motionless with eyes closed for 75 seconds, inhibiting impulsive reactions to distracting sounds. An assessment is performed for each 5-second interval: 2 points are awarded if the child did not make any mistakes in the 5-second interval, 1 point is given if 1 mistake was made, and 0 points if 2 or more mistakes were made. Large movements of the arms, body, legs, head, opening of the eyes, vocalization or laughter are all considered errors. The total score (max. 30) and the number of errors are calculated for three categories: movements, eyes, and sounds.

We used the “Schematization” technique to assess planning and checking and visual-spatial orientation. Here, children are asked to find a “route” through an extensive system of streets, using the notation of this route with the help of a diagram and/or a conditioned image in the form of a system of landmarks. The child has to take into account the sequence of landmarks and/or the direction of turns.

Methods for Assessing Intellectual Development

As a supplement, non-verbal intelligence was diagnosed using Color Progressive Matrices by D. Raven (Raven & Kort, 1997). In this technique, the children need to choose one of the six proposed images in order to complete a drawing while following a certain logic. The technique contains three series of 12 tasks (maximum score — 36).

All the techniques were presented to the children in digitized form with a mobile app.

Procedure

The study comprised several stages. First, the cognitive processes of children were assessed using the NEPSY-II subtests “Card Sorting” and “Schematization,” as well as D. Raven’s matrices. After evaluating their EF, the children were divided into three subgroups by level of cognitive development (low, medium, high) according to the results of cluster analysis (K-means clustering) performed in IBM SPSS Statistics 22. Before the beginning of the experimental sessions, a pre-test of mathematical concepts and skills was conducted using the authors’ diagnostic tools.

Next, participants from each subgroup with low, medium, and high EF levels were randomly assigned to four experimental groups and one control group, so that the ratio of participants in the groups was uniform. For each approach, 15 experimental sessions lasting 15–20 minutes were held in mini-groups of 3–4 children. The sessions occurred twice a week in the first half of the day in the groups at the kindergarten. The control group did not attend any special sessions.

The sessions were completed for all approaches simultaneously, after which a post-test of mathematical conceptions and skills was performed, similar to the baseline diagnostics in the experimental and control groups. A month after the experimental sessions, some of the children took part in a delayed post-test.

Formative Sessions

The programs we developed for the formation of concepts of magnitudes corresponded to the types of methods that “grow out of” the natural activity of preschool children.

In the first program (“traditional”), an exemplar was offered as the main instruction for performing actions. The children were given specific instructions on how to perform an action as a way of solving a problem (for example, “here is how you measure with a ruler,” “look how I do it,” etc.). The meaningfulness of the tasks was not specifically addressed; the children were presented with tasks such as “measure,” “compare,” “find one that’s the same.” Why this had to be done was not discussed. Note that analysis of modern Russian programs and mobile apps for preschoolers has shown that the main teaching resource used is the exemplar, a rule taught to the children for performing a task or action by demonstration of the action, while the need to use the mathematical concepts and actions is given as an external condition (Aslanova et al., 2020; Sidneva et al., 2021).

In the second program (“traditional with imaginary characters”), the concept of magnitude was introduced in exactly the same way as in the first program: through a directive instruction about the mode of action and tasks that did not disclose the meaning of this action. However, the tasks given to the children were presented by characters in a game (Dumbo, Wizard, etc.), depicted in a colorful picture. These characters did not perform a symbolic function, nor did they help to make the task more meaningful. They were an external game element, introduced in order to evaluate the role of this type of game element, while maintaining the basic orientation to the exemplar.

In the third program (“model-building”), we introduced the concept of magnitude and worked on it through design tasks (“choose a suitable column for the building,” “what kind of tiles can be used to lay the floor in the bathroom?”). Here, meaningfulness was determined by, on the one hand, a real everyday or engineering situation that needs to be resolved, and on the other, the child’s desire to act like an adult, for example, like an engineer or like Dad, who repairs things. The solution was introduced as something that could help solve this type of problem. When actions with real objects were difficult (for example, they are too heavy, big, or fragile, or you need to perform the action right the first time so as not to have to redo the repair, etc.), the problem could be solved by constructing a model of the real objects (a diagram, drawing, or other type of model) and using it to test hypotheses. Using various models and schematized methods, the children were able to learn generalized information about the essential properties of the real world (Shapovalenko, 2004). And research has shown that it is indeed through manipulation of such models, that both the development of initial mathematical concepts and the formation of the main mental neoformations take place (Venger, 1978).

In the fourth program (“symbolic”), the concept of magnitude was introduced and worked out through tasks of helping an imaginary character (for example, “pour the same amount of the water of life to save the queen,” “help Winnie the Pooh find his way home from the dark forest”) that created emotional meaningfulness for the goal of the action. The means of solving the problem situation were also symbolic objects (for example, a magic ball for measuring a route; umbrellas that can protect a drawing on asphalt from rain; a magic cup). These symbolic representations established the problem situation, key points of orientation, and relationships for its solution, becoming reference points for mastering the concept of magnitude. In this case, the children did not need a model of the action; they themselves could construct the necessary action based on the symbolic image of the situation, since the symbol as a cognitive tool facilitates perception of the conditions of the task in a situation of uncertainty (Veraksa et al., 2014; Veraksa et al., 2020). And at the same time, it ensures the children’s emotional involvement in the activity (Leont’ev, 2000; Veraksa et al., 2015)

The programs we developed are identical in terms of the object-specific actions performed by the children: measurement and selection with the help of conditional measures, but they differed in the teaching resources used. The following concepts were chosen as formed concepts in all the programs: length (including width and height), area, and volume.

Experimental sessions were conducted by specially trained teachers, who did not themselves perform the preliminary and subsequent testing.

Results

The final sample of the formative experiment included 116 preschoolers who had gone through both EF diagnostics and a pre-test in mathematics. The children who were included in the formative experiment did not differ from those excluded from it in the development of their visual working memory (Chi-square = 0.9, $p = 0.3$), inhibition and switching (Chi-square = 0.3, $p = 0.6$), cognitive flexibility (Chi-square = 1.9, $p = 0.16$), visuospatial memory (Chi-square = 0.01, $p = 0.9$), and verbal intelligence (Chi-square = 0.2, $p = 0.6$). However, differences were found in their auditory-verbal working memory (Chi-square = 5.7, $p = 0.01$), which we did not consider significant, since research has shown that auditory-verbal working memory is weakly associated with mathematical development (Bull & Johnston, 1997)

The participants comprised 51 boys (44%) and 65 girls (56%). No significant statistical differences were found in the level of mathematical abilities for boys and girls (Mann-Whitney U test, $p > 0.05$).

Before further analysis, we will provide statistics on the distribution of children by approach in the formative experiment.

Descriptive Statistics

The preschoolers’ EF level of development was taken into account when they were distributed according to the experimental conditions (see Table 1). Four experimental groups (“Traditional,” “Traditional with imaginary characters,” “Model-

building,” “Symbolic”) and one control group were equalized in terms of the level of the children’s executive functions (Pearson’s Chi-square, $p > 0.05$). No statistically significant differences were found in the distribution of children based on EF level by approach. Children with different EF levels were divided proportionally into the experimental groups. In that way, further analysis of group differences is justified without taking into account the limitations in this part.

Table 1

Analysis of the distribution of students with different levels of EF into groups of the formative experiment

		Level of regulation			Total
		Low	Medium	High	
Control group	Quantity	5	11	6	22
	%	22.7%	50.0%	27.3%	100.0%
Symbolic approach	Quantity	5	14	6	25
	%	20.0%	56.0%	24.0%	100.0%
Model-building approach	Quantity	4	13	5	22
	%	18.2%	59.1%	22.7%	100.0%
Traditional approach	Quantity	5	13	5	23
	%	21.7%	56.5%	21.7%	100.0%
Traditional with imaginary characters	Quantity	6	13	5	24
	%	25.0%	54.2%	20.8%	100.0%
Total	Quantity	25	64	27	116
	%	21.6%	55.2%	23.3%	100.0%

Pearson’s Chi-square = 0.718, $p = 0.999$

Also, none of the identified groups differed in the pre-testing for mathematics (see Table 2). The lack of differences in the pre-testing is a prerequisite for correct interpretation of the results of the formative influence.

Table 2

Analysis of the distribution of students by mathematical abilities into groups in the formative experiment

	Control group	Symbolic approach	Model-building approach	Traditional approach	Traditional approach with imaginary characters	Kruskell-Wallis test
Final pre-test score	M+/-SD 13.4+/-6.2	M+/-SD 10.9+/-5.4	M+/-SD 14.7+/-4.7	M+/-SD 11.8+/-5.2	M+/-SD 13.7+/-5.2	$H = 4,870;$ $p = 0.300$

After the formative part of the experiment, only children who had attended more than half of the sessions were included in the subsequent study. Eighty 80 children were tested in the post-test, and 44 in the delayed post-test. Although the number of children who participated on the post-test was lower than on the pre-test, the proportional distribution of EF levels within the experimental conditions was maintained (see Table 3). The groups remained equal according to this criterion, which removes further limitations on data analysis. There were 44 children in the delayed post-test: 12 children from the control group, 9 from the “Symbolic” approach, 11 from the “Model-building” approach, and 6 from the “Traditional” approaches.

Table 3

Analysis of the distribution of students with different levels of EF in the groups of the formative experiment based on the results of the post-test

		Level of regulation			Total post-test
		Low	Medium	High	
Control group	Quantity	5	9	5	19
	%	26.3%	47.4%	26.3%	100.0%
Symbolic approach	Quantity	3	10	5	18
	%	16%	55.6%	27.7%	100.0%
Model-building approach	Quantity	2	6	4	12
	%	16.7%	50.0%	33.3%	100.0%
Traditional approach	Quantity	3	5	4	12
	%	25.0%	41.7%	33.3%	100.0%
Traditional with imaginary characters	Quantity	5	9	5	19
	%	26.3%	47.4%	26.3%	100.0%
Total	Quantity	18	39	23	80
	%	21.5%	49.4%	29.1%	100.0%

Pearson's Chi-square = 0.209, p = 0.978

Analysis of the Effectiveness of Teaching Resources in the Formation of Concepts of Magnitudes

In order to assess the effectiveness of the formative sessions, we performed a non-parametric statistical analysis of the final scores of the pre- and post-tests for the experimental and control groups. The comparison showed significant differences in the total score for diagnostics of mathematical ability between the results of the pre-test and post-test, and between the pre-test and delayed post-test (Wilcoxon Z test, $p < 0.05$). There were no significant differences found between the post-test and delayed post-test (Wilcoxon Z test, $p > 0.05$), which may suggest some stability in the results of the formative sessions (Wilcoxon Z test, $p < 0.05$). The minimum overall post-test score was in the control group — 2 points out of 31, with a minimum score of 7.5 for the experimental conditions. Thus, the results of both post-tests were significantly higher than the pre-test results.

We also note that the maximum score for diagnostics was indeed achieved on the post-test, with 29 points, and the maximum score for the delayed post-test, 27.5, demonstrates a slight decline. Since no significant differences were found between the post-test and delayed post-test, and the post-test had the larger variation in total score (2 to 29 for the post-test; 4.5 to 27.5 for the delayed post-test) and a larger sample, the post-test results will be considered for further analysis.

Table 4

Descriptive statistics of the final test score for the experimental and control groups.

		M	SD	Min	Max
Experimental groups	Pre-test	12.74	5.3	2	27
	Post-test	19.15	5	7.5	29
	Delayed post-test	18.04	6.47	4.5	27.50
Control group	Pre-test	13.4	6.2	2	25.5
	Post-test	15.6	7.3	2	29
	Delayed post-test	17.4	6.4	7	27

To assess the effectiveness of specific teaching resources, we compared the increase in the final score on the post-test for each approach (see Table 5, Figure 1). We found that the type of formative lesson does indeed have a significant impact on the increase in the overall score for diagnosis of mathematical concepts and skills (ANOVA with non-parametric Welch correction, $p < 0.05$ with equality of variances, Levene's criterion, $p > 0.05$).

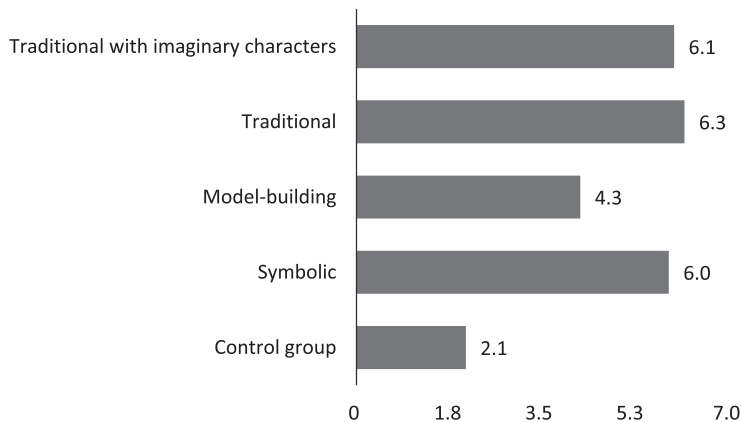


Figure 1. Increase in mean values for various approaches to formation.

Note: Levene's test, $p > 0.05$, ANOVA with non-parametric correction (robust criterion), $p < 0.05$

Pairwise comparison of the increase in mean values for different approaches to formation showed that children who studied according to the "Symbolic" and "Traditional with imaginary characters" programs showed a significantly greater increase in total score on the post-test compared with the control group (LSD, $p < 0.05$). Significant differences were also found between children from the control group and chil-

dren in the “Traditional” program (Mann-Whitney U-test, $p < 0.05$). The formative effect of the “Model-building” program does not show significant differences from the natural development of a child attending kindergarten (the control group) (see Table 5). We also note that children who attended formative sessions with the “Symbolic” approach showed a significantly greater increase in scores than those from the “Model-building” approach (LSD, $p < 0.05$).

Table 5

Analysis of multiple comparisons of approaches by increase in post-test score

(I) Approach	(J) Approach	Difference in mean values for increase (I-J)	Standard error	Significance, LSD
Control group	Symbolic	-5.8*	1.5	0.000
	Model-building	-2.2	1.7	0.2
	Traditional	-2.98	1.7	0.07
	Traditional with imaginary characters	-3.97*	1.5	0.010
Symbolic	Control	5.78*	1.5	0.000
	Model	3.6*	1.7	0.041
	Traditional	2.8	1.7	0.1
	Imaginary characters	1.8	1.5	0.2
Model-building	Control	2.2	1.7	0.2
	Symbol	-3.6*	1.7	0.041
	Traditional	-0.8	1.8	0.65
	Imaginary characters	-1.8	1.7	0.3
Traditional	Control	2.98	1.7	0.07
	Symbol	-2.8	1.7	0.1
	Model	0.8	1.8	0.65
	Imaginary characters	-0.98	1.6	0.5
Traditional with game elements	Control	3.97*	1.5	0.010
	Symbol	-1.8	1.5	0.2
	Model	1.8	1.7	0.3
	Traditional	0.98	1.6	0.5

Note: Least significant difference (LSD) indicators of increase are in bold.

For individual mathematical representations and actions, the following results were found:

1. The participants in the “Symbolic” approach showed a significantly greater increase in post-test scores than the children from the control group, in terms of the formation of concepts of length and area, the dependence of the number on the measurement; and the ability to select values and assemble “complex” sets (LSD, $p < 0.05$);

2. Children following the “Symbolic” approach also differed significantly in their formation of the concept of the dependence of the number on the measurement, from the children in the “Model-building” and “Traditional with imaginative characters” approaches (LSD, $p < 0.05$);
3. The increase in the total score for area and the ability to select magnitudes, in children who attended formative sessions according to the “Traditional with imaginative characters” program, was significantly greater than in children from the control group (LSD, $p < 0.05$);
4. There were no significant differences in the increase in the score on the post-test for volume, or the ability to use a measuring instrument to measure magnitudes (LSD, $p > 0.05$).

Analysis of the Effectiveness of Teaching Resources Depending on the Level of EF

An analysis of variance with repeated measurements was performed to test the hypothesis that children with a lower level of EF will most effectively master the mathematical concepts of magnitudes when they are taught with the “Symbolic” approach. Table 6 shows the differential characteristics of differences between baseline test scores (pre-test) and subsequent ones (post-test). The joint interaction of the two factors — approach and level of EF — has a statistically significant effect on the increase in the total score on the post-test (ANOVA with nonparametric correction, $p < 0.05$).

Table 6

Differential characteristics of differences in test scores of final and baseline diagnostics for different approaches

	Low EF	Medium EF	High EF
Approach / statistic for increase of score	M+/-SD	M +/- SD	M +/- SD
Control group	-0.5+/-0.7	1.44+/-4.2	6+/-3.95
Symbolic	11.3+/-0.3	5.68+/-7.5	7.7+/-3.98
Model-building	4.75+/-6.7	1+/-2.2	9+/-1.78
Traditional	6.83+/-8.95	8+/-5.1	3.75+/-1.3
Traditional with imaginary characters	3.4+/-3.96	6.3+/-2.8	8.5+/-5.8
Total score			

ANOVA with nonparametric correction, $F = 2.15$, $p = 0.04$ for approach*EF level

Looking at the assessment of the mean values of differential differences, it is important to note that the greatest increase in scores among students with low EF was found in the formation of concepts of magnitude in the symbolic approach. The mean increase in the score of children with low EF in the symbolic approach was more than 11 points, with an overall average increase of 3.94, and this was the high-

est compared to other groups. We emphasize that children with low EF who did not attend formative sessions showed a tendency toward some decrease in scores on the post-test compared to the pre-test and showed the smallest increase compared to the other groups.

To demonstrate the differences more clearly, Figure 2 shows profile plots for estimating the mean values of the differential differences.

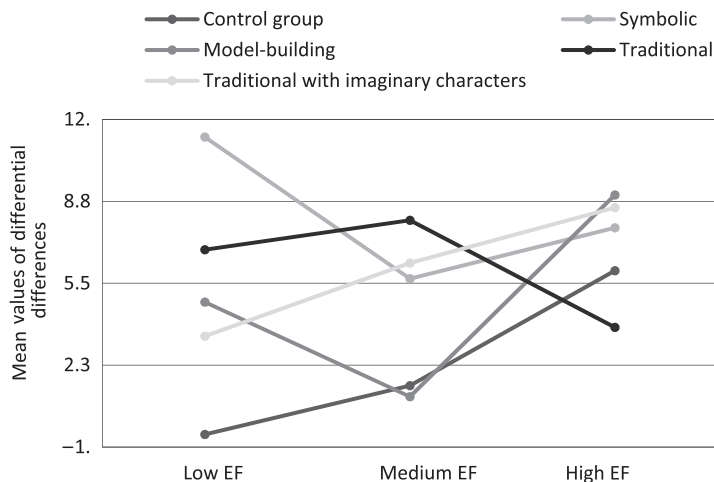


Figure 2. Profile plots for estimating the mean values of differential differences

An a posteriori analysis of the combined influence of the children's executive functions and type of formative activities did not show statistically significant differences between children with the same level of EF who studied under the different programs.

However, children with a low level of self-regulation (executive function) mastered mathematical representations when following the "symbolic" approach significantly better than children from the control group and the "traditional with imaginary characters" approach (Welch's t-test, $p = 0.001$ and $p = 0.01$, respectively). Preschoolers with a medium level of EFs mastered the material better when taught using both traditional programs than did the children from the control group and those taught according to the model-building approach (Welch's t-test, $p < 0.05$ for each pair), and children with a medium level of self-regulation who studied with the "symbolic" program showed a significantly greater increase in scores than the control group (Welch's t-test, $p = 0.015$). Participants with a high level of EF mastered the mathematical content in the Model-building approach more successfully than did the children from the Traditional with Imaginary Characters approach (Welch's t-test, $p = 0.004$).

That said, we emphasize that, in general, the children with a high level of regulation showed a significantly greater improvement in mastery of mathematical concepts than those with a medium or low level (LSD, $p < 0.05$). Even in the control group, the scores of these children increased by an average of 6 points. On the other hand, children with low and medium levels of EF from the control group showed the

least increase and even a worsening of results on the post-test. Pupils with a medium level of development of self-regulation who were taught with the “model-building” approach also showed an increase by an average of 1 point; that is, the level of formation of their concepts of magnitudes did not actually change.

Discussion

An important result of this study was the significant increase in scores on the post-test compared to the pre-test, which indicates the effectiveness of our sessions. We have also seen that this effect has some stability, since a month after the experiment, the children completed the test just as successfully as they had immediately after the completion of the formative sessions. Besides the general developmental effect of the formative sessions, we also obtained significant differences among the approaches, and, accordingly, among the teaching resources used in them. The use of symbols and exemplars to form concepts of magnitude turned out to be the most productive and successful, whereas learning based on models did not differ in its impact from children’s natural development and what is learned from standard kindergarten classes. We attribute this result to the fact that operating with abstract signs of objects requires children to have quite developed visual-effective thinking and an internal plan of action (Venger, 1995). Therefore, for most children, this program may lie outside the zone of their actual and proximal development, since research has shown that the formation of abstract thinking only begins at the end of the preschool years (El’konin, 1989; Karabanova, 2005). We also emphasize that only the children who had been taught according to the “symbolic” approach coped with the making sets task (this action was not specially formed) significantly better than the control group, which once again indicates the effectiveness of the symbol as a teaching tool in expanding the child’s ZPD. Thus, our first hypothesis about the different effectiveness of the approaches was partially confirmed.

It is interesting that we did not find any increase in scores that differed from natural development in our testing for the concept of volume, the ability to use a measuring instrument, and to measure magnitudes. That is, formative sessions did not help children to master these actions specifically for a magnitude such as volume. Why is that? Volume is the most complex of the formed magnitudes. It is known that understanding of the conservation of volume arises much later than the conservation of length and quantity (Piaget, 1994). The formation of this concept is more difficult and occurs more slowly in preschoolers than the concepts of length and area (Obukhova, 1972), and some studies have shown that this concept does not lie within the ZPD of a preschooler (Veraksa et al., 2020). For volume as a magnitude, the strongest visual attributes (for example, the height of water in a jar, the width of a flask, etc.), prevent one from “grasping” the essential characteristics and fully mastering the concept. However, this result may be associated with incorrectly selected guidelines and actions for this concept in the programs and with methodological inaccuracies.

From analyzing the results, it can be asserted that the initial level of development of cognitive processes in older preschoolers is directly related to the children’s

ability to learn new mathematical concepts. Children with a high level of EF are more successful in mastering new mathematical skills and concepts than those with a low and medium level of development of executive functions. This is consistent with earlier research findings that the level of EF is a predictor of the development of mathematical skills (Bull & Scerif, 2001; Clements et al., 2016; Jarvis, 2003; Veraksa et al., 2020).

The fact that children with a low level of EF scored the highest increase in points after completing their instruction according to the “symbolic” approach, and children with a high level of EF according to the “modeling” approach, may indicate the importance of choosing suitable tools for forming mathematical concepts, considering the level of formation of cognitive processes for student development (Clements et al., 2016; Veraksa et al., 2020) and confirms our second and third hypotheses.

It should also be emphasized that preschoolers with low EF who did not attend any special sessions showed worse results on the second test, which suggests the importance of special work with this group of children.

Conclusion

We see the possibility of effective teaching even of children with a low level of voluntary self-regulation, by using a symbolic approach, whereby new ideas and concepts are introduced in a special emotionally constructed form, which makes it possible to motivationally include the children in learning and simplify their perception of the task (Veraksa et al., 2014). This approach is based on the use of symbols as a special form of mental representation of an object. Children use symbols in play as a means of self-expression (Veraksa et al., 2016). Mathematical instruction can also be symbolized to increase the effectiveness of the learning of children with low EF, whereas for children with high levels of cognitive development, more actions can be included in their mathematical instruction to operate with visual models, schematized representations of objects to stimulate their cognitive development (Venger, 1995).

Limitations

Finally, we note that the limitations of this study include the experimenter effect, which could affect the results of the formative sessions and the entire study, as well as the relatively small number of children in each of the subgroups at the time of the post-test.

Ethics Statement

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

Informed Consent from the Participants’ Legal Guardians

Participants gave informed consent before taking part.

Author Contributions

A.N. Veraksa and A.N. Sidneva conceived of the idea and supervised the project, A.N. Sidneva and V.A. Plotnikova developed the design of the experiment. M.S. Aslanova made a statistical analysis. 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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SOCIAL PSYCHOLOGY

An Adaptationist Framework to Examine Intergroup Contact

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Background. Many culturally-plural societies like Canada or Russia seek ways to manage their cultural diversity in order to promote harmony among coexisting groups. The social sciences have long viewed intergroup contact as a beneficial intervention to achieve such harmony.

Objective. This paper proposes an adaptationist framework within which to explain how and why intergroup contact contributes to the positive and negative outcomes for individuals who live together in a plural society. We employed this framework in a case study that may serve as an example of the conceptualization and analysis of these issues in international research. Its structural framework included both positive and negative contact and the role of this contact in the distribution of intercultural and psychological adaptation among a large representative sample of the Canadian population.

Design. We used a correlational design with a representative sample of Canadians from a survey carried out by Environics in 2019, which was stratified according to the most current population statistics. The total sample was 3,111 persons age 18 and over and included the largest racialised groups in the country.

Results. Our main finding was that intergroup contact (both positive and negative) related to both psychological and intercultural adaptation. These findings have implications for improving intercultural relations, especially through the role of positive contact.

Conclusion. The experience of negative contact (e.g., discrimination) in the near term is an important factor in undermining both forms of adaptation. Nonetheless, while intergroup contact can bring both positive and negative experiences during intercultural interactions, it leads to mutual adaptation over time.

Keywords: Intergroup contact, intercultural adaptation, psychological adaptation, personal wellbeing, multicultural ideology, prejudice, acculturation.

Introduction

All societies are culturally diverse, including the Russian Federation. This poses the challenge of how we shall live together (Berry, 2017). Plural societies are made up of groups such as indigenous peoples, immigrants, different nationalities, and established ethnocultural groups, all of which differ in many respects, including their cultures, languages, and religions. At present, the main concern in these societies has come to focus on intergroup relations, particularly the phenomenon of racism (UNESCO, 2020).

Individuals develop their behaviours by adapting to their specific ecological and cultural contexts, a process which results in variations in behavioural repertoires across cultures (Berry et al., 2011). When individuals with these different repertoires meet in these diverse societies, they face the important issue of how they may adapt to each other and live successfully together (Berry et al., 2022). An ecocultural framework, developed by Berry (2018), proposes that variations in the development and display of features of peoples' cultures and their individual behaviours can be accounted for by long-term adaptations to their ecological contexts and to their intercultural contact with members of other cultural groups. In addition to these cultural differences, one particularly salient difference between groups is the perceived physical differences in appearance (often thought of as "race").

The mutual adaptation of these groups to living together has been studied for decades by researchers from many disciplines, including demography, economics, political science, sociology, and psychology. In the field of intercultural psychology, the overarching framework used in many of these studies has been rooted in the concept of acculturation (Sam & Berry, 2016), which has been defined as the cultural and behavioural changes resulting from intercultural contact (Berry, 2005). Various outcomes to acculturation have been conceptualized in different ways, in these studies, such as economic success, social engagement, cultural competence, and personal wellbeing. These different outcomes to living in these intercultural settings have been classified by Ward (2005) as psychological adaptation ("feeling well") and sociocultural adaptation ("doing well"), to which Berry (2005) has added a third: intercultural adaptation ("relating well").

The daily intercultural contacts of individuals in these culturally diverse societies creates a need for mutual adaptation. To meet this need, some societies have developed policies and practices to manage these relationships in order to achieve a positive intergroup climate. To deal with the diversity, Canada introduced a policy of multiculturalism (Canada, 1971). This policy has two main planks: promoting the value to a society of having diverse groups maintain their cultures over generations, and promoting contact among cultural groups. These two features (cultural diversity and contact among groups) provide a context that is ripe for the study of the effects of intergroup contact and its consequences (Berry, 1984; 2016). Since such contact among peoples of diverse backgrounds is a fundamental experience of daily life in all contemporary societies, the consequences of such contacts are a matter of great concern to policymakers, community leaders, and citizens, as well as social and behavioural scientists in many societies.

Contact Hypothesis

One way of conceptualizing the consequences of intergroup contact has been formulated as the “contact hypothesis” (Allport, 1954). The core idea is that the more intergroup contact individuals have, then the more they will develop and express positive attitudes and behaviours towards individuals in the groups with which they are in contact. The contact hypothesis is one of the most enduring ideas in the field of intergroup relations (Christ & Kauff, 2019; Crisp & Turner, 2011; Dovidio et al., 2017; Kotzur et al., 2018; Pauluck et al., 2019; Pettigrew & Tropp, 2006). One characteristic of the contact hypothesis is the differentiation between amount of contact (how much and how often) and the quality of contact (friendly or hostile) (Bornmann, 2016; Nezlek & Schaafsma, 2010).

A good deal of research has been carried out to test the contact hypothesis internationally. In a large meta-analysis of this work, Pettigrew and Tropp (2006) examined hundreds of studies of the contact hypothesis, which were carried out in many countries and many diverse settings (in schools, at work, and in experiments). Their findings provided general support for the contact hypothesis: intergroup contact does generally relate negatively to prejudice in both dominant and non-dominant samples (see also Berry et al., 2022). That is, the results from the meta-analysis revealed that greater levels of intergroup contact are typically associated with a lower level of prejudice. In sum, the contact hypothesis proposes that under certain conditions, more intercultural contact will be associated with more mutual acceptance. Specifically, more contact will predict more positive intercultural adaptation.

Although contact is known to be related to intercultural adaptation, less is known about any relationship between contact and psychological adaptation (i.e., personal wellbeing). In this paper, we propose a relationship between individuals’ intercultural contacts and their psychological adaptation, as well as their intercultural adaptation. One basis for this possibility is the recent research finding that extensive social contacts promote the wellbeing of individuals. This relationship has been found for many kinds of social contacts, with many kinds of samples and in many societies (Jetten et al., 2015; Sønderlund et al., 2017).

Many studies have found such relationships between intercultural contacts and wellbeing. For example, in a study of first and second generation immigrants in Canada, Berry and Hou (2016, 2017) showed that social engagements with the larger society (termed “bridging social capital”) predicted higher self-esteem and mental health among immigrants and their descendants, and that contacts with their own ethnocultural group (termed “bonding social capital”) predicted higher life satisfaction. A three-year longitudinal study of refugees in the UK showed that intergroup contact at one point in time was associated with increased wellbeing at a later point in time but provided no reliable evidence for the reverse associations (Tip et al., 2018). In a study of Koreans who settled in New Zealand, Ward et al. (2020) examined the relationship between three aspects of normative multiculturalism (multicultural policies/practices; ideology; and contact) and wellbeing. They found that perceived multicultural policies and practices positively predicted subjective wellbeing, and multicultural ideology predicted wellbeing via a sense of belonging, but multicultural contact was not significantly related to wellbeing.

Some authors have raised questions about the reciprocity of contact and adaptive outcomes such as lower prejudice; that is, whether the intergroup contact is mutual, and is the cause and/or the effect of lower prejudice (Kalin & Berry, 1996; Nezlek & Schaafsma, 2010). In a longitudinal study with students, Binder et al. (2009) found that prior intergroup contact and liking led to subsequent intergroup contact, and that such contact promoted even greater acceptance of the other group, thus demonstrating a two-way relationship between contact and acceptance. We propose that these relationships constitute a behavioural syndrome: that is, the covariance of a set of psychological features involved in the process of adaptation to changing social and cultural conditions in plural societies.

The approach of coalitional psychology (Pietraszewski et al., 2014) considers the evolutionary core of intergroup relations to be a cognitive mechanism that evolved to detect coalitional alliances via the categorization of the social world into “Us” vs. “Them.” This mechanism is what ultimately predisposes humans to have a bias in favor of their ingroup and against the outgroup. For human beings, ethnic, cultural, or racial groups are simply one historically rooted type of coalition. This is because our long human history has shown this distinction to be an ecologically valid predictor of people’s social alliances and coalitional affiliations (Grigoryev et al., 2020). Adaptation to cultural diversity following contact takes place through the redefinition of concepts and the adjustment of the boundaries of ingroup and outgroup (“Us” vs. “Them”). This process includes both improving intergroup attitudes (intercultural adaptation) and reducing the effects of the stress of the heterogeneous environment on personal wellbeing (psychological adaptation).

Discrimination as a Form of Negative Contact

In our view, discrimination may be conceptualized as a form of negative contact, one which is hostile as opposed to positive or friendly. Culturally and racially diverse neighbourhoods expose people to negative as well as positive intergroup contact; they go together. While positive contact is associated with more positive mutual attitudes (as documented above), negative contact increases prejudice, and limits intercultural adaptation (Barlow et al., 2012). As reviewed above, the negative psychological consequences of discrimination for both adults and youth of non-dominant peoples have also been well-documented world-wide for non-dominant peoples (Carter et al., 2019; Paradies, 2006; 2015). These studies showed that the experience of discrimination has a negative impact on people’s psychological adaptation.

While the effects of perceived discrimination on the adaptation of non-dominant peoples have been studied and documented, their effects on dominant groups are less well known (Leonardelli & Brewer, 2001). This group’s experience of discrimination may be seen as the result of laws that mandate employment equity requirements, such as quotas, for example. This may generate feelings of resentment (Yang, 2000), and lead them to develop higher levels of racism and lower acceptance of multiculturalism.

The Present Study

Our research examined the contact hypothesis in a culturally pluralistic society (Canada) within an adaptationist framework. It concentrated on the role that both positive contact and negative contact play in shaping the quality of intergroup relations and personal wellbeing. It supplemented the descriptive findings of the Environics report (2019) by using multivariate statistics and structural modeling to show how these variables related to each other, and provided a framework for explaining these relationships. In addition, this adaptationist framework broadens our understanding of the role of contact in intercultural relations (see Berry et al., 2022).

We focused on four main classes of phenomena within the adaptationist framework: (1) intergroup contacts among individuals; (2) the individual and group experience of discrimination; (3) intergroup attitudes; and (4) personal wellbeing. We asked the question: Does the quantity and quality of intergroup contact and the experience of discrimination (i.e., negative contact) impact individuals' attitudes (their intercultural adaptation) and wellbeing (their psychological adaptation)? The adaptationist framework posits a basic situation in which individuals from two or more groups engage in direct contacts, leading to eventual adaptation by individuals. The core idea is that individuals and groups have adapted psychologically to each other's presence over the course of history and continue to do so at the present time (see the ecocultural framework, Berry, 2018, for background to this approach).

Based on our adaptationist framework, we expected that:

- 1-(H1). Both positive contact and negative contact are two distinct aspects of intergroup contact, and are associated;
- 2-(H2). Intercultural adaptation and psychological adaptation are positively associated with each other;
- 3-(H3). Positive contact predicts higher levels of both intercultural and psychological adaptation, whereas negative contact shows the opposite.

Method

Sample

The Environics survey sampled the population of Canada (over 18 years of age) online in April and May of 2019. The total sample was 3,111 persons. The sample was stratified to ensure representation by province, age, and sex, according to the most current population statistical breakdown (2016 Census). It had oversamples of the largest racialised groups in the country: Blacks, Chinese, South Asians, and Indigenous Peoples.

Measures

Contact

In order to assess the degree and quality of inter-racial contact, we used three measures from the Environics survey:

- 1) Contact frequency. “In your daily life, how much contact do you, personally, have with people who have a different racial background than your own?” Answers ranged from 1 = no contact at all to 5 = a lot of contact ($M = 3.87$, $SD = 1.23$).
- 2) Contact quality. “And, in general, would you say the interactions you have with people with a different racial background than yours is friendly or unfriendly?” Answers ranged from 1 = *very unfriendly* to 5 = *very friendly* ($M = 4.28$, $SD = 1.01$).
- 3) Number of friends. “Do you have friends from racial groups different from your own?” Answers were either 0 = no or 1 = yes; 81% of respondents answered “yes.”
- 4) Discrimination. We used two items to distinguish between discrimination against the group, and against an individual personally (for more detail, see Rafiqi & Thomsen, 2021). For group discrimination, “Thinking about people close to you who share your racial background, to what extent do you think their lives have been affected because of discrimination due to their race?” Answers ranged from 1 = not at all to 5 = to a great extent. For personal discrimination, “Now thinking about your own experience, have you ever personally experienced discrimination or been treated unfairly because of your race or ethnicity?” Answers ranged from 1 = never to 5 = regularly. The mean of this scale was 2.28, $SD = 1.15$. The scale reliability measured by the Spearman-Brown coefficient was .79.

Intercultural Adaptation

We have previously argued (Berry & Kalin, 2000) that the conditions for intercultural harmony in culturally-plural societies include among other phenomena: an acceptance of cultural diversity in the society (i.e., a positive multicultural ideology), and having positive attitudes toward specific other groups in the society. In the present study, this positive pattern was referred to as intercultural adaptation.

- 1) *Negative attitudes*. We use items from the index of modern racism that was developed by Environics to refer to people’s general attitude regarding four specific racial groups in Canadian society. Participants were asked to respond with respect to one of four racialised groups (Blacks, Chinese, South Asians, and Indigenous Peoples) selected randomly, but excluding members of their own. For each respondent the same group was used for all four questions. Responses ranged from 1 = *strongly disagree* to 5 = *strongly agree* ($M = 2.64$, $SD = 0.70$). A high score indicated a high level of racism. It was made up of six items, e.g.: “Over the past few years [group] have gotten more economically than they deserve.” This scale’s reliability as measured by the omega coefficient was .63, which is a sufficient value for such a large-scale survey with non-psychodiagnostic purposes (Nunnally, 1978).

- 2) Multicultural ideology. In addition to using this modern racism measure, we used one of the items (“Generally speaking, Canada would be a better place if ethnic and racial groups maintained their cultural identities”) to assess the concept of Multicultural Ideology (originally developed as a 10-item scale by Berry et al., 1977). This ideology refers to the degree to which individuals accept the extant and continuing cultural diversity of Canadian society. In the present study, this one item had the lowest factor loading on the Modern Racism Index scale used by Environics and hence shows some discriminant validity; we thus decided to remove it from their original Modern Racism scale, and use it as a stand-alone measure for Multicultural Ideology. Responses ranged from 1 = *strongly disagree* to 5 = *strongly agree* ($M = 3.16$, $SD = 1.32$).

Psychological Adaptation

As noted above, research has shown that personal wellbeing is usually supported by having extensive social contacts (Jetten et al., 2015). Hence, having more contacts, including intercultural ones, may well promote psychological adaptation. Personal wellbeing is often measured by such concepts as satisfaction with life and personal health (e.g., Berry & Hou, 2019).

- 1) Life satisfaction. Life Satisfaction was assessed using the question: “All things considered, how satisfied are you with your life as a whole these days” (from 1 = very dissatisfied to 10 = very satisfied, [$M = 6.91$, $SD = 2.31$]). This is the usual question employed in Canadian national surveys and has been widely used in the subjective wellbeing literature (e.g., Bonikowska et al., 2014).
- 2) Personal health. The other questions used to assess psychological adaptation were: “In general, would you say your mental health is excellent, very good, good, fair, or poor?” (mental health) and “In general, would you say your health is excellent, very good, good, fair or poor?” (physical health). These answers were coded from 1 = poor to 5 = excellent ($M = 3.32$, $SD = 0.93$). The items were derived from the RAND Corporation Short Form Survey. These measures have been used by Statistics Canada in national health surveys since 2000. Some literature supports the items’ construct validity (Canadian Institute for Health Information, 2009). This scale reliability measured by the Spearman-Brown coefficient was .66.

Results

We present our results in the following sequence: correlations among focal variables in the sample (Table 1); multivariate linear (OLS) regressions predicting intercultural and psychological adaptation in the sample (Tables 2); and the structural model for relationships among the variables (Figure 1). For all of the analyses, we used the same sample weights as Environics.

Preliminary Analysis

Correlations

- 1) Contact Measures. The three positive contact variables (frequency, quality, and friends) were positively correlated (Table 1) among themselves (range from +.19 to +.34). This allowed their later use as a single combined contact variable in the structural model. Two of the contact measures (quality and discrimination) were correlated (–.18) and were used to create a negative contact variable.
- 2) Adaptation Measures. The two measures of intercultural adaptation (negative attitudes and multicultural ideology) were negatively and significantly correlated as expected (–.25). The correlation between the two measures of psychological adaptation (life satisfaction and personal health) was also significant as expected (+.49). Life satisfaction was positively associated with multicultural ideology only (+.06), whereas personal health was positively associated with both negative attitudes and multicultural ideology (at +.09 and +.05, respectively).

Table 1

Weighted Bivariate Correlations of the Focal Variables

	1	2	3	4	5	6	7
Intercultural adaptation							
1. Negative attitudes	–						
2. Multicultural ideology	–.25*	–					
Psychological adaptation							
3. Life satisfaction	.01	.06*	–				
4. Personal health	.09*	.05*	.49*	–			
Contact							
5. Frequency	–.06*	.04*	.04	.04*	–		
6. Friends	–.13*	.13*	.06*	.02	.34*	–	
7. Quality	–.18*	.14*	.18*	.17*	.19*	.22*	–
8. Discrimination	.10*	.08*	–.11*	–.06*	.23*	.17*	–.18*

Note. * = $p < .05$

Regressions

Contact quality had a beneficial effect on all four adaptation variables in the sample (Table 2). Contact frequency had a negative association with multicultural ideology. Contact with friends had a beneficial effect on the two intercultural adaptation variables, but not on the psychological ones. Discrimination had variable effects on adaptation: it undermined life satisfaction in the sample and showed opposite patterns for both forms of intercultural adaptation.

Table 2

Standardized Weighted Estimates and Their 95% CIs Predicting Intercultural Adaptation (Negative Attitudes and Multicultural Ideology) and Psychological Adaptation (Life Satisfaction and Personal Health)

	Intercultural adaptation		Psychological adaptation	
	Negative attitudes	Multicultural ideology	Life satisfaction	Personal health
Socio-demographic variables				
Sex (0 = female; 1 = male)	.16 [.11, .22]*	-.01 [-.11, .09]	-.19 [-.36, -.02]*	.06 [-.01, .13]
Age	.02 [-.01, .05]	-.25 [-.30, -.20]*	.38 [.29, .46]*	.12 [.09, .16]*
Education	-.07 [-.10, -.04]*	.04 [-.02, .09]	.15 [.06, .24]*	.02 [-.02, .05]
Income	.04 [.01, .07]*	-.05 [-.10, .01]	.38 [.29, .47]*	.11 [.07, .15]*
Contact				
Frequency	-.01 [-.04, .02]	-.09 [-.14, -.03]*	.04 [-.05, .13]	.02 [-.02, .06]
Friends	-.18 [-.26, -.11]*	.30 [.16, .44]*	.20 [-.03, .43]	-.04 [-.14, .05]
Quality	-.09 [-.12, -.06]*	.20 [.15, .26]*	.27 [.18, .36]*	.14 [.10, .18]*
Discrimination	.07 [.04, .10]*	.09 [.04, .14]*	-.12 [-.21, -.03]*	.01 [-.04, .04]
	$R^2 = .07$	$R^2 = .07$	$R^2 = .10$	$R^2 = .06$
	$F(8, 2525) = 24.4,$ $p < .001$	$F(8, 2525) = 25.2,$ $p < .001$	$F(8, 2525) = 35.1,$ $p < .001$	$F(8, 2525) = 21.2,$ $p < .001$

Note. * = $p < .05$

Structural Equation Model (SEM)

To present an overall picture of how all these variables are related, we created Figure 1. It shows a structural model with a combined positive contact variable (made up of three constituent variables of frequency, quality, and friends) and a combined negative contact variable (made up of two constituent variables of quality of contact and discrimination). These were used to predict the latent variables of intercultural adaptation (made up of negative attitudes and multicultural ideology) and psychological adaptation (made up of life satisfaction and personal health). This structural model initially showed a good model fit and did not require any post hoc modification. Thus, the SEM model with the fit, which meets the “gold standard” (i.e., CFI > .950, SRMR < .050; see e.g., Hu & Bentler, 1999), showed that our interpretation of covariances between the focal variables, based on our adaptationist framework, did not contradict the data.

The core features of interest are the relationships between the combined contact variable and the two adaptation latent variables. First, our main finding was that positive contact predicted both positive intercultural adaptation and psychological adaptation, while negative contact predicted the opposite (H3). Second, the two main predictor variables (positive and negative contact) were positively related (H1), whereas, unexpectedly, the two adaptation variables were negatively related (H2).

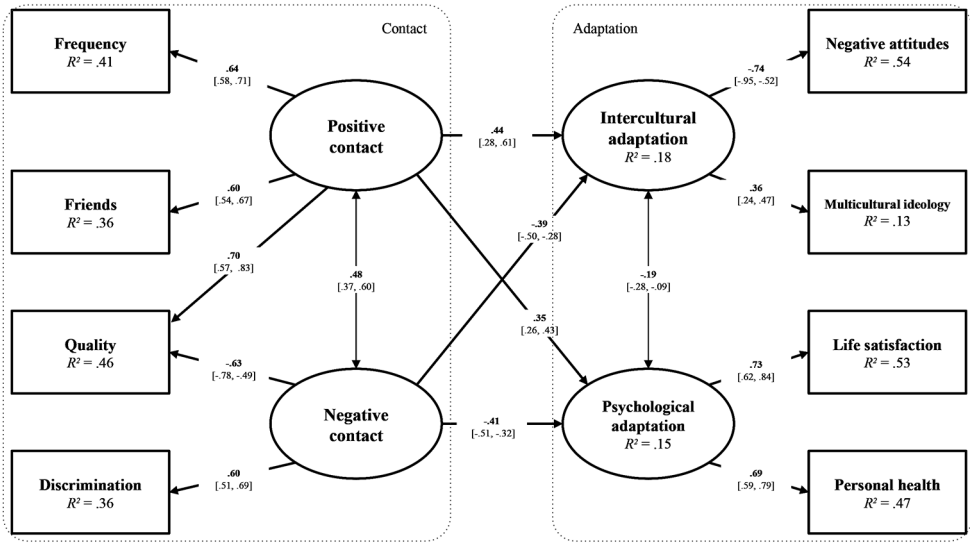


Figure 1. Structural model of relationships among contact, intercultural adaptation, and psychological adaptation

Note. We used the estimator MLR and the FIML imputation method to deal with missings in the structural model, which showed standardized weighted estimates and their 95% CIs. Model fit was $\chi^2(13, N = 3111) = 74.6, p < .001$; CFI = .954; RMSEA [90% CI] = .039 [.033, .046]; SRMR = .026. All the coefficients were significant at $p < .001$.

Discussion

We used our adaptationist framework to examine the role of positive and negative contact in intercultural and psychological adaptation in a case study with the Canadian population. In general, the findings and interpretations of the present paper corresponded with those of the Environics report. However, the present analyses shed more light on the question ‘what goes with what’ by using multivariate statistics and putting the findings into an explanatory adaptationist framework.

Contact and Adaptation

Both the regression models and the structural model revealed that positive contact (especially a high quality of contact) supported and promoted both forms of adaptation in the Canadian population. This can mean not only that majority group members could possibly aid the wellbeing of minority groups by seeking contact with them (Tip et al., 2018), but that contact with minority group members could aid majority group members as well. This finding of the mutual benefits of contact corresponds with the international findings of Berry et al. (2022) in their examination of mutual intercultural relations. That is, intercultural contact is not a zero-sum game, but a win-win opportunity for all groups.

This benefit of contact for both forms of adaptation, means that “relating well” and “feeling well” are linked to positive contact in the same way. The only other study

to examine a relationship between intergroup contact and the wellbeing of members of ethnocultural groups (Ward et al., 2020), did not find any relationship. However, they did find that multicultural ideology positively predicted wellbeing. In the present study, multicultural ideology was also positively related to life satisfaction and personal health.

The positive association between multicultural ideology and negative contact (i.e., discrimination) needs explanation. This positive relationship may mean that respondents react to discrimination by increased favoritism for their ingroup (higher multicultural ideology and less negative attitudes; see e.g., Verkuyten, 2007). Taking into account the cross-sectional design of this study (which lacks a time perspective), a possible interpretation is that the more that individuals endorse multicultural ideology and the less they endorse negative attitudes, the lower will be the level of discrimination against them in the future. Thus, this relationship may be a functional and adaptive response of individuals to discrimination in the present in order to avoid these experiences in the future.

Of further interest in these relationships was the finding that they hold for both dominant and non-dominant groups in the contact. A mutuality or reciprocity in intercultural relations corresponds with the main contention and finding of the project on mutual intercultural relations (Berry, 2017). This study often found common views about intercultural relations by both dominant and non-dominant groups in the 17 societies (and the more than 40 groups) studied. This reciprocity showed that when one group likes the other, the other reciprocates this positive affect. The finding indicates that there is no trade-off or “zero-sum” character to contact: everyone benefits (as found by Berry et al., 2022).

Contact

The correlations among the three indicators of positive contact (in Table 1) are all significant and positive, indicating that they go together: more frequent contact is associated with higher quality contact and having more friends in other groups. Of course, the number of friends available outside one’s own group varies as a demographic factor between groups: in most neighbourhoods more members of the non-racialised group are available to racialised persons than the other way around. Earlier studies in Canada (Kalin, 1996; Kalin & Berry, 1982) showed that judgments of “familiarity” with a specific ethnocultural group were related to their actual presence in a neighbourhood. Moreover, the larger the group’s population, the more positive were the attitudes towards them. The findings in current studies (almost 50 years later) indicate that the social ecology of the community may play a role in how much intergroup contact there is, and how well each group accepts the other.

Positive and negative contact were positively related because contact is a function of social interaction. Indeed, neighbourhood diversity has been shown to be positively associated with both positive and negative intergroup encounters (see Prati et al., 2022). Hence, more contact means more both positive and negative contact, but normally the weight of positive contact is higher, and ultimately this leads to adaptation in a population.

Adaptation Relationships

Of particular interest in this study was whether there were any consistent relationships between the two forms of adaptation. The positive contribution of contact to both forms of adaptation in both kinds of groups noted above suggested that there could be some kind of consistency: since more contact promoted better adaptation, the two forms of adaptation might also be positively related. But no; they were negatively related.

This negative association between the two forms of adaptation can be understood in the context of the positive correlations between personal health, and both negative attitudes and multicultural ideology, as evident in the results. Negative racial bias among people has been found to have a negative effect on their psychological distress (Samson, 2018) and in non-self-report measures of personal health (Lee et al., 2015; Leitner et al., 2016). However, the present study used a self-report measure of personal health. There was possibly a confounding factor here: perhaps it was due to some common optimistic bias among some respondents that led to overrating both their personal health and the situation with respect to racism in Canada.

Implications

Theoretical Implications

A recent cross-country study (Shira, 2020) showed that the historical level of cultural heterogeneity (over the past 500 years) was associated with lower levels of prejudice among the population, while the current level of cultural heterogeneity in the country has the opposite relationship. Other authors argue that populations tend to react negatively to threats to their homogeneity in the short term, while in the long run, these negative results are offset by people getting to know the beneficial effects of intergroup contact, which mitigates the initial negative effects (Ramos et al., 2019). Thus, the possible mechanism behind the contact hypothesis may be that people over time simply adapt to a culturally heterogeneous environment, in keeping with our adaptationist perspective.

The experience of intergroup interactions over time can enrich the cognitive and behavioral repertoire of individuals, thereby adapting individuals to a culturally diverse context. For example, intergroup contact leads to changes in perceptive processing at the neural level (Farmer et al., 2020; for extended reading, see Amodio & Cikara, 2021). Also, stereotypes change in the process of socio-cognitive adaptation to a new cultural environment (Stanciu et al., 2019) and to more heterogeneous contexts (Bai et al., 2020); they also reduce perceptions of threat (McKenna et al., 2018). A common beneficial result of intergroup contact is termed cognitive liberalization, which suggests the presence of generalized cognitive flexibility beyond the realm of intergroup relations (Hodson et al., 2018; also see Verkuyten et al., 2022). Intergroup contact also leads to affective changes (e.g., reductions in group-based anxiety and increases in empathy). These affective changes are even stronger than changes that involve enhanced knowledge of the other group (Pettigrew & Tropp, 2006). They can indicate reduced chronic stress from the impact of this new heterogeneous environment as well.

Meleady et al. (2019) presented a taxonomy of transfer effects that explained the generalization effects as distinct outcomes of the contact process. This taxonomy included three types of transfer effect: (1) primary transfer effect (i.e., when intergroup contact enables generalized improvements in attitudes toward outgroups as a whole); (2) secondary transfer effect (i.e., when intergroup contact can enable generalized improvements in attitudes toward other, non-contacted outgroups); and (3) tertiary transfer effect (i.e., when intergroup contact impacts more general cognitive processes outside the intergroup context; this is termed cognitive liberalization). All of these effects can be considered consequences of evolved person-environment fit mechanisms in our adaptationist framework.

The structural model presented in this study is an example of how to use our adaptationist framework. Dovidio et al. (2017) noted that some important lacunae remain after 20 years of research progress, and suggested that future research might explore the health consequences of intergroup contact. We propose that our adaptationist framework can be an especially helpful perspective.

Practical Implications

Our findings show support for the contact hypothesis, using the individual measures of contact (in the correlations) and the combined measure (in the structural models). In addition to showing support for the usual relationship between positive contact and mutual acceptance (intercultural adaptation), we also showed that contact is positively related to psychological adaptation. That is, contact not only promotes more harmonious relations between groups, but also higher levels of psychological wellbeing.

Conclusions

Despite lingering questions, we conclude that the contact hypothesis has largely been supported in the present study, with respect to both intercultural and psychological outcomes. We also conclude that the experience of negative contact (e.g., discrimination) in the near term is an important factor in undermining both forms of adaptation. Nonetheless, while intergroup contact can bring both positive and negative experiences during intercultural interactions, it leads to mutual adaptation over time. We suggest using such an adaptationist framework to carry out future research into intergroup relations in order to further develop the approach.

Limitations and Further Research

There are some critiques that contact measures do not distinguish between different outgroups and do not differentiate the various types of contacts people have (e.g., personal socializing vs. work contact; Nezlek & Schaafsma, 2010). In the present study, we have dealt with the second point by differentiating between having friends, and the frequency and quality of contact. However, we have not dealt with the first point. Furthermore, in a complex multicultural society, contact among members of

different minority groups has received relatively little attention (van Oudenhoven & Ward, 2013).

While our findings are representative and generalizable for the Canadian population, future research with other representative samples could explore the relationships for the specific groups that make up the multicultural Canadian society. Moreover, future research could be carried out in other plural societies (e.g., Russia) using this adaptationist framework. This research could employ the same replication strategy used in the MIRIPS study (Berry, 2017; Berry et al., 2022) to search for possible universal relationships between intergroup contact and psychological and intercultural adaptations.

Another limitation concerns using previously collected data to operationalise the focal variables. The items available in the Environics survey are not the best measures to test all components of our adaptationist framework. For example, the survey asked respondents to provide retrospective accounts of their intergroup contact over unspecified periods of time, which may serve as a bias in assessing these variables. Further analyses into the structure of the data presented in this paper may also be carried out after a second survey to examine how these complex relationships develop over time, despite the likely changes in the levels of contact and mutual adaptation.

Ethics Statement

The secondary data was used according to the Survey Research License Agreement with Environics Institute dated December 7, 2020.

Author Contributions

J.B. initiated the project and coordinated all the stages. J.B. and D.G. were both involved in the conceptualization of the study, drafting of the manuscript, and critical revisions.

Conflict of Interest

The authors declare no conflict of interest.

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PSYCHOMETRICS

The Development and Psychometric Characteristics of the “Virtual Identity of Social Media Users” Test

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Introduction. Modern society is characterized by the widespread use of social media, which provides users with communication, leisure, work, and study opportunities. With the growth of such opportunities, more time is being spent online. These circumstances explain why we developed a test entitled the Virtual Identity of Social Media Users (VISCUMU).

Objective. To develop and test the psychometric characteristics of the VISMU test.

Design. The research methods included theoretical analysis, modeling, expert assessments, questionnaires, and statistical analysis. The research sample was comprised of 285 users of VKontakte and other social media.

Results. The results of factor analysis proved the acceptability of the three scales identified in the test. Expert assessments showed that the test had sufficient face and content validity. The scales were characterized by optimal indicators of internal consistency, homogeneity, and discriminatory power. The test-retest reliability values demonstrated that the test indicators were stable. Statistically significant differences in the parameter measuring virtual identity in groups with different levels of success in adult life justified a sufficient level of criterion validity. The correlation between the test scales and the components of the factor structure of the modified test “Who am I online?” indicated its compliance with construct validity norms. Positive connections between virtual identity and Internet addiction, smartphone addiction, aggressiveness, hostility, and negative relationships with vitality, indicated sufficient convergent validity. The test has been standardized and specified.

Conclusion. The test was aimed at measuring the extent to which a person’s virtual identity would reveal the specific characteristics of its impact on the individual’s personal development.

Keywords: Virtual identity, social media, social media users, test, psychometric characteristics, standardization, specification

Introduction

Modern life is difficult without the use of the Internet. Since the 1990s, a new virtual socio-cultural space has formed, characterized by wide access to various sources of information. Information openness is becoming one of the defining vectors of social development (Norman, 2017).

Various digital devices mediate mental functions as cultural tools, which leads to the appearance of new activities, the transformation of social interactions, and the formation of new cultural practices. An individual socializing in a digitalized world acquires social experience in online contexts, which leads to people forming a digital persona as part of their personality profile (Soldatova & Rasskazova, 2020).

Currently, social media are one of the most popular online Internet services (Yudina, 2015). These resources are characterized by almost unlimited possibilities: they allow people to communicate and to organize leisure, learning, and work. The massive spread of the Internet in general, and social media in particular, is increasing the time users spend online (Chen, 2013; McNicol & Thorsteinsson, 2017). The current situation, along with the increasing importance of the virtual environment, threatens to reduce the adaptability of individuals to real life and has led to the formation of a special type of ego identity — the virtual identity of social media users (Soldatova & Pogorelov, 2018).

Parents, teachers, and psychologists are alarmed by the increase in the time children and teenagers spend on social media, and the increase in the severity of Internet addictions, especially the need to actively get information from the Internet for educational purposes (Park & Sun, 2017). The global COVID-19 pandemic has also increased the use of the Internet by older generations, which has resulted in the transformation of the subculture of this environment (Chen, Pakpour & Leung, 2020).

Ego identity can be interpreted as the identity and integrity of the personality, the continuity of the “I” in the transformations taking place during personal growth and development (Erickson, 1996). The formation of ego identity is based on generalized childhood identifications, the system of norms and values assimilated by the personality, the attitudes of society, and the expectations and requirements of the peer environment. During the development of consciousness, a person generalizes the experience of past events, which underlies the formation of their system of goals, values, and attitudes. In this context, an increase in the need to reference the virtual space of social media is fraught with the potential for the formation of Internet addiction and decreasing interest in the development of real personal qualities (Moreno, 2019). This subsystem of ego identity—the virtual identity of social media users—duplicates the real identity in virtual space, acting as a modification of the image of the real self. The virtual identity of social media users is compiled from the standardized interface components of the virtual world, aimed at self-presentation on the Internet, and reflects the integrity and identity of the personality in virtual space (Asmolov & Asmolov, 2010).

The analysis of domestic and foreign studies on the problem of virtual identity served as the basis for our development of a conceptual model of the virtual identity of social network users. The virtual identity structure has three components.

The first of them, “cyberaddiction,” reflects the individual’s level of reference to social networks, as well as the emergence of addictive tendencies with excessive use of social networks (Kochetkov, 2020; Kuss, 2021; Rajesh & Rangaiah, 2020). The main prerequisite for the development of cyberaddiction is the incomplete resolution of age-related crises, which manifests itself in the development of an identity crisis. The Internet environment is attractive for resolving this crisis since it allows the user to construct a desired reality in it. Unresolved problems of aging, which serve as criteria-based grounds for the formation of an alternative to a person’s real identity, indicate a lack of human vitality and actualize various kinds of dependencies, including, probably, cyberaddiction. Virtual “friends,” “likes,” and “posts” are becoming more valuable than communication in a real environment, which reflects the high reference of social networks. Moreover, cyberaddiction is characterized by an increase in tendencies for aimless activity on the Web.

The second component, “acceptance of subculture,” characterizes the degree of approval by the individual of the specific norms adopted in virtual communities (Kurbatov, Volkov, & Vodenko, 2019; Senchenko, 2016). The virtual personality creates a new virtual culture, which becomes part of the culture as a whole. New forms of mass collective behavior of users on social networks act as a kind of electronic frontier on which users can oppose traditional reality that does not suit them for reasons of justice, morality, order, and values. The most striking manifestation of the subculture of social network users is the potential for user anonymity, which does not require providing true personal data on social networks, and thus reduces moral barriers in communication, and permits manifestations of aggressiveness, including cyberbullying. It is also impossible not to note the ratio of obscene vocabulary, images of a “beautiful life,” and tolerance for punctuation and grammatical errors.

The third component, “virtual image,” reflects a complex representation of the individual’s physical and psychological properties as projected in virtual space, as well as the possibilities and advantages of communication in social networks (Luchinkina, 2016; Zekeryaev, 2019). This image has no real content, but consists solely of signs-symbols, including the physical and psychological properties of the individual, and actions unfolding within the framework of Internet communication. Since the user is not physically present in the virtual space of social networks, his actions can be implemented exclusively through virtual communication.

The foregoing determines the importance of adequately measuring the virtual identity of social media users. However, since this phenomenon is new and insufficiently studied, there are no special psycho-diagnostic tools for studying aspects of virtual identity. Such a tool could aid in preventing excessive Internet use and solving the problem of the negative impact of Internet content on personal development and interpersonal interaction of people of all ages. The purpose of our study was to develop and test the psychometric characteristics of the Virtual Identity of Social Media Users (VISMU) test by:

1. Conceptually justifying and developing the structure of the VISMU test to measure the virtual identity of social media users.

2. Checking the main psychometric characteristics of the test: face and content validity, reliability, homogeneity, discriminatory power, and criterion and construct validity.
3. Standardizing the VISMU test.
4. Giving a descriptive specification of the test.

Method

Our research was based on the methods of theoretical analysis, synthesis and generalization, induction and deduction, modeling, expert evaluation, and questionnaires. Descriptive statistics, factor analysis (principal component analysis (PCA) followed by Varimax rotation), Kendall's W , Cronbach's α , Spearman-Brown's rt , Ferguson's σ , Pearson's r , Mann-Whitney's U , Kolmogorov-Smirnov's d , and Student's t criteria were used for mathematical processing of the data. The results were processed using the IBM SPSS Statistics v. 26.0 and MS Excel statistical analysis suites.

Participants

The research sample was comprised of 285 users of VKontakte and other social media, age 18 to 72 ($X = 37.49$, $SD = 13.61$). The sample involved 197 women (69.1%) and 88 men (30.9%), including university students, and representatives of the blue and white collar professions. The procedures of factor analysis and verification of the psychometric characteristics of the test were carried out on this sample.

To confirm the criterion validity, a content analysis of the pages of users of an additional sample ($N = 30$) on VKontakte and other social media was carried out. This type of validity is based on comparing test indicators with data obtained on the basis of objective (external) criteria. Such criteria can be success in adult life, such as personal and professional self-determination, creating a family, and performing pro-social activities (Ananiev, 2001). The first group ($N = 15$) included subjects who currently had no families, had no job, showed signs of alcoholism, or use obscene language. The second group ($N = 15$) included subjects who created families, had a profession, and showed no signs of obscene language, deviant, or aggressive behavior.

The test was standardized using an additional sample of 495 people, including 231 men (46.7%) and 264 women (53.3%), age 18 to 57 ($X = 34.96$, $SD = 10.35$). The sample included students in secondary and higher educational institutions, teaching staff (educators and heads of preschool educational institutions, teachers and headmasters, and lecturers at secondary and higher educational institutions), representatives of business (individual entrepreneurs), service professionals (cleaners, storekeepers, drivers), and the unemployed. In this regard, we can consider this sample to be representative.

The data was collected and processed between 2017 and 2021.

Procedure

During the first stage, using theoretical analysis, we developed a conceptual model of the structure of the virtual identity of social media users, which included three components: Cyberaddiction (CA), Acceptance of Subculture (AS), and Virtual Im-

age (VI) (Pogorelov & Rylskaya, 2021). In the second stage, we selected methods to diagnose each of the identified structural components, formed a data base for the research, and developed test statements (initially 103 items). The third stage included factor analysis, for which we selected the questions with the maximum factor load. We then verified the face and content validity of the VISMU test. As a result, we formed a version of the VISMU methodology which includes 43 items and the three scales: CA, AS, and VI. Further, we determined the psychometric characteristics of the VISMU test (internal consistency, test-retest reliability, criterion and construct validity), and standardization, taking into account that women and men do not differ in the structural components of their virtual identity; however, we found and took age differences into account.

Results

A conceptual model of the virtual identity of social media users. The conceptual foundations for the development of the VISMU test are the understanding of virtual identity as an integral phenomenon, which is a subsystem of ego identity coexisting with the structure of real identity, consisting of the textual, visual, and audio characteristics of a virtual image, and reflecting the physical and psychological properties and communication features which determine the integrity and identity of the personality within the subculture of social media users (Rylskaya & Pogorelov, 2021). Virtual identity is understood from the standpoint of the relationship between the concepts of ego identity and vitality at two points of contact: normative crises and life tasks (Rylskaya, 2005; Soldatova, 2005). To prepare the test, we used the technology developed by Baturin, which has been actively used by representatives of the Chelyabinsk School of Psychology (Baturin & Melnikova, 2009).

We described the conceptual model of the virtual identity of social media users in our previous publications (Pogorelov, 2020; Rylskaya & Pogorelov, 2021). In characterizing virtual identity, we distinguished the three components.

1. Cyberaddiction (CA) is considered an obsessive desire to use the Internet or to spend much time on the Internet (Kochetkov, 2020; Kuss, 2021; Rajesh & Rangaiah, 2020).
2. Acceptance of Subculture (SA) is the degree of a person's approval of the special norms, rules, and values characteristic of the virtual space of social media (Kurbatov, Volkov & Vodenko, 2019; Senchenko, 2016).
3. Virtual Image (VI) ensures the integrity and identity of the personality in the social media space and reflects the desired image of its creator (Luchinkina, 2016; Zekeryaev, 2019).

According to this conceptual model of the virtual identity of social media users, we created a databank for the development of test statements. The bases for the test design were the scales of standardized psycho-diagnostic techniques (Lee and Quigley's scale for measuring self-presentation tactics; Thomas' questionnaire "Style of behavior in conflict;" Sukhikh and Korytchenkova's test of the moral and ethical characteristics of a person and the level of their psychoethical development; Mikhelson's

communication skills test; Morosanova's questionnaire "Behavioral self-regulation style;" and the method for diagnosing addictive identity developed by Dmitrieva, Perevozkina, Perevozkina, and Samoilik). When formulating the test statements, we both used separate items to diagnose the components of the structure of virtual identity, and developed new items; this was to ensure that the phenomenon of the virtual identity of social media users was taken into account as precisely as possible. As a result, we compiled 103 items for the original version of the VISMU test.

Factor analysis of the test items. At the next stage, we carried out a factor analysis to select the items with the maximum factor load. An analysis of the eigenvalues for the items allowed us to identify three factors. After the rectangular Varimax rotation, we selected the items with the maximum factor loads. At this stage, we analyzed all the test items and excluded those with unsatisfactory psychometric characteristics. The selected factors accounted for 75.6% of the variance. The items obtained as a result of factorization formed a version of the VISMU test, which measured the three scales: CA, AS, and VI.

CA was formed by statements about the highly subjective significance of social media, which is often even more significant for users than the real world. This factor served as a content-related confirmation of the conceptual model.

AS included variables demonstrating the level of changes in the user's behavior or opinion under the influence of the norms accepted in virtual communities. The set of items (variables) of this factor corresponded to the hypothetical scale.

VI described attitudes towards social media presentation and included characteristics linked with the ability to more flatteringly present one's physical characteristics and personality traits, as well as the benefits and opportunities of online communication.

Further, we identified the test items with the maximum factor load (no less than 0.4). The items obtained during the factor analysis formed the basis of the original version of the VISMU test; during the repeated factorization, we obtained a reproducible structure.

Then, this test version was presented to a sample of 285 people simultaneously with the original version. The results were above the critical values (*Table 1*).

Table 1

Correlation coefficients between the scales of the VISMU test versions

The scale of the VISMU test	Correlation coefficients r
CA	0.721**
AS	0.837**
VI	0.734**

** — the correlation is significant at the level of 0.01

We found that all the selected items made the largest contributions to the corresponding factors and the smallest contributions to the other factors (*Table 2*). In this regard, we justified the optimality of the selected 3-factor model.

Table 2
Factorization of the VISMU test items

Statements of the VISMU test	Factors/Loads		
	1	2	3
I often photoshop my pictures before posting them on the Internet;	0.045	-0.220	0.887
I prefer being online to being intimate with a partner;	0.844	-0.248	-0.095
I think insults and foul language on the Internet are a matter of course;	0.038	0.663	-0.163
I enjoy watching pictures or videos on the Internet rather than reading a text;	0.793	-0.071	0.019
I believe you should not post photos on social media showing flaws in appearance;	-0.122	-0.204	0.926
The Internet allows me to express myself;	0.156	0.499	-0.221
I communicate on the Internet with people from other cities or countries;	0.074	0.920	-0.185
Sometimes I use social media without intending to communicate with anyone;	0.861	0.089	0.023
I feel guilty when I realize that my image in the real world is different from my social media image;	0.163	-0.435	0.795
I exaggerate the significance of my achievements on the Internet;	-0.017	-0.333	0.867
I fail to reduce my time online;	0.884	0.051	0.245
I like that I can fully express myself on the Internet;	0.186	0.867	-0.139
Sometimes I give incorrect information about my identity on the Internet;	0.176	0.884	-0.029
I post pictures of important events in my life on social media;	0.806	0.460	0.039
I do not always indicate my true identity, such as name, picture, location, when registering on social media;	0.299	0.527	-0.214
I believe social media posts allow me to convey my thoughts to many people;	0.926	0.092	-0.043
I am a member of Internet groups dedicated to an ideal appearance;	0.049	0.032	0.919
I often visit profiles of strangers on social media;	0.150	0.503	-0.177
I believe it is not necessary to follow the rules of the Russian language on the Internet;	0.024	0.538	-0.150
Unfortunately, the merits of a person in the real world often remain unrecognized, no matter how hard they try;	0.815	-0.074	0.138
I make the impression of a successful and attractive person on social media;	-0.042	-0.032	0.940
Playing online or visiting social media helps me to change my mood;	0.841	0.043	0.093
I feel empty, depressed, and irritated when I'm not connected to the Internet;	0.860	0.272	0.202
It is much more convenient to make purchases on the Internet;	0.167	0.883	0.017
I believe my image should be perfect on the Internet;	0.147	-0.185	0.901

The first thing I do when I wake up is check my email and open social media pages;	0.888	0.257	0.082
I believe it is quite conceivable to take on a different persona on the Internet;	-0.006	0.929	-0.032
The Internet allows me to get rid of boredom;	0.782	0.076	0.006
Internet users think I am more professional than I really am;	0.130	-0.044	0.939
I believe I look younger and more attractive in pictures and videos on the Internet;	0.061	-0.029	0.891
I have entered into conflicts on social media without identifying my real identity;	0.173	0.874	-0.038
I have alternative pages on social media where I take on a different persona;	0.378	0.829	-0.227
I think I look more impressive in pictures than in reality;	0.252	0.132	0.892
If I have a bad opinion of a person and do not like their behavior on the Internet, I hardly try to hide it from them;	0.051	0.876	-0.257
I notice that the time I spend on the Internet is increasing;	0.823	0.144	0.020
Internet users think I am smarter than I really am;	0.304	-0.064	0.866
I do not go to the library, as it is easier for me to find any information on the Internet;	0.236	0.817	-0.181
I often scroll through the news feed on the social media aimlessly;	0.898	0.229	0.091
Sometimes I feel an overwhelming urge to refresh a page on social media;	0.867	0.308	0.087
It happens that I insist on my own way when discussing on the Internet, even when I am not sure that I am right;	0.064	0.950	-0.076
My mood improves when I use the Internet;	0.814	0.193	0.095
I am sure to highlight my achievements and success on social media;	0.730	0.172	0.145
I aimlessly browse other people's pages on social media.	0.790	0.154	-0.030

Factoring method: principal component analysis. Rotation method: Varimax with Kaiser normalization. Rotation converged in 9 iterations.

The factor loading values higher than |0.4| are highlighted in bold and indicated as the significant loadings for the corresponding factor.

Face and content validity. At the next stage, we determined the face validity of the test to assess the degree of understanding of the test content by people who did not know about the social networks where our study was performed. They took part in the assessment of the face validity evaluating the items according to the criteria of “specificity, “literacy,” and “understandability.” To measure the concordance of expert opinions, we calculated Kendall’s concordance coefficients was presented in Table 3 for the three scales. As a result of analyzing the expert opinions, we reformulated six test items marked as insufficiently specific or understandable.

Further, we determined the content validity to highlight the representativeness of the content of the test items. To do this, the VISMU test was evaluated by experts to

determine its compliance with the subject of our diagnostics — the structural components of the virtual identity of social media users. Three experts participated in the evaluation: one PhD in psychology, one PhD in pedagogy, and a practicing psychologist. The experts were experienced in theoretical and empirical research and practical work on virtualization and the impact of the Internet on personal development. Based on the expert assessments, we adjusted five items in the test which were not formulated specifically enough and were not sufficiently substantial.

Table 3

Concordance of the expert opinions on the scales of the VISMU test

The scale of the VISMU test	Kendall's concordance coefficients W	
	Non-professional experts	Professional experts
CA	0.59**	0.73**
AS	0.71**	0.73**
VI	0.81**	0.82**
Integrated index	0.68**	0.75**

** — the coefficient of concordance is significant at the level of 0.01 (value χ^2)

Thus, we selected and adjusted 43 items of the VISMU test, or 42% of the initial 103 items.

At subsequent stages, we determined the reliability, homogeneity, discriminatory power, and criterion and construct validity, and performed standardization and specification.

To determine the main psychometric characteristics of the test, the respondents were tested using the final version of the VISMU test, the modified Kuhn-McPartland test, Young's "Internet addiction" test (adapted by Loskutova), a short version of Sheinov's questionnaire "Smartphone Addiction Scale," Bass and Darka's questionnaire for studying the level of aggressiveness (adapted by Khvanov, Zaitsev, and Kuznetsova), and Rylskaya's "Human vitality" test. To determine criterion validity, we carried out a content analysis of the pages of users from an additional sample (N = 30).

Reliability, homogeneity, and discriminatory power. To determine the test's reliability as an indicator of its stability concerning measurement errors, we calculated Cronbach's α for its final version. To identify the test's internal homogeneity, we split the scales into two parts. Then, we calculated the Spearman-Brown coefficient. We determined the discriminatory power as the ability of the test to differentiate the subjects from the minimum to the maximum result by calculating Ferguson's σ . The results showed satisfactory indicators of the internal consistency, homogeneity, and discriminatory power of the VISMU test (Table 4).

Table 4*Indicators of reliability, homogeneity, and discrimination power of the VISMU test*

The scale of the VISMU test	Cronbach's reliability coefficient α	Spearman-Brown homogeneity coefficient r_t	Ferguson's discrimination coefficient σ
CA	0.976	0.854	0.938
AS	0.967	0.835	0.946
VI	0.979	0.939	0.943

Further, we determined the coefficients of the correlation between the test scales, presented in *Table 5*. We found that the structural components of virtual identity were moderately correlated with each other. The results allowed us to assume that the nature of virtual identity is integral, given a certain autonomy and qualitative uniqueness of its individual components.

Table 5*Correlation of the scales of the VISMU test*

The scale of the VISMU test	CA	AS	VI	Integrated index
CA	–	0.302**	0.169**	0.826**
AS	0.302**	–	0.274**	0.505**
VI	0.169**	0.274**	–	0.528**
Integrated index	0.826**	0.505**	0.528**	–

** — the correlation is significant at the level of 0.01

Test-retest reliability. We calculated the test-retest reliability to assess the stability of the VISMU test indicators during repeated measurements. To this end, we twice tested the participants of advanced training courses of the State Budgetary Institution of Additional Professional Education Chelyabinsk Institute of Professional Development and Retraining of Educators (N=92) using the VISMU test. The interval between the tests was three weeks. The correlation indicators between the results of the first and second tests demonstrated high test-retest reliability, which indicated the stability of the VISMU test as to time and, consequently, the stability of the virtual identity of social media users over time (*Table 6*).

Table 6*Indicators of the test-retest reliability of the VISMU test*

The scale of the VISMU test	Correlation coefficient r
CA	0.945**
AS	0.963**
VI	0.956**

** — the correlation is significant at the level of 0.01.

Criterion validity. This type of validity is based on comparing test indicators with data obtained on the basis of objective (external) criteria using the extreme group approach. Based on the theoretical analysis, such criteria can be the success in adult life — namely, personal and professional self-determination, creating a family, and performing pro-social activities (Ananiev, 2001). These tasks can be carried out when performing such social roles as citizen, family member, or professional (Rylskaya, 2013). For the formation and harmonious development of a mature personality in the real world, it is necessary to successfully solve the main life tasks of this period in life. Successfully solved age-related tasks are correlated with weakly expressed virtual identity. Low success rates in solving the main life tasks of the period of maturity (lack of a family, a permanent place of work, a tendency to addictive behavior) are associated with dissatisfaction with life in the real world. These characteristics lead to a pronounced virtual identity.

As a result, two samples were formed based on the content analysis of the pages of the social media users, which took note of their personal semantic units (the content of the profile, topics of posts, content of visual and textual information) and universal semantic units (having a family, having a job, the presence of obscene language, demonstrating deviant and aggressive behavior). The first group (N = 5) included subjects who currently had no families or job, showed signs of alcoholism, or used obscene language. The second group (N = 15) included subjects who created families, had a profession, and showed no signs of obscene language, deviant, or aggressive behavior. As a result of applying the Mann-Whitney U criterion, we obtained statistically significant differences between the two groups of respondents in terms of the integral indicator of virtual identity ($U = 33, p < 0.01$), as well as in all scales, in particular, CA ($U = 34, p < 0.01$), AS ($U = 39, p < 0.01$), and VI ($U = 36, p < 0.01$).

Accordingly, those users who were assigned to the group with high rates of success in adult life were found to have the lowest rates of virtual identity in general as well as on individual scales, which significantly differed from the group with low rates of success in adult life. Users who were assigned to the group with high rates of success in adult life were less prone to Internet addiction, more critical of the specific norms of the subculture of social network users, and less prone to idealization of their virtual image.

The Contextual (concept) validity of the test was based on a factor analysis of the results of the modified Kuhn-McPartland's test, with the subsequent calculation of correlations with the scales of the VISMU test. This method highlights the substantive features of the identity revealed through the use of the respondents' answers to the question "Who am I?" through self-descriptions of the personality. Accordingly, the modification of the "Who am I online?" method assumes the respondents' answer to the corresponding question regarding the virtual environment. The primary processing of the Kuhn-McPartland's test included the conversion of qualitative data represented by identification characteristics into quantitative indicators by the coding data. The factor analysis of the results of the PCA (principal component analysis) followed by Varimax rotation allowed us to identify the factor structure correlated with the previously identified structure of the virtual identity of social media users.

The first factor included self-descriptions related to the specific features of their social media activities (“user”), which were often aimless (“gamer,” “music addict”) and reflected the high importance of social media for them (“writer,” “reader”). This factor also included self-descriptions of emotional states arising from these activities (“cheerful,” “joyful,” “inspired,” “delighted”). Notably, positive emotions arising from social media activities can reinforce the tendencies toward cyberaddiction described within the factor structure of the virtual identity of social media users. This factor is called Virtual Activity and is correlated with the CA factor.

The second factor involved self-descriptions reflecting the norms accepted in the virtual space of social media: an aggressive style of behavior (“harsh,” “evil”), a tendency to conceal information about oneself and hide behind the associated anonymity (“deceptive,” “opposite”), and the desire to attract attention and openness in communication (“demonstrative,” “critic”). This factor was called “Norms of behavior in social media” and correlates with the AS factor.

The next factor described the specific features of the user’s self-presentation on social media. This factor included a self-description of the virtual image (“user picture,” “depicted”) at the level of physical (“fashionable,” “beautiful”) and psychological properties (“sociable,” “active,” “open-minded”). This factor included idealized self-descriptions (“ideal,” “bright”). The factor included self-descriptions demonstrating the particular features of the sphere of communication and interaction with people (“sociable,” “friend,” “open-minded”), as well as the ratio of the real and virtual image (“real,” “as in life,” “true,” “different”). This factor was called “Virtual self-presentation” and correlated with the VI component.

Next, we calculated the correlations between the scales of the VISMU test and the components of the factor structure of the modified Kuhn-McPartland test (Table 7). The correlation coefficients were found to be satisfactory, which indicated the optimal level of construct validity and simultaneously emphasized the uniqueness of the VISMU test.

Table 7

Correlations between the scales of the VISMU test and the components of the factor structure of the modified Kuhn-McPartland test

The scale of the VISMU test	Component of the factor structure of the modified Kuhn-McPartland test	Correlation coefficient r
CA	Virtual activity	0.524**
AS	Norms of behavior in social media	0.457**
VI	Virtual self-presentation	0.431**

** — the correlation is significant at the level of 0.01.

For *convergent validity*, the virtual identity of social media users diagnosed by the questionnaire should have positive correlations with Internet addiction, smartphone addiction (Luppincini, Alotaibi, 2021; Sheinov, 2020), and aggressiveness and hostility (Terizi, Chatzakou, Pitoura, Tsaparos, & Kourtellis, 2021), and negatively correlate

with vitality (Rylskaya, 2016). To establish convergent validity, we used several psychodiagnostic techniques: to determine Internet addiction—Young’s test “Internet addiction” (adapted by Loskutova); to identify smartphone addiction—a short version of Sheinov’s questionnaire “Smartphone Addiction Scale”; to diagnose the level of aggressiveness and hostility—Bass and Darka’s questionnaire for studying the level of aggressiveness (adapted by Khvanov, Zaitsev, and Kuznetsova); and to identify the level of vitality—Rylskaya’s test “Human vitality.” The results of the correlation analysis are presented in *Table 8*.

Table 8

Correlations between the virtual identity of social media users and its components and conceptually related mental properties

The scale of the VISMU test	Internet addiction	Smartphone addiction	Aggressiveness	Hostility	Vitality
CA	0.703**	0.601**	0.375**	0.332**	-0.574**
AS	0.312**	0.404**	0.511**	0.401**	-0.291*
VI	0.366**	0.303**	0.115*	0.141*	-0.52**
Integrated index	0.759**	0.71**	0.52**	0.465**	-0.685**

* — the correlation is significant at the level of 0.05; ** — the correlation is significant at the level of 0.01

The results demonstrated the presence of significant positive correlations between virtual identity and its components with Internet addiction, smartphone addiction, aggressiveness, and hostility, as well as significant negative correlations of virtual identity and its components with vitality, which indicates that the test has sufficient convergent validity.

The test was standardized using a sample of 495 people, including 231 men (46.7%) and 264 women (53.3%) age 18 to 57 ($X = 34, 96$, $SD = 10.35$). The sample included students from secondary and higher educational institutions, teaching staff (educators and heads of preschool educational institutions, teachers and headmasters, lecturers of secondary and higher educational institutions), representatives of business (individual entrepreneurs), service professions (cleaners, storekeepers, drivers), and the unemployed. In this regard, we can consider this sample to be representative.

The check of the distribution type of the test scores (Kolmogorov-Smirnov’s d test) according to the final VISMU test version showed that the empirical distributions for the indicator had a normal form ($p > 0.05$). The results obtained using a Student’s t test allowed us to assert that women and men do not differ in their degree of expressing their virtual identity. Therefore, to standardize the results and build norms, we did not take gender into account. However, we found age differences for some components of virtual identity, namely, according to the CA and VI scales.

At ages under 35 years, the indicators of cyberaddiction ($t = 2.534$; $p = 0.05$) and virtual image ($t = 2.642$; $p = 0.05$) were significantly higher. Age differences in the degree of expressing virtual identity were apparently linked with the fact that these

resources are more actively used by young people, for whom social media is more referential. We divided the sample into two subgroups: younger and older than 35, because, according to Strauss and Howe's generational theory (Howe & Strauss, 1991), people under 35 (representatives of generations Y and Z) are most susceptible to the influence of digitalization, since their socialization from an early age was connected with the spread of the Internet.

Table 9

Mean values and standard deviations for the virtual identity of social media users and each of its components

M±σ	Integrated index	CA	AS	VI
Users aged from 18 to 35	143.92±26.62	57.83±9.25	48.18±8.91	37.9±7.15
Users aged from 36 to 57	133.73±24.64	53.74±8.6	47.25±8.62	32.74±6.37

Table 10

Recalculation of raw scores of the VISMU test into stens

Stens	1	2	3	4	5	6	7	8	9	10
Levels	Low level			Medium level			High level			
Users from age 18 to 35	CA									
	≤39	40– 44	45– 49	50– 53	54– 58	59– 62	63– 67	68– 72	73– 76	≥77
	AS									
	≤30	31– 35	36– 39	40– 44	45– 48	49– 53	54– 57	58– 62	63– 66	≥67
VI										
≤24	25– 27	28– 31	32– 34	35– 38	39– 41	42– 45	46– 49	50– 52	≥53	
Integrated index										
≤91	92– 104	105– 117	118– 131	132– 144	145– 157	158– 170	171– 184	185– 197	≥198	
Users from age 36 to 57	CA									
	≤37	38– 41	42– 45	46– 49	50– 54	55– 58	59– 62	63– 67	68– 71	≥72
	AS									
	≤30	31– 34	35– 39	40– 43	44– 47	48– 52	53– 56	57– 60	61– 64	≥65
VI										
≤20	21– 23	24– 26	27– 30	31– 33	34– 36	37– 39	40– 42	43– 45	≥46	
Integrated index										
≤84	85– 97	98– 109	110– 121	122– 134	135– 146	147– 158	159– 171	172– 183	≥184	

During the standardization procedure, we calculated mean values and standard deviations for the virtual identity of social media users and each of their components (Table 9). They were converted to a standard 10-point sten scale (Table 10). The number of points scored according to the integrated index from 1 to 3 corresponded to a low level of virtual identity, from 4 to 7 to a medium level, and from 8 to 10 to a high level. The levels of manifestation for the components of virtual identity were determined similarly.

Processing of the results. To calculate points for each of the scales and the integrated index, scores from 1 to 5 were assigned to the answers to the test items according to the Likert scale (from 1 = strongly disagree to 5 = strongly agree). The indicators were summed for each scale and the integrated index of virtual identity. The Appendix contains the instructions, stimulus material, the answer sheet, and the key for processing the results.

Discussion

The design of the VISMU test assumed the construction of a conceptual model of the structure of virtual identity which included three components: Cyberaddiction (CA), Acceptance of Subculture (AS), and Virtual Image (VI). Based on the empirical data and using factor analysis, we showed that distinguishing the corresponding scales in the VISMU test is justified.

When checking face and content validity, based on the results of the expert assessment (non-professional and professional experts), we adjusted some items, which allowed us to increase the degree of their content-richness and specificity.

We determined that the scales of the VISMU test were characterized by sufficient indicators of internal consistency ($\alpha = 0.967\text{--}0.979$), homogeneity ($r_t = 0.835\text{--}0.939$), and discriminatory power ($\sigma = 0.938\text{--}0.946$). The test-retest reliability check showed satisfactory results ($r = 0.945\text{--}0.963$).

When determining criterion validity, a comparison of the extreme groups according to the criterion of success in adult life showed statistically significant differences in the parameter of the extent of virtual identity ($U = 33$, $p < 0.01$).

When justifying construct validity, we faced difficulties connected with the insufficient development of the concept of the “virtual identity of social media users” in the literature, on the one hand, and in choosing diagnostic tools to measure the indicators with which the components of virtual identity could be correlated, on the other. When analyzing the diagnostic tools, it seemed to be most appropriate to use the modified Kuhn-McPartland test, as it allowed us to diagnose the features of virtual identity based on personality self-description. The structure revealed on the basis of the factor analysis was correlated with the factor structure of the VISMU test. These correlations between the scales of the developed test and the components of the factor structure of the modified Kuhn-McPartland test were satisfactory ($r = 0.431\text{--}0.524$), which indicates the construct validity of the VISMU test.

When checking convergent validity, we relied on the conceptual model of virtual identity, according to which there are positive connections between virtual identity

and its components with Internet addiction ($r = 0.312-0.759$), smartphone addiction ($r = 0.303-0.71$), aggressiveness ($r = 0.115-0.52$) and hostility ($r = 0.141-0.465$), and negative connections with vitality ($r = -0.291- -0.685$). The correlations indicated the convergent validity of the test.

The standardization of the VISMU test involved the calculation of the mean values and standard deviations for virtual identity and each of its components. The data were converted into a standard 10-point sten scale. When analyzing the data, we found no significant differences for gender; however, there were differences for age. At ages under 35 years, the components CA and VI were significantly higher, which was taken into account to standardize the VISMU test.

When developing the test specification, we described the interpretation of the test results in general, as well as for the scales separately using three indicators: high, medium, and low.

The VISMU test enriches the range of diagnostic tools that can be used in theoretical and applied research on personal development in the digital world. The VISMU test can be used in practical psychology when organizing preventive work on the problems of Internet addiction, and reducing the negative impact of virtual content on personal development in representatives of all age groups.

At the same time, we note that in our study, cyberaddiction acted as one of the components of virtual identity. This leads to the fact that the severity of virtual identity acquires a negative meaning, is associated with cyber-aggression, and the low ability for self-control and low vitality. Meanwhile, studies on the social identity of the individual (in its organizational, ethnic, civil, and universal aspects) indicate the inconsistency of this phenomenon, and its multidirectional influence on the individual and social interaction. In this regard, it seems appropriate to consider not only the severity, or strength of identification, but also its valency, that is, an individual's assessment of his belonging to a social category.

We believe that in future studies, clarifications are needed which take into account the motives for users to access social networks, as well as the nature of personal requests, personal expectations, and subjective preferences in network interaction. We also suggest that the analysis of the identified phenomenon will be more meaningful if, with the help of cluster analysis, various types of virtual identity are distinguished, differing in the degree of expression of its three indicators.

In the future, we plan to continue work on checking the test validity (construct, competitive, and environmental), and study the social desirability of the respondents' answers. Another promising area of study is the specifics of the virtual identity of users of different social media, including those which are currently gaining popularity (for example, Tik-Tok). We also plan to study the connections between virtual identity and the personal characteristics of social media users, and regional and national characteristics.

Turning to the limitations, further plans, and prospects of the study, we note the importance of expanding the standardization sample of the test to clarify the levels of virtual identity severity. We also note the need for a more even distribution of respondents according to the qualitative characteristics inherent in the general population.

Conclusion

We developed the VISMU test and analyzed its psychometric characteristics. The use of the test revealed the extent of the structural and content components of the virtual identity of social media users. Distinguishing the indicators of virtual identity during diagnostic procedures will reveal the presence of virtual identity in the personality structure, determine its components, and reveal their influence on personal development.

High scores on the VISMU test were connected with the significance of the virtual space for the user, spending time on social media aimlessly, a high degree of acceptance of the norms of social media users' subculture, and the creation of an idealized virtual image. Users with high levels of virtual identity were Internet-addicted, prone to smartphone addiction, aggressive, and less active. Their expressed virtual identity performed a compensatory function for activity in real life.

The theoretical basis of the test was a conceptual model of the virtual identity of social media users based on an analysis of domestic and foreign sources on this problem. We proved that it is optimal to identify the CA, AS, and VI scales in the VISMU test. These scales were characterized by satisfactory indicators of face and content validity, internal consistency, homogeneity, and discriminatory power, as well as test-retest reliability, and meet the norms of criterion and construct validity. The VISMU test is a standardized psycho-diagnostic tool. Within the development of the test specification, we described a detailed interpretation of the results.

Limitations

We note the importance of using more precise constructs in assessing the criterion validity of the VISMU test. The sample of the test standardization could also be extended to specify the manifestation levels of the indicators of the social media users' virtual identity. The sample of the test standardization could also be extended to specify the levels of manifestation of the integral indicator of virtual identity and its three components. A more detailed interpretation of the scales of the VISMU test is also needed. These issues will be studied in our future research.

Ethics statement

All the participants gave informed consent to participate in the research, which included background on the research, the option to refuse the procedure if they were not interested, and age requirements (over 18).

Author Contributions

D.P. and E.R. proposed a research idea. D.P. and E.R. analyzed the literature on the research problem. D.P. carried out the experimental procedure, and E.R. monitored the results of the work. Both the authors discussed the results and contributed to the final manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

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Appendix

Тест «Виртуальная идентичность пользователей социальных сетей («ВИПСС»)»

ФИО _____ Возраст _____

Дата _____ Пол _____

Адрес электронной почты _____

Инструкция: Перед Вами утверждения, касающиеся тех или иных аспектов поведения, общения, а также Вашего образа в социальных сетях. Опираясь на шкалу ответов от 1 до 5, выразите степень Вашего согласия с каждым из утверждений, приведенных ниже. Степень Вашего согласия соответствует следующим показателям:

- 1 — совершенно не согласен;
- 2 — отчасти не согласен;
- 3 — не знаю ответа;
- 4 — согласен;
- 5 — полностью согласен.

Стимульный материал

№ п/п	Утверждение	1	2	3	4	5
1	Я часто прибегаю к ретуши собственных фотографий, прежде чем выкладывать их в сеть Интернет.					
2	Я предпочитаю пребывание в сети интимному общению с партнером.					
3	Я считаю, что оскорбления и нецензурная брань в Интернете — это нормально.					
4	Мне приятнее смотреть изображения или видео в Интернете, чем читать текст.					
5	Я считаю, что в социальных сетях не стоит выкладывать фотографии, на которых заметны недостатки внешности.					
6	Интернет позволяет мне выразить себя.					
7	Я общаюсь в Интернете с людьми из других городов или стран.					
8	Бывает, что я захожу в социальные сети без намерения с кем-либо пообщаться.					
9	Я испытываю чувство вины, когда понимаю, что мой образ в реальном мире отличается от моего образа в социальных сетях.					
10	Я преувеличиваю значимость моих достижений в Интернете.					
11	Я терплю поражение в попытках сократить время, проводимое «онлайн».					
12	Мне нравится, что в Интернете можно полностью проявить себя.					
13	Иногда я указываю неверные данные о своей личности в Интернете.					
14	Я публикую фотографии важных событий своей жизни в социальных сетях.					
15	Я не всегда указываю истинные данные о своей личности, такие как имя, фотография, местоположение, при регистрации в социальных сетях.					
16	Я считаю, что посты в социальных сетях позволяют мне донести мои мысли до большого количества людей.					
17	Я состою в Интернете в группах, посвященных идеальной внешности.					

№ п/п	Утверждение	1	2	3	4	5
18	Я часто посещаю профили незнакомых людей в социальных сетях.					
19	Я считаю, что в Интернете необязательно соблюдать правила русского языка.					
20	К несчастью, достоинства человека в реальной среде часто остаются непризнанными, как бы он ни старался.					
21	Я произвожу впечатление успешного и привлекательного человека в социальных сетях.					
22	Игры в интернете или посещение социальных сетей помогает мне изменить настроение.					
23	Я чувствую пустоту, депрессию, раздражение, находясь не за компьютером.					
24	В Интернете гораздо удобнее совершать покупки.					
25	Я считаю, что в сети Интернет мой образ должен быть идеальным.					
26	Я проверяю электронную почту и открываю страницы в социальных сетях первым делом после пробуждения.					
27	Я считаю, что вполне допустимо выдавать себя за другого человека в Интернете.					
28	Интернет позволяет мне избавиться от скуки.					
29	Пользователи Интернета считают, что я более профессионален, чем есть на самом деле.					
30	Я считаю, что на фотографиях и видео в Интернете я выгляжу моложе и привлекательнее.					
31	Случалось, что я вступал в конфликты в социальных сетях, не идентифицируя свою реальную личность.					
32	У меня есть альтернативные страницы в социальных сетях, где я выдаю себя за других людей.					
33	Я считаю, что выгляжу на фотографиях более эффектно в сравнении с реальностью.					
34	Если я плохого мнения о человеке и мне не нравится его поведение в Интернете, то почти не стараюсь скрыть это от него.					
35	Я замечаю, что время, проводимое мной в Интернете, увеличивается.					
36	Пользователи Интернета думают, что я умнее, чем есть на самом деле.					
37	Я не хожу в библиотеку, так как мне проще найти любую информацию в Интернете.					
38	Я часто листаю ленту новостей в социальной сети «просто так».					
39	Порой я чувствую непреодолимое желание обновить страницу в социальной сети.					
40	Бывает, что настаиваю на своем при обсуждении в Интернете, даже когда не уверен в своей правоте.					
41	При использовании Интернета мое настроение улучшается.					
42	Свои достижения и успехи я обязательно освещаю в социальных сетях.					
43	Бывает, я бесцельно просматриваю чужие страницы в социальных сетях.					

Спасибо за сотрудничество!

Virtual Identity of Social Media Users (VISMU) Test

Full name _____ Age _____

Date _____ Gender _____

E-mail _____

Instructions: Here you have statements concerning certain aspects of your behavior, communication, and image on social media. Using the answer scale from 1 to 5, express your degree of agreement with each of the statements below. The degree of your agreement corresponds to the following indicators:

- 1 — strongly disagree;
- 2 — disagree;
- 3 — not sure;
- 4 — agree;
- 5 — strongly agree.

Stimulus material

# of item	Statement	1	2	3	4	5
1	I often photoshop my pictures before posting them on the Internet;					
2	I prefer being online to being intimate with a partner;					
3	I think insults and foul language on the Internet are a matter of course;					
4	I enjoy watching pictures or videos on the Internet rather than reading a text;					
5	I believe you should not post photos on social media showing flaws in appearance;					
6	The Internet allows me to express myself;					
7	I communicate on the Internet with people from other cities or countries;					
8	Sometimes I use social media without intending to communicate with anyone;					
9	I feel guilty when I realize that my image in the real world is different from my social media image;					
10	I exaggerate the significance of my achievements on the Internet;					
11	I fail to reduce my time online;					
12	I like that I can fully express myself on the Internet;					
13	Sometimes I give incorrect information about my identity on the Internet;					
14	I post pictures of important events in my life on social media;					
15	I do not always indicate my true identity, such as name, picture, location, when registering on social media;					
16	I believe social media posts allow me to convey my thoughts to many people;					
17	I am a member of Internet groups dedicated to an ideal appearance;					
18	I often visit profiles of strangers on social media;					
19	I believe it is not necessary to follow the rules of the Russian language on the Internet;					
20	Unfortunately, the merits of a person in the real world often remain unrecognized, no matter how hard they try;					
21	I make the impression of a successful and attractive person on social media;					
22	Playing online or visiting social media helps me to change my mood;					

# of item	Statement	1	2	3	4	5
23	I feel empty, depressed, and irritated when I'm not connected to the Internet;					
24	It is much more convenient to make purchases on the Internet;					
25	I believe my image should be perfect on the Internet;					
26	The first thing I do when I wake up is check my email and open social media pages;					
27	I believe it is quite conceivable to take on a different persona on the Internet;					
28	The Internet allows me to get rid of boredom;					
29	Internet users think I am more professional than I really am;					
30	I believe I look younger and more attractive in pictures and videos on the Internet;					
31	I have entered into conflicts on social media without identifying my real identity;					
32	I have alternative pages on social media where I take on a different persona;					
33	I think I look more impressive in pictures than in reality;					
34	If I have a bad opinion of a person and do not like their behavior on the Internet, I hardly try to hide it from them;					
35	I notice that the time I spend on the Internet is increasing;					
36	Internet users think I am smarter than I really am;					
37	I do not go to the library, as it is easier for me to find any information on the Internet;					
38	I often scroll through the news feed on the social media aimlessly;					
39	Sometimes I feel an overwhelming urge to refresh a page on social media;					
40	It happens that I insist on my own way when discussing on the Internet, even when I am not sure that I am right;					
41	My mood improves when I use the Internet;					
42	I am sure to highlight my achievements and success on social media;					
43	I aimlessly browse other people's pages on social media.					

Thank you for your cooperation!

The Key For Processing the Results of Virtual Identity of Social Media Users (VISMU) Test

Full name _____ Age _____

Date _____ Gender _____

Cyberaddiction		Acceptance of Subculture		Virtual image	
Statement #	points	Statement #	points	Statement #	points
2		3		1	
4		6		5	
8		7		9	
11		12		10	
14		13		17	
16		15		21	
20		18		25	
22		19		29	
23		24		30	
26		27		33	
28		31		36	
35		32			
38		34			
39		37			
41		40			
42					
43					
Sum of points on the scale		Sum of points on the scale		Sum of points on the scale	
Total points					

Test specification

When developing the specifications for the VISMU test, we defined the levels of virtual identity and its components. Interpretation and detailed description of different levels of the scales were based on content analysis of profiles of social network users with different kinds of virtual identity. When conducting a content analysis, we relied on an assessment of the specific content of the profile, and the features of the topics of the submitted posts, as well as the content of the graphic (photos) and text (signatures, comments) information.

CA scale. A high level (8–10 points) indicated an uncontrollable desire to use social media daily, generally without pursuing specific goals. We also observed a loss of interest in the real world combined with the increased importance of the virtual space of social media. There was a loss of control over the amount of time spent on social media, and a constant desire to use gadgets (smartphones, tablets, or computers). There was a desire to cover a wide range of life events on social media in a wide and detailed manner. The nature of users' time spent on the Internet was aimless, and they had difficulty interacting with the real world. They experienced a change in mood depending on the possibility of using social media, a lack of critical attitudes to materials posted on social media, and the negative consequences of excessive spending time online.

A medium level (4–7 points) indicated the daily use of social media for a wide range of uses from communication to information searches. We observed the active use of the possibilities of social media, and users emphasized their advantages. Despite a significant amount of time spent on social media, control and criticality were preserved.

A low level (1–3 points) reflected purposeful, controlled, and non-systematic use of social media for specific tasks: informal or business communication, viewing news, etc. We observed selectivity in posting materials (pictures, videos, etc.) on social media. The advantages of real communication were emphasized. A selective attitude towards information posted on social media was noted.

AS scale. A high level (8–10 points) was characterized by the user's expressed approval of the norms of the subculture of social media users in a wide range of situations. A low level of criticality combined with a fear of possible virtual sanctions was typical. The nature of Internet activities, as well as the user's opinions, judgments, and perceptions, changed under the influence of these norms. In particular, users approved of otherwise unacceptable communication styles (use of foul language, rude and cynical expressions, cyberbullying); anonymity was acceptable (concealment or indication of false personal information); the use of written colloquial speech (characterized by tolerance to grammatical and punctuation errors) was allowed; and the possibilities of remote communication (with representatives of other cities, regions, countries) were used.

A medium level (4–7 points) reflected a partial acceptance of the norms of the users' subculture mediated by the tasks of social media, and the specifics of a particular situation. The attitude towards these norms could change depending on the virtual sanctions imposed by reference users. The approval of some norms of the subculture and the rejection of other norms could be combined.

A low level (1–3 points) was characterized by a critical assessment of the norms of the subculture of social media users based on compliance with the individual's value attitudes. The absence of a fear of virtual sanctions and a low dependence on the opinions and judgments of other social media users were typical. We observed independence in decision-making and defending one's own opinion in the virtual space of social media.

VI scale. A high level (8–10 points) reflected the creation of an idealized self-image in the virtual space of social media, reflecting a complex of ideas about the user's desired physical appearance and preferred psychological properties, through which the user enters into vir-

tual communication. We observed digital enhancement before publishing pictures on social media and a critical attitude towards the shortcomings of people's appearances as presented in the virtual space. The exaggeration of professional achievements, exaggerated demonstration of success and status in social media, and the creation of a virtual reputation were evident. In the case of significant discrepancies between the real and the virtual image, feelings of guilt might arise.

A medium level (4–7 points) was characterized by the creation of a virtual self-image reflecting a complex of physical and psychological personal properties partially corresponding to the real self-image. We observed the embellishment or concealment of some components of the created image for a more flattering self-presentation and effective communication on social media. The user emphasized the advantages of an easy transformation of the virtual image depending on the goals of using social media and also noted some possibilities for its idealization.

A low level (1–3 points) indicated the creation of a self-image in the virtual space of social media reflecting a complex of physical and psychological properties highly correlated (at the level of the capabilities of the social media interface) with the properties of the real self-image. We observed authenticity and stability in the user's virtual image reflecting the genuine, unique, factual aspects of their real image (including ascriptive characteristics). Internet activities were carried out in the first person.

Integrated index. A high level (8–10 points) indicated the importance of social media for the user. We observed an increase in the value of online friends and building of virtual communication with a simultaneous decrease in the value of real communication. There was a lack of purpose for using social media. Reference users' assessments on the individual's values were important. Significant changes in the behavior or opinion, depending on the norms adopted in virtual communities, were evident. Manifestations of aggressiveness, including cyberbullying, were possible due to distorting or concealing personal data. We found attitudes towards a more effective presentation of physical characteristics and personal properties in social media underlying the creation of a virtual image aimed at demonstrating success and achievements on social media and creating a special virtual reputation. Playing alternative roles in the virtual space was possible. We observed the aimless use of time on social media and idealization in the creation of a virtual image, which performed a compensatory function.

A medium level (4–7 points) was characterized by the systematic use of social media, not limited to virtual communication. Although the time spent online was significant, the user showed criticality toward the negative consequences of excessive immersion in virtual space. Depending on the goals of using social media, the attitude towards the specific norms of the subculture adopted by the virtual communities changed. When creating a virtual image, both properties corresponding to the real self-image and idealized properties aimed at a more flattering self-presentation were demonstrated, which was determined both by the goals of using social media and the specifics of a particular situation. Although there were online friends and virtual communication, real interactions were still valuable to the user.

A low level (1–3 points) reflected the purposeful and conscious use of social media: communication, information search, and self-presentation. We observed a combination of a critical attitude towards the information posted on social media and the opportunities provided by them. The technologically determined limitation of the virtual space of communication was realized, which indicates more significance for real communication. The attitude towards the norms of the subculture of social media users was based on compliance with the individual's values. The created virtual image generally reflected the user's real self and was stable. We observed the purposeful use of social media and the creation of an authentic image.

CLINICAL PSYCHOLOGY

Post-traumatic Stress Symptoms, Distress, and Optimism in Mexican Colorectal Cancer Patients

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Background. The diagnosis and treatment of colorectal cancer are considered highly stressful and potentially traumatic events that can generate post-traumatic stress symptoms and distress among patients.

Objective. This study assessed levels of post-traumatic stress symptoms, distress, and optimism, as well as differences between these conditions relative to sociodemographic and medical variables, in Mexican patients with colorectal cancer.

Design. A cross-sectional descriptive study design was employed, in which 192 colorectal cancer patients over the age of 18 years participated. They filled out the following questionnaires in person: a sociodemographic and medical data questionnaire; the Event Impact Scale-Revised (EIE-R); the Hospital Anxiety and Depression Scale (HADS); and the Life Orientation Test (LOT-R).

Results. The results showed that 32.3% of the patients reported post-traumatic stress symptomatology, and 21.4% reported distress. Post-traumatic stress symptoms and distress varied according to age and monthly income. Significant differences between the sexes were also observed in the levels of post-traumatic stress symptoms and distress. Post-traumatic stress was positively and significantly related to distress, and negatively and significantly to optimism.

Conclusion. Based on these data, we concluded that a significant percentage of colorectal cancer patients present high levels of post-traumatic stress symptoms as well as distress, and that these levels may vary according to sociodemographic and medical characteristics.

Keywords: Cancer, colorectal cancer, distress, post-traumatic stress, optimism

Introduction

Colorectal cancer is considered the third most frequent type of cancer in Mexico, and ranks first in mortality (Organización Panamericana de la Salud [OPS], 2020). Evidence suggests that a substantial proportion of people with this form of cancer may experience their diagnosis and treatment as traumatic (Cordova et al., 2017).

Some studies have examined the prevalence of post-traumatic stress symptoms in adult cancer patients 6.5 months after treatment; the estimates range from 5% to 19%. In total, 10% of patients have reported such symptoms during the first six months after diagnosis and obtained a score above the clinical limit for probable post-traumatic stress disorder (Kangas et al., 2002; Schuster et al., 2014). It has been observed that patients with colorectal cancer with a diagnosis more than one year old, present greater post-traumatic stress, intrusive thoughts, and hypervigilance, compared to patients with a diagnosis less than six months old, or between six months and one year. Post-traumatic stress has also been reported to be a predictor of distress and intestinal pain (Pereira et al., 2012).

Post-traumatic stress symptoms are strongly associated with anxiety and distress, and a negative association with physical quality of life is also observed in the cancer population (Shand et al., 2015). Similarly, psychological distress has been negatively associated with health-related quality of life, independent of disease parameters, physical and mental indicators, and social relationships (Hyphantis et al., 2011; Paika et al., 2010).

In patients with colorectal cancer, having a stoma and low optimism are risk factors for lower quality of life and greater distress (Meng et al., 2012). In addition, having a stoma has a negative impact on a patient's body image, which is a strong predictor of initial levels of anxiety, depression, and distress (Sharpe et al., 2011). For its part, optimism shows a positive association with a positive emotional quality of life (Acevedo-Ibarra et al., 2021). Higher optimism is associated with better global health-related quality of life and better physical, role, emotional, cognitive, and social functioning in colorectal cancer patients with sensory peripheral neuropathy in their one-year follow-up after diagnosis (Trompetter et al., 2022). In this way, optimism favors adaptation to the disease and acts as a protective factor by reducing patients' vulnerability to other types of emotional and physical illnesses associated with cancer (Mera & Ortiz, 2012).

Currently, there is little information on the psychological alterations in Mexican patients with colorectal cancer. There are only two studies; one examining quality of life, which found that patients presented low emotional functioning (Balderas-Peña et al., 2011), and the other reviewing the psychosocial adaptation of the patient, which found that both the clinical characteristics of cancer and sociodemographic factors influence adaptation. That study, however, implied that there might be other factors that influence disease adaptation (Alvarado-Aguilar et al., 2011). Previous studies have focused on measuring quality of life and sociodemographic and medical aspects (Alvarado-Aguilar et al., 2011; Balderas-Peña et al., 2011).

Our study thus aimed to further advance the literature by providing theoretical and empirical scientific evidence on psychological variables such as symptoms of post-traumatic stress, distress, and optimism in patients with colorectal cancer

during the disease, in order to identify those who need psychological care, and design more personalized support care interventions (Russell et al., 2015). Based on the above, our objective was to evaluate the levels and relationships of symptoms of post-traumatic stress, distress, and optimism, as well as to examine differences relative to sociodemographic and medical characteristics in Mexican patients with colorectal cancer. We sought to test the hypothesis that there is a correlation between symptoms of post-traumatic stress, distress, and optimism, as well as examine differences based on sociodemographic and medical characteristics in Mexican patients with colorectal cancer.

Methods

Participants

A descriptive cross-sectional design was used with Mexican patients with colorectal cancer. The inclusion criteria were having a diagnosis of colorectal cancer, being over 18 years of age, and knowing how to read and write. Patients with a previous history of cancer or psychiatric disorders were excluded.

Questionnaires

Sociodemographic and medical data questionnaire. The questionnaire included sociodemographic data such as age, marital status, work, schooling, and monthly income. Clinical data included type of cancer, clinical stage, and type of treatment.

Impact of Event Scale-Revised (IES-R). The IES-R was designed by Horowitz et al. (1979) to assess subjective discomfort caused by stressful and/or traumatic experiences. It is one of the most commonly used instruments for the measurement of post-traumatic symptoms in adults (Ferrer & Delgado, 2018). The Spanish version by Caamaño et al. (2011) is based on a review of the IES-R by Weiss and Marmar (1997) that utilized the diagnostic criteria of the DSM-IV and consists of 22 items grouped into three subscales: intrusive thoughts, avoidance, and hyperarousal. It had a total Cronbach's alpha of 0.98. Cronbach's alpha for our study's population was 0.91.

Hospital Anxiety and Depression Scale (HADS). Designed as an instrument to detect states of anxiety and depression in the hospital environment, HADS is one of the most widely used instruments in oncology for measuring distress (Linden et al., 2012). The Spanish version, which has been used for Mexican cancer patients, has 12 items divided into two subscales — depression and anxiety; they have a total Cronbach's alpha of 0.86 (Galindo et al., 2015). Cronbach's alpha for our study was 0.72. The HADS has good psychometric properties for discriminating between cancer patients with and without the presence of clinical distress (López et al., 2012).

Life Orientation Test (LOT-R). The LOT-R was designed by Scheier et al. (1994) to measure the degree to which people generally have favorable expectations of their future. Likewise, the Spanish version is an adequate and practical tool for diagnostic purposes and epidemiological research in samples from Latin America (Zenger et al., 2013). We used the Spanish version; it is comprised of 10 items and has a reliability of $\alpha = 0.79$ (Otero et al., 1998). Cronbach's alpha for our study was 0.57.

Procedure

The patients were recruited from a public hospital on the basis of a review of medical files. Once the review identified the patients who met the inclusion criteria, they were searched out in the waiting room and invited to participate. Subsequently, they were asked about previous or current diagnoses of cancer and mental illness to identify whether they met the inclusion criteria. Then, the purpose of the research, the confidentiality of the data provided, and their right to receive information about their doubts regarding the study were explained to them. Once they decided to participate in the study, the participants signed an informed consent form. Subsequently, the questionnaires on symptoms of post-traumatic stress, distress, and optimism were administered. Participants did not receive any type of reward for their participation.

The data were analyzed using SPSS 24. Descriptive data of frequency and percentages were obtained for categorical variables, and means and standard deviations for continuous variables. For the prevalence of post-traumatic stress symptoms, the cut-off point of ≥ 20 suggested by Costa and Gil (2007) was used; the cut-off point of ≥ 10 suggested by Costa et al. (2009) was used for distress. The Kolmogorov-Smirnov normality test was performed, in which p values $<.01$ were obtained, which indicated non-normality. Therefore, non-parametric tests were used to analyze the relationship between the psychosocial, sociodemographic, and medical variables. The Mann-Whitney U test was used for variables with two categories and the Kruskal-Wallis test was used for variables with more than three categories; Spearman's correlation was used for continuous variables. The Holm-Bonferroni correctness test was performed to prevent the type I error.

Effect size was obtained using Cohen's d to measure the relative strength of the differences between the means of two groups (d). The values indicated by Cohen (1988) are the following: $d=0.20$ to 0.49 is considered low effect, $d=0.50$ to 0.79 a medium size effect, and $d=0.80$ or greater a large effect. Likewise, the partial square eta was used to obtain the effect size of three or more groups (η^2p). The values indicated by Cohen are the following: $\eta^2=0.01$ is considered low effect, $\eta^2=0.06$ a medium size effect, and $\eta^2=0.14$ a large effect.

Results

The data collection period was from March 2016 to August 2017. A total of 206 patients was evaluated, of which 14 submitted incomplete questionnaires; therefore, the data of 192 patients with colorectal cancer were analyzed. Their characteristics are described in *Table 1*. The age range of the participants was from 22 to 82; most of the participants were female, not currently working, and married. Regarding the prevalence of post-traumatic stress symptoms, 32.3% presented clinically significant symptoms. Further, 21.4% of the patients presented clinically significant emotional distress. Likewise, significant differences were found between men and women in levels of post-traumatic stress and distress, with medium effect size for post-traumatic stress.

Post-traumatic stress was different between patients with and without surgery, with low effect size. For distress, differences were found with significant trends for

Table 1
Prevalence and comparison analysis between psychosocial, sociodemographic and medical variables (N = 192)

	n	%	EIE-R	HADS M(SD)	LOT-R
Sex					
Female	102	53.1	21.9(16.5)	4.8(3.9)	40.1(4.3)
Male	90	46.9	13.6(11.7)	7.5(4.9)	38.7(5.6)
P value			.000**	.000**	.129
d			.580	-.609	.280
Works					
Yes	56	29.2	17.0(14.2)	5.0(4.1)	40.3(4.6)
No	132	68.8	17.8(15.2)	6.6(4.7)	39.1(5.1)
P value			.906	.024*	.158
d			-.054	-.362	.247
Marital status					
Married	137	71.4	17.7(14.3)	6.1(4.5)	39.8(5.1)
Single	22	11.5	15.4(16.0)	7.0(5.2)	38.4(4.7)
Divorced	18	9.4	20.2(18.1)	5.5(4.7)	38.8(5.5)
Widower	14	7.3	15.5(13.9)	5.5(4.1)	39.2(3.4)
P value			.407	.807	.423
η^2			.007	.007	.010
Type of cancer					
Colon cancer	96	50.0	16.9(15.5)	6.1(5.0)	39.9(4.8)
Rectal cancer	96	50.0	18.1(13.9)	6.0(4.1)	39.0(5.2)
P value			.296	.688	.165
d			-.081	.021	.179
Clinical stage					
I	15	7.8	17.8(14.4)	6.1(8.0)	41.1(3.8)
II	53	27.6	16.2(16.7)	5.9(4.7)	38.8(5.3)
III	86	44.8	17.5(14.4)	5.9(4.0)	39.5(4.9)
IV	30	15.6	17.4(13.1)	6.0(3.8)	39.8(5.3)
P value			.609	.763	.546
η^2			.003	.002	.012
Surgery					
Yes	155	80.7	21.7(13.8)	5.8(4.7)	39.7(4.7)
No	37	19.3	16.5(14.8)	7.1(4.0)	38.4(5.9)
P value			.013*	.039*	.154
d			.363	-.297	.243
Colostomy					
Yes	105	54.7	17.5(14.2)	5.9(4.3)	39.5(4.7)
No	87	45.3	17.6(15.4)	6.2(4.9)	39.5(5.3)
P value			.719	.710	.739
d			-.006	-.065	0
Current treatment					
RT / QT Neo	23	12.0	26.0(16.1)	8.1(4.1)	38.5(6.5)
RT or QT Ady	56	29.2	15.8(14.7)	6.1(4.6)	38.9(4.8)
Palliative QT	50	26.0	17.0(13.4)	6.2(3.8)	38.3(5.3)
Observation	59	30.7	16.1(14.4)	5.1(5.2)	41.3(3.8)
P value			.054	.022*	.015*
η^2			.048	.037	.065

Note. Continuous mean (SD) categorical %; ** $p \leq .001$ Alpha adjusted by Holm Bonferroni test * $p \leq .05$; SD = Standard Deviation. d = Cohen's d . η^2 = partial square etc. IES-R = Impact of Event Scale — Revised. HADS = Hospital Anxiety and Depression Scale. LOT-R = Life Orientation Test. RT / QT Neo = Neoadjuvant Radiotherapy / Chemotherapy. RT or QT Ady = Radiotherapy or Adjuvant Chemotherapy. Palliative QT = Palliative chemotherapy.

patients with and without surgery, with and without work, and type of current treatment with low effect size. As for optimism, tendencies for significance were only found in the type of current treatment, with medium effect size. No significant differences were found for the other comparisons (Table 1).

Table 2 shows that post-traumatic stress and distress symptoms were negatively and significantly related to age, monthly income, and optimism. Post-traumatic stress symptoms were positively and significantly related to distress. Optimism was positively related to monthly income.

Table 2

Correlation analysis between psychosocial and sociodemographic variables (N = 192)

	M(DE)	IES-R	HADS r_s	LOT-R
Age	54(12.6)	-.262**	-.277**	-.004
Monthly income	7742.7(7350.9)	-.258**	-.247**	.258**
Scholarship	9.6(4.2)	-.090	-.099	.044
IES-R			.657**	-.273**
HADS				-.450**

Note. ** $p \leq .01$ * $p \leq .05$. M = Mean. SD = Standard Deviation. r_s = Spearman's Correlation. EIE-R = Revised Event Impact Scale. HADS = Hospital Anxiety and Depression Scale. LOT-R = Life Orientation Test.

Discussion

The general objective of this study was to evaluate the levels of symptoms of post-traumatic stress, distress, and optimism, as well as to examine their differences relative to sociodemographic and medical variables in Mexican patients with colorectal cancer.

In our study, 32.3% of patients with colorectal cancer presented symptoms of post-traumatic stress. These results are similar to those of Naidich and Motta (2000), who found that women with breast cancer had a current incidence of post-traumatic stress symptoms of 32%, which was significantly higher than that in women without cancer.

However, the prevalence of post-traumatic stress found in this study was lower than that reported in veterans with colorectal, gastric, esophageal, and head and neck cancer, of whom 85.5% reported having experienced post-traumatic stress symptoms related to their experience of cancer. These differences may have occurred because that study used a different instrument than the one in our research, and because participants were military veterans diagnosed with cancer. Combat-related post-traumatic stress disorder has been found to increase the risk of developing post-traumatic stress symptoms related to cancer diagnosis and treatment (Schuster et al., 2014). By contrast, the present investigation showed a higher prevalence of post-traumatic stress than that for patients with breast cancer after surgery (18.5%) and at their six month follow-up (16.3%) (Mehnert & Koch, 2007).

Regarding distress, 21.4% of patients presented symptoms of clinically significant emotional distress. These results are low compared to those of other investigations, such as the longitudinal study by Dunn et al. (2013), where clinically significant levels of psychological distress were reported in up to 49% of 1703 colorectal cancer patients five months after diagnosis. However, our results are high compared to those of a study that was conducted through an Australian prospective survey of 1822 patients with colorectal cancer; that study reported significant levels of psychological distress in 8.3% and 6.7% of patients at 6 and 12 months after diagnosis, respectively (Lynch et al., 2008). By contrast, in our study, it was observed that the levels of symptoms of post-traumatic stress and distress according to sociodemographic and medical variables.

In relation to post-traumatic stress symptoms, a significant negative relationship was obtained depending on age and monthly income. These results are similar to those of Schuster et al. (2014), who showed in a sample of veterans with colorectal cancer that younger age was associated with more symptoms of post-traumatic stress related to cancer. This may be because younger people are generally more distressed after being diagnosed with cancer than older patients (Kangas et al., 2002). In addition, they are probably less used to receiving diagnoses of this magnitude, which they may perceive as traumatic (Pereira et al., 2012).

On the other hand, O'Connor et al. (2011) reported that low social status was one of the predictors of severe post-traumatic stress symptoms 15 months after breast cancer surgery. Furthermore, in this study, women had more post-traumatic stress symptoms than men, with medium effect size. These results are similar to those of Rucklos and Frombach (2000), who observed that in cancer patients with a diagnosis at least 12 months old, women reported symptoms of post-traumatic stress more frequently. Current studies report that cancer patients may suffer from financial distress during and after the cancer process; this distress is usually determined by sociodemographic, financial, and employment factors (Pauge, et al., 2021; Semin et al., 2020).

In our research, significant differences in post-traumatic stress symptoms were found between patients with and without surgery, with low effect size. These results are similar to those reported in patients with breast cancer where 20.1% of women had total scores suggesting severe post-traumatic stress symptoms three months after surgery (O'Connor et al., 2011). Likewise, colorectal cancer patients who underwent surgery/chemotherapy or surgery/radiotherapy had more symptoms of post-traumatic stress disorder than those who didn't (Pereira et al. 2012). These results may be due to side effects after surgery, such as diarrhea and sexual dysfunction (Benedict et al., 2018; Milbury et al., 2013). They may also have occurred because in some patients who undergo surgery, it is necessary to create a stoma, which, depending on the extent of the disease and the surgical procedure, can be temporary or permanent (Sharpe et al., 2011). However, this study did not find differences between patients with and without a colostomy, so it would be interesting to inquire about what specific aspects of surgery are associated with post-traumatic stress in patients with colorectal cancer.

A significant and negative relationship was found between distress, and age and income. Likewise, higher distress scores were found in men than women, as well as in patients who did not work, those who did not undergo surgery, and patients un-

dergoing radiation treatment and/or neoadjuvant chemotherapy, with low effect size. This is similar to what was reported in a study of colorectal cancer survivors in which young men, in a late stage of the disease, with low educational levels and social support, were more likely to have a high level of distress (Dunn et al., 2013). Therefore, it is considered important to inquire about cancer-related concerns in younger adults. Additionally, our results are similar to those of Miles et al. (2017) that suggested that age is a significant predictor of distress related to colorectal cancer. Some authors explain that the negative associations between age and distress may be due to the unexpectedness of the diagnosis and a greater impact on the life of the patient and their family members, as well as on work commitments (Green et al., 1998).

Iconomou et al. (2004) showed in their study, which sampled outpatients with colorectal, genitourinary, lung, and breast cancer, that almost a third of patients experienced severe psychological distress during chemotherapy. Cancer patients who receive chemotherapy or radiotherapy may perceive the cancer as more serious, may have less control over the treatments, and therefore show higher symptoms of psychological distress. Likewise, more frequent trips to the hospital and longer periods of treatment can contribute to greater psychological comorbidity (Denlinger & Barsevick, 2009; Pereira et al., 2012).

This result is consistent with the finding of Baker et al. (2005) who showed that patients who were currently undergoing cancer treatment reported, on average, a significantly higher number of problems related to the disease, compared to those who were not currently undergoing treatment. These data were obtained by patients diagnosed with lung cancer, followed by survivors of breast, colorectal, and prostate cancer. Pettersson et al. (2014) report that 6% of colorectal cancer patients receiving chemotherapy score high (quite or very much) on the dimension of distress related to the problem, which indicates that patients experience symptoms of psychological distress both at the beginning and during the treatment phase.

As to the association between the psychological variables, our results show that post-traumatic stress symptoms are positively and significantly related to distress, which is similar to the finding by Salsman et al. (2009) that post-traumatic stress disorder symptomatology is positively associated with depression and anxiety. In addition, symptoms of post-traumatic stress are associated with depression and anxiety symptoms in cancer patients admitted for unplanned hospitalization (Nipp et al., 2019).

Regarding optimism, a positive and significant relationship was obtained with monthly income and a significant difference depending on the current stage of treatment, with medium effect size. That is, patients under observation showed the highest optimism score. This is consistent with the findings by Deimling et al. (2006) that long-term cancer survivors were less optimistic in the time closest to cancer diagnosis, which may be due to symptoms of cancer and its treatment. Likewise, Croft (2014) observed that self-perception of good or excellent health was significantly associated with higher optimism in long-term survivors of breast cancer. These results are consistent with those of our study because the patients were not undergoing cancer treatment.

In this regard, Taber et al. (2016) found that optimism may be associated with beneficial health-related outcomes among cancer survivors. Additionally, analyses by Meng et al. (2012) showed that low optimism is a risk factor for increased distress

in colorectal cancer survivors. Similarly, the results of Applebaum, Stein et al. (2014) showed that greater optimism is significantly associated with fewer anxiety and depression symptoms in patients with advanced cancer. This highlights the importance of optimism in facilitating psychological adaptation to living with cancer.

Thus, the previous results showed the importance of psychosocial factors in cancer diseases such as post-traumatic stress symptoms, distress, and optimism. In this regard, Schuster et al. (2014) mentioned that patients' individual and psychosocial characteristics can play an important role in variables related to the disease, and help determine an individual's response to the stress of cancer. Similarly, in line with Kangas et al. (2002), future research needs to identify the influence of different stressors that can occur during cancer experience. In addition, Pereira et al. (2012) suggested that health professionals should also be attentive to signs of clinical distress and have a better understanding of the factors that can predict cancer-specific distress, which could allow for better clinical and psychoeducational interventions.

Conclusion

A significant percentage of colorectal cancer patients present high levels of post-traumatic stress symptoms as well as distress, and these levels may vary according to sociodemographic and medical characteristics.

Limitations

This study had some limitations. First, the Cronbach's alpha of the optimism scale was low for this study so the results should be interpreted with caution. Also, a descriptive cross-sectional design does not allow drawing inferences about the direction of causality. In this sense, we recommend carrying out longitudinal studies that would allow us to observe the trajectory of the psychosocial variables that patients present over time. Likewise, given that the results are only from patients found at a hospital entity, they cannot be generalized. Thus, future research is required to confirm these findings.

Nevertheless, this study is valuable because it shows the prevalence of symptoms of post-traumatic stress and considerable distress in Mexican patients with colorectal cancer, and how these symptoms differ according to sociodemographic and medical conditions. This highlights the need to provide care to these patients so that they can effectively manage the consequences of the disease. With this information, health professionals could identify the patients most likely to experience distress and refer them to psycho-oncology services. In accordance with the above, this study served to promote more comprehensive work in oncology services.

Ethics Statement

The study was approved by the hospital's research committee (R-2016-1901-89).

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

All study participants signed the consent for voluntary participation.

Author Contributions

J.A. and D.J. designed the study. A.E. and S.B. supervised data collection. J.A. and D.J. verified the analytical methods. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

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COGNITIVE PSYCHOLOGY

The Manifestation of Incidental Findings in Different Experimental Visual Search Paradigms

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Background. Incidental findings are items of visual search that are potentially of significance, but were not the main object of the initial search. They have been previously widely discussed in the field of radiology. However, the underlying perceptual mechanisms of such phenomenon are still unclear.

Objective. The current study aims to examine incidental findings in different paradigms of visual search in order to reveal their primary perceptual aspects.

Design. Two behavioral visual search experiments were conducted. The mixed hybrid search task model was used in the first experiment, while the subsequent search miss effect was employed in the second experiment. The task was to find targets among distractors, according to given instructions. Stimuli material consisted of images of real-life objects that were randomly distributed across the screen for each trial.

Results. Accuracy and reaction time of the participants were analyzed in both experiments. Similar effects were observed for both parameters. Specific targets in the first experiment and typical targets in the second experiment were found significantly faster and more accurately in comparison to categorical and atypical targets. Moreover, this tendency did not depend on the order of target identification. Hence, the prevalence of the targets was revealed to be the primary factor in the case of incidental findings.

Conclusion. The study revealed the emergence of incidental findings in both experiments. Typical or specific targets were detected significantly more accurately, compared to atypical or categorical targets. Subsequent search misses were not detected, suggesting that target prevalence could be a crucial factor that is specific for incidental findings.

Keywords: Incidental findings, visual search, subsequent search misses, prevalence effect, target similarity, visual attention, visual perception

Introduction

Incidental findings are items that were not the primary targets of the visual search, but nonetheless have potential value for the searcher. Initially, they were widely studied in radiology as medical artifacts, unrelated to the main diagnosis (e.g., Berbaum et al., 1990; Beigelman-Aubry, Hill, & Grenier, 2007). Finding signs of cancer while examining a patient with pneumonia might serve as an example of such findings. However, recent work by Wolfe et al. (2017) examined the underlying mechanisms of such phenomena in visual search. The authors used a model specifically designed to compare categorical and specific searches in different conditions. They suggested that incidental findings were associated with categorical searches, while typical targets corresponded to specific searches. Specific search is a search for targets with a specific identity (for example, when one searches for their own keys in a bag), and categorical search (Yang & Zelinsky, 2009) is a search for all targets from one category (for example, looking for vegetables in the store). Specific search is simpler since it is based only on one representation of the primary target. Categorical search, however, demands more attentional resources, since there is no clear representation of targets. Experimental research supports these assumptions. A good illustration is a study by Maxfield and Zelinsky, which investigated the influence of categorical hierarchy on visual search (Maxfield & Zelinsky, 2012). Within the study, searchers were primed with subordinate (e.g., dalmatian), basic (e.g., dog) or superordinate (e.g., animal) category names, which helped to guide and clarify searches. It was revealed that the guidance increased with increasing specificity of the category labels. Hence, targets classified by a subordinate, or narrower, category, were easier to find. In a similar manner, it can be harder to find less defined targets in the case of the incidental findings phenomenon. The searchers do not have clear representations of such items, although they constitute the general category of medical abnormalities.

Incidental findings seem to be closely connected to the effect of the prevalence of targets. It was shown in several studies that targets of high prevalence are typically identified much faster and more precisely than those of low prevalence (e.g., Hout et al., 2015). In case of incidental findings, targets of low prevalence would correspond to less defined categorical items. The underlying mechanism of the low-prevalence effect is possibly based on forced-choice decisions made by searchers while performing the task. The thresholds responsible for making the decision to continue the search after finding one target can be altered by various factors. Research shows that in the case of low-prevalence targets, the threshold for abandoning further search is significantly lower compared to the high-prevalence condition (Wolfe, Van Wert, 2010).

One of the main issues when it comes to identifying the real mechanisms of incidental findings is the problem of experimental paradigms used for the investigation of the studied phenomena. It is a common practice for researchers to choose a standard paradigm, which enables the detection of a studied effect and which has already shown its effectiveness in previous experimental projects. However, for novel effects of visual search, such as incidental findings, the question arises of

whether to choose one of the existing paradigms of visual search or to develop a new one. There are experimental models used in visual search research that seem to be suitable for studying incidental findings. Potentially, different paradigms could aid the study of various aspects of this phenomenon, since they have not yet been precisely defined in terms of the underlying cognitive mechanisms. One model for research, closely linked to the hybrid search paradigm, was used by Wolfe and co-workers (Wolfe et al., 2017). The distinctive characteristic of the hybrid search paradigm is that it involves visual search from memory (e.g., Schneider & Shiffrin, 1977; Wolfe, 2012). This is advantageous, since it resembles a visual search in real-life conditions. Another possible method, optimal for incidental findings, could be a subsequent search misses (SSM) paradigm. SSM are the effect of a significant decline in the accuracy of the identification of the second target (Adamo, Cain, & Mitroff, 2013; Adamo et al., 2019; Fleck et al., 2010). Originally, SSM were referred to as “satisfaction of search” and were widely studied in radiology (e.g., Tuddenham, 1962; Berbaum et al., 1994). SSM are related to primary targets of search, as opposed to incidental findings, and the target found second is typically very similar to the target found first. Nevertheless, SSM resemble incidental findings as perceptual phenomena of visual search. Both effects can be related to the identification of additional targets following the detection of the first target. Therefore, the visual search errors related to them might be due to perceptual biases or resource limitations related to the processing of the first target. This is specifically important, since in experimental conditions both incidental findings and SSM are studied within multiple target search paradigms. Hence, it is crucial to understand how to behaviorally dissociate between the two phenomena. There were several studies that revealed the factors responsible for the accuracy shift in the case of the detection of the second target. Some studies illustrated that perceptually similar targets were identified more accurately (e.g., Gorbunova, 2017), while others showed the role of their categorical identity (Biggs et al., 2015) as more significant. All aspects considered, the similarity of targets may play a crucial role in the emergence of the discussed visual search effects.

Different experimental paradigms allow the identification of various factors that lead to the emergence of specific perceptual effects. The traditional SSM paradigm provides very high target-distractor similarity. When targets closely resemble distractors, the overall visual search task becomes much harder (Duncan & Humphreys, 1989). Therefore, the SSM errors might be due to the perceptual noise created by the distractors. On the other hand, the mixed hybrid search model includes objects from different categories, therefore creating a much larger perceptual variance among all items on display. Hence, target-distractor similarity may be a factor that behaviorally separates incidental findings from SSM. However, the two paradigms also differ in terms of target prevalence representation. Wolfe and colleagues’ model was created to easily manipulate the percentage of particular targets on screen. In standard SSM paradigms, this parameter is not varied. As such, a bias towards specific targets throughout the task is not created. Rather, the emphasis is put on the bias created by the initially identified target in each individual experimental trial. This difference might be crucial in differentiating incidental findings from SSM. If target prevalence

is manipulated in both experimental paradigms, the results could specify the perceptual underlying mechanisms of these phenomena.

The objective of this research was to study incidental findings using two different experimental visual search paradigms: a mixed hybrid search model developed by Wolfe and colleagues, and an SSM paradigm. The mixed hybrid model involves searching for several targets from memory, some of which are defined by category, while others are specific. The procedure is separated into several blocks, so that targets and distractors are defined for each individual block separately. In contrast, the SSM paradigm involves searching for initially defined targets during the whole procedure. Target prevalence was chosen to be manipulated in both experimental paradigms in order to reveal its specificity to incidental findings. The main criterion for identifying incidental findings was the absence of statistical differences between conditions with one target (categorical or non-typical) and two targets, as suggested by Wolfe et al. (2017). Therefore, if incidental findings emerge in both experimental models, it suggests that target prevalence is indeed the crucial factor for distinguishing the described perceptual phenomena. However, if SSM were to be found in the paradigm for SSM research, it would mean that target prevalence is not specific for incidental findings, and there are likely other perceptual factors that play a significant role.

Experiment 1

Methods

Participants

There were originally 17 participants in this experiment. The sample size was based on the experimental work by Wolfe et al. (2017), who originally introduced the mixed hybrid search model. Slightly more participants were invited, in order to compensate for distant data collection. All were required to have normal or corrected to normal vision and to have no neurological or psychological problems. Every participant read and signed the informed consent. Data from 3 participants were excluded from further analysis, due to misunderstanding of the instructions. Therefore, the final sample consisted of 12 females and 2 males, their ages ranging from 18 to 36 years old ($M = 24.14$, $SD = 5.14$).

Stimuli material

Eight categories of food were chosen as stimuli material: vegetables, fruit, groceries, drinks, meat products, dairy products, bakery, and desserts. For each of those categories, ten different objects were chosen as stimuli. The images were taken from open stock-images bases and modified in Adobe Photoshop to isolate the objects from the background and change the image size. The stimuli represented real life objects in order to correspond to the experimental task, so primary perceptual factors like color and brightness were not specifically controlled. However, since different stimuli were randomly distributed across trials, possible systematic biases related to such factors were eliminated. Each image was 160x120 pixels in size, vertically oriented. Stimuli

were presented on a plain white background. There were also two additional buttons “NO” and “OK” for reporting the absence of the targets.

Overall, six experiments were created with the following conditions: one specific target (36% of tasks), two specific targets (16% of tasks), one categorical target (9% of tasks), two categorical targets (1% of tasks), both specific and categorical targets in the same task (8% of tasks) and no targets (30% of tasks). The percentage distribution is similar to that in experiments by Wolfe et al. (2017). These conditions were then distributed among three experimental blocks: specific, categorical, and mixed. The blocks differed in the type of search, which was specified in the instructions. Within a specific block particular objects would be searched for, in a categorical block the search would be for all objects from a given category, and a mixed block was a combination of those two types of search. The mixed block was critical in this experiment, since it implied both specific and not clearly defined targets, representing incidental findings.

The stimuli were distributed randomly across the screen (1248x640 pixels) within a 5 by 5 invisible grid. Participants could move along up to 55 pixels horizontally and up to 4 pixels vertically randomly from the centers of the cells in each trial. Overall, there could be 4, 8, or 12 stimuli in each individual trial, the number of targets varied from 0 to 2.

Procedure

The experiment was conducted remotely on the participants' computers. They could use any computer with any monitor, but they were specifically required not to use a smartphone or tablet. The participants were sent all the necessary materials, including video-instructions and the experiment files. Before running the experiment, the participants were asked to look through the list containing all the images of stimuli in order to familiarize themselves with which object belonged to which category. After that they were asked to begin the experiment in quiet, comfortable conditions. They were also required to use a computer mouse and a space bar during the experiment.

When the participants ran the experiment, instructions describing the task appeared. It was stated that the task resembled a “grocery shopping” task, and the participants would need to find objects, based either on their specific labels or the name of the category. The labels appeared before the start of each experimental block. The objective was to remember objects or category names and then search for the targets as quickly as possible. As soon as the target was found, it needed to be clicked on using a computer mouse. The buttons “OK” and “NO” served for reporting the absence of targets in conditions with only one or no targets. After the end of each task, the participants could rest if necessary and begin the new task by pressing the spacebar.

Each specific, categorical, and mixed block was evenly divided into two blocks, making six separate blocks. The participants had a chance to rest in between the blocks and begin a new one by pressing the spacebar. Before each block, four labels of objects or category names appeared for 12 seconds. In the specific block there were

four labels of specific objects, in the categorical block there were four names of different categories, while in the mixed blocks there were two specific labels and two category names. The labels and category names for each block were chosen at random. The order of the tasks within each block was random. Following the initial instructions, there was a training block consisting of 20 trial tasks to enable the participants to practice and contact the experimenter if anything was unclear. Next, the main part of the experiment began. This consisted of 820 tasks in total.

Results

Accuracy and reaction time for both mouse clicks were analyzed. The condition with no targets was excluded from the analysis, since it was used as a control to determine the participants' attention to a given instruction and did not contain any relevant data. Accuracy and reaction time were analyzed for conditions with one specific target, one categorical target, two specific targets, two categorical targets, and the condition with both types of targets present together. Moreover, these conditions were analyzed separately for each experimental block: specific, categorical, and mixed. It was necessary to examine the errors, depending on the type of search.

The error analysis was carried out for different experimental conditions. For experiments with no targets, the accuracy and reaction time were calculated using the times when participants successfully clicked the "NO" button twice. For experiments with one specific or categorical target, the accuracy and reaction time were calculated using times when the click on the target was followed by a click on "OK" button. For experiments with two specific or categorical targets, the accuracy and reaction time were measured for the second target, regardless of the order in which the targets were clicked. For the experiments with both target types (in the mixed block), the accuracy and reaction time were calculated for the categorically defined target, but only if it was found after the specific one. Accuracy and reaction time then were compared for the relevant experimental conditions. Reaction time was analyzed for correct response trials. Reaction times (RTs) greater than $M+2SD$ and less than $M-2SD$ were excluded from further analysis.

IBM SPSS Statistics v. 22.0.0.0 was used for data analysis. In order to determine which type of search (specific or categorical) was more accurate, two-way ANOVA was used. Moreover, multiple paired sample t-tests were applied for pairwise comparisons of different conditions with Bonferroni adjustments. For analyzing the effects within the mixed block repeated measures, ANOVA and pairwise comparisons with Bonferroni-Holm adjustment were used. The Greenhouse-Geisser corrections were applied when Mauchly's sphericity tests were significant.

Incidental findings were detected based on the accuracy parameter. If there were no significant differences between dual- and single-target tasks, incidental findings would be detected. Otherwise, in the case of the significant decrease in accuracy related to dual-target trials, SSM would be detected. The reaction time parameter was considered secondary to the accuracy parameter. It was used to further clarify the differences between different experimental conditions, particularly between categorical and specific visual search.

Accuracy

Two-way ANOVA revealed a significant effect of the target type factor ($F(1,13) = 30.314$, $p < .001$, $\eta_p^2 = 0.7$) and the number of targets factor ($F(1,13) = 10.013$, $p = .007$, $\eta_p^2 = 0.435$). The factor interaction was insignificant ($F(1,13) = 2.083$, $p = .173$, $\eta_p^2 = 0.138$). The search for specific targets was more accurate in conditions with one target ($t(13) = 6.661$, $p < .001$, $d = 1.31$) and two targets ($t(13) = 3.144$, $p = .016$, $d = 2.91$). The participants were significantly more accurate in detecting the only target in a task compared to two targets, but only in the specific block ($t(13) = 3.267$, $p = .018$, $d = 5.23$). The accuracy did not differ significantly depending on the number of targets ($t(13) = 0.852$, $p = .409$, $d = 0.14$). The results are presented in Figure 1.

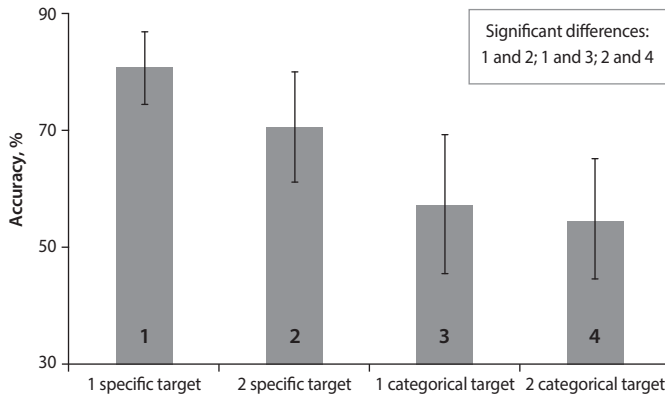


Figure 1. The results of accuracy analysis for conditions in specific and categorical blocks

Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of paired sample t-tests.

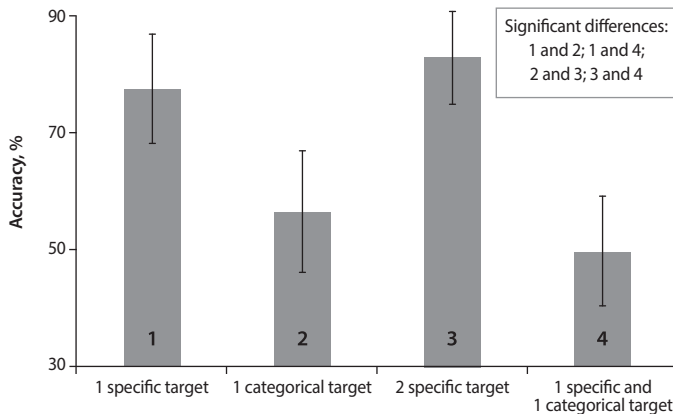


Figure 2. The results of accuracy analysis for the mixed block

Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of pairwise comparisons.

In the mixed block, ANOVA showed a significant effect of the experimental condition factor: $F(3,39) = 35.012$; $p < .001$; $\eta_p^2 = 0.729$. Pairwise comparisons with

Bonferroni adjustments revealed significant differences between the following conditions: one specific target and one categorical target ($p < .001$), one specific target and both specific and categorical targets in the same trial ($p < .001$), one categorical target and two specific targets ($p = .001$), and two specific targets and both specific and categorical targets in the same trial ($p < .001$). The results are presented in *Figure 2*.

Reaction time (first click)

Two-way ANOVA revealed a significant effect of the target type factor ($F(1,13) = 48.481$, $p < .001$, $\eta_p^2 = 0.789$) and the number of targets factor ($F(1,13) = 28.938$, $p < .001$, $\eta_p^2 = 0.69$). The factor interaction was insignificant ($F(1,13) = 0.012$, $p = .916$, $\eta_p^2 = 0.001$). It took significantly less time to find a specific target than a categorical one in experiments with either one target ($t(13) = -4.459$, $p = .001$, $d = 0.87$) or two targets ($t(13) = -5.758$, $p < .001$, $d = 1.42$). Furthermore, it took more time to identify a single target as opposed to one of two targets. This was true for both specific ($t(13) = 4.5$, $p = .002$, $d = 1.06$) and categorical blocks ($t(13) = 3.671$, $p = .003$, $d = 3.13$). The results are illustrated in *Figure 3*.

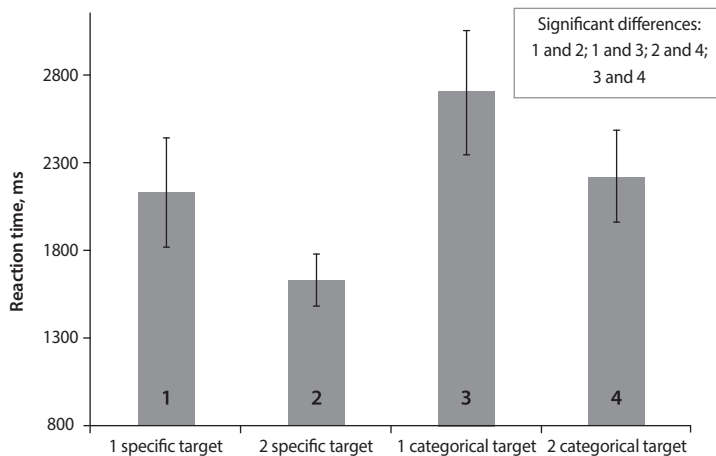


Figure 3. The results of the reaction time (first click) analysis for different experimental conditions in specific and categorical blocks

Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of paired sample t-tests.

In the mixed block, ANOVA showed a significant effect of the condition factor: $F(3,39) = 32.071$; $p < .001$; $\eta_p^2 = 0.712$. Pairwise comparisons with Bonferroni adjustments revealed significant differences between the following experimental conditions: one specific and one categorical targets ($p = .001$), one specific and two specific targets ($p < .001$), one categorical and two specific targets ($p < .001$), and one categorical target and both specific and categorical targets in the same task ($p = .001$). The results are presented in *Figure 4*.

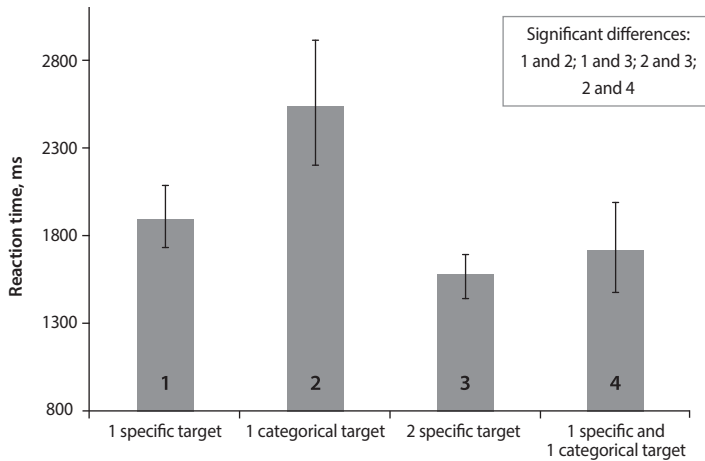


Figure 4. The results of reaction time (first click) analysis for the mixed block
Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of pairwise comparisons.

Reaction time (second click)

Two-way ANOVA revealed a significant effect of the target type factor ($F(1,13) = 17.556$, $p = .001$, $\eta_p^2 = 0.575$) and the number of targets factor ($F(1,13) = 34.542$, $p < .001$, $\eta_p^2 = 0.727$). Moreover, the effect of factor interaction detected was significant ($F(1,13) = 26.36$, $p < .001$, $\eta_p^2 = 0.67$). Due to this significant interaction, an additional one-way ANOVA was conducted separately for specific and categorical targets (the factor being the number of targets), and another for one target and two targets conditions (the factor being target type).

The additional one-way ANOVA revealed the significant effect of the number of targets for specific ($F(1,13) = 45.394$, $p < .001$, $\eta_p^2 = 0.777$) but not categorical targets ($F(1,13) = 4159.197$, $p = .469$, $\eta^2 = 0.041$). Hence, the participants were significantly quicker to find the second specific target than to report the absence of the second specific target ($p < .001$). However, such a pattern was not found for categorical targets. In this case, it took a statistically similar amount of time to report the second target as it did its absence ($p = .469$). Regarding the effect of target type, it was significant for conditions with two targets ($F(1,13) = 35.525$, $p < .001$, $\eta^2 = 0.732$) and insignificant for conditions with only one target ($F(1,13) = 1.112$, $p < .311$, $\eta^2 = 0.079$). The participants were significantly quicker to click on the second specific target than the categorical one ($p < .001$), but they tended to require an equal amount of time to report the absence of the second target, whether specific or categorical ($p = .311$). The results are illustrated in *Figure 5*.

In the mixed block repeated measures, ANOVA revealed a significant effect of the condition factor: $F(2,24) = 26.323$; $p < .001$; $\eta_p^2 = .669$. Pairwise comparisons with Bonferroni adjustments revealed significant differences between the following conditions: one specific target and two specific targets ($p < .001$), one categorical target and two specific targets ($p = .001$), and two specific and both specific and categorical targets in the same task ($p < .001$). The results are illustrated in *Figure 6*.

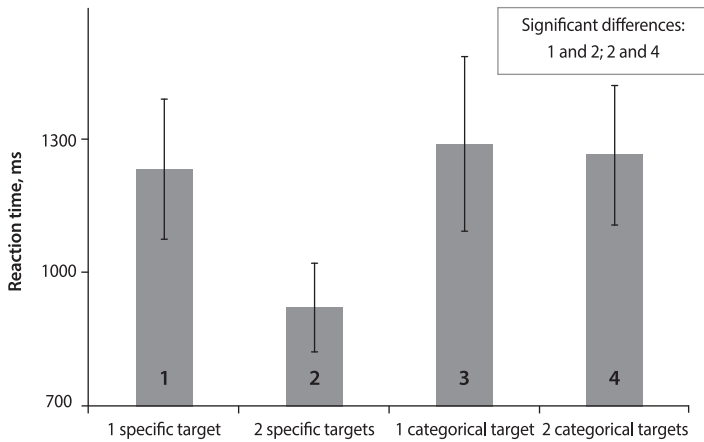


Figure 5. The results of reaction time (second click) analysis for conditions in specific and categorical blocks

Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of paired sample t-tests.

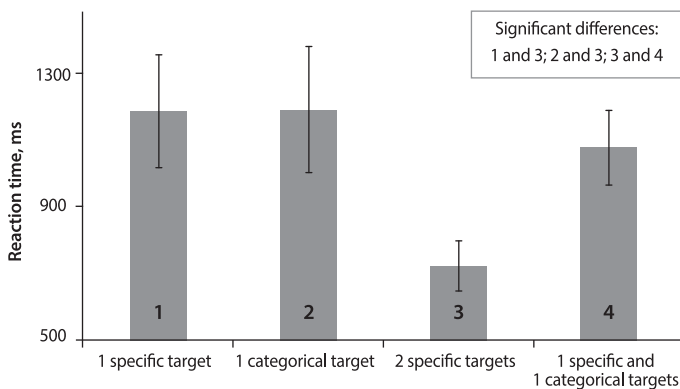


Figure 6. The results of reaction time (second click) analysis for the mixed block

Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of pairwise comparisons.

Discussion

The results of the accuracy analysis within specific and categorical blocks illustrate that the search for categorically defined targets was significantly more prone to errors. The accuracy in detecting specific targets was higher for experiments with both with one and two targets. This is similar to the findings obtained in the research by Wolfe and colleagues, where error rates were significantly higher for categorical targets (Wolfe et al., 2017). The findings are supported by the perceptual set hypothesis, since specific objects are better represented in the working memory, and visual attention is guided towards them (Kristjánsson & Campana, 2010). Categorical targets are less precisely defined, therefore the search for such items is less efficient. Similar results were reported in the study by Maxfield and Zelinsky, where the effects of the

category level were studied and it was found that the less defined the target, the lower the accuracy (Maxfield & Zelinsky, 2012). As well as that, there was the effect of SSM for the specific block only: the accuracy declined significantly for the condition with two targets compared with the condition with one target. However, this was not the case for the categorical block: there were no statistically significant differences between the corresponding conditions. This may be explained by the overall difficulty of categorical search, particularly because the participants were accurate in no more than 60% of the trials.

Within the mixed block, there were no significant differences between the experiments with both specific and categorical targets and the experiments with only one categorical target. This finding implies that, by definition, no SSM were observed in this block. It also corresponds to the results of Wolfe and colleagues' experiment (Wolfe et al., 2017). This is interesting since incidental findings were indeed separated from other visual search phenomena in their study. Furthermore, in the mixed block, as in the other blocks, the search for one specific target was significantly more accurate than the search for one categorical target. Furthermore, the accuracy in the experiments with one categorical target was far lower than the accuracy in experiments with two specific targets. Hence, categorical search seems to be far less precise than specific search.

The results of the first click reaction time analysis further clarify the differences between categorical and specific search. The identification of a specific target was significantly quicker in tasks with both one and two targets in specific and categorical blocks. The same effect was observed in the mixed block experiments with one specific and one categorical target. These findings, once again, resemble those reported in papers by Wolfe (Wolfe et al., 2017) and Maxfield (Maxfield & Zelinsky, 2012). Hence, it can be assumed that finding a categorically defined target takes more time than a specific one. The participants were also significantly quicker to find the first target in tasks with two targets compared to tasks with one target. This suggests that, statistically, it takes less time to find at least one out of two present targets, rather than to find the only present target. This is typical for visual search experiments, as supported by previous experiments and known data (e.g. Kwak, Dagenbach, & Egeth, 1991; Moraglia, 1989).

With regards to the reaction time of the second click for specific and categorical blocks, it took significantly less time to detect the second target if it was specific. Moreover, it took significantly less time to find the second specific target compared to reporting its absence. This was true for both specific and mixed conditions. This finding illustrates the higher probability of detecting the second present target before searching through all present distractors. However, in the categorical block, there were no significant differences between the mentioned conditions. It took a statistically similar amount of time to detect either the second target or report its absence. A possible explanation for this finding is that the time required to make a decision is increased, whether the observed item is a target or not, due to poorly defined target representation. As previously discussed, in the case of specific targets such decisions are made quicker, due to both attentional guidance and distinct perceptual representations of targets. Furthermore, the reaction time for tasks with one target was not significantly

different between all three experimental blocks. This is a typical finding since set sizes were evenly distributed among the various experimental conditions, meaning it would take the same amount of time to report the absence of the second target.

Experiment 2

Method

Participants

There were originally 24 participants in this experiment. The sample size was based on previous experimental research on SSM (e.g., Gorbunova, 2017). All the participants confirmed *via* Google forms (<https://www.google.com/forms/about/>) that they had normal or corrected to normal vision and did not have any neurological or psychological problems. Data from one participant were excluded from further analysis, due to misunderstanding of the instructions. Therefore, there were 21 females and 2 males. Their ages ranged from 19 to 34 years old ($M = 22.22$, $SD = 4.13$). The participants were given 100 rubles each for participating in the experiment.

Stimuli

Food images were used as targets and distractors belonged to several categories: cars, furniture, hats, musical instruments, and shoes. Fruits and vegetables corresponded to typical targets, while spices corresponded to non-typical targets. There were five objects chosen for each category and 60 images in total. The images were taken from open stock-images bases and modified in Adobe Photoshop to isolate the objects from the background and change the image size. Each image was 140x100 pixels in size, vertically oriented. Stimuli were presented on a plain white background. There were also two additional buttons made for participants' answers, they contained the words "NO" and "OK" correspondingly.

The salience of the two types of targets was varied. Fruits and vegetables were used as typical targets, while spices were non-typical targets. There were five experimental conditions: two typical targets (18% of tasks), one typical target (37% of tasks), no targets (30% of tasks), one non-typical target (5% of tasks), and both typical and non-typical tasks (10% of tasks).

The stimuli were distributed randomly across the screen (1248x640 pixels) within a 5 by 5 invisible grid. There could be 12, 16, or 20 stimuli in each individual trial. The number of targets could be 0, 1, or 2.

Procedure

The experiment was conducted online using Pavlovia software (<https://pavlovia.org/>). The participants used their personal computers and were required not to use smartphones or tablets. They were instructed to search for food among objects from other categories. The participants were informed that they could find 0, 1, or 2 targets in each individual task. They were asked to perform the task as quickly as possible. They used a computer mouse to click on targets and the buttons at the bottom of the screen in order to report the presence or absence of targets, similar to Experiment 1.

After the end of each task, the participants could rest if necessary and begin the next task by pressing the spacebar.

The first 60 tasks did not contain non-typical targets, and the order of presentation in the following trials was randomized among all five experimental conditions. There were 495 tasks in the main block of the experiment.

Results

The analysis was the same as for the mixed block in Experiment 1.

Accuracy

Repeated measures ANOVA revealed the significant impact of the experimental condition factor: $F(2,50) = 10.671$; $p < .001$; $\eta_p^2 = 0.327$. Pairwise comparisons with Bonferroni-Holm adjustments revealed significant differences between the following conditions: one typical and one non-typical target ($p < .001$), one typical target and both typical and non-typical targets in the same task ($p = .015$), two typical targets and one non-typical target ($p = .009$), and two typical targets and both typical and non-typical targets in the same task ($p = .035$). The results are presented in *Figure 7*.

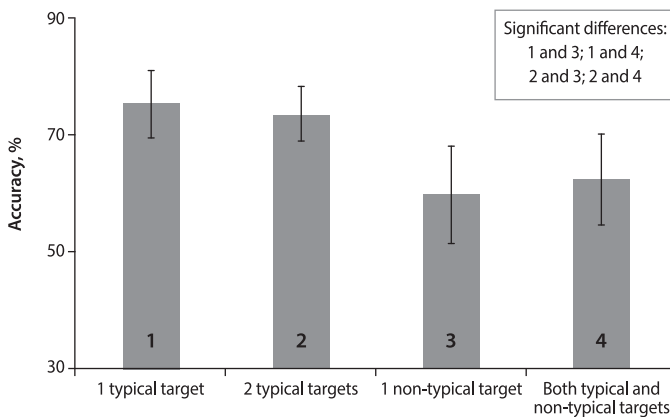


Figure 7. The results of accuracy analysis for Experiment 2

Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of pairwise comparisons.

Reaction time (first click)

Repeated measures ANOVA revealed the significant impact of the experimental condition factor: $F(2,50) = 144.546$; $p < .001$; $\eta_p^2 = 0.868$. Pairwise comparisons with Bonferroni-Holm adjustments revealed significant differences between the following conditions: one typical target and two typical targets ($p < .001$), one typical target and one non-typical target ($p < .001$), one typical and both typical and non-typical targets in the same task ($p < .001$), two typical and one non-typical target ($p < .001$), two typical and both typical and non-typical targets in the same task ($p = .015$), and one non-typical target and both typical and non-typical targets in the same task ($p < .001$). The results are presented in *Figure 8*.

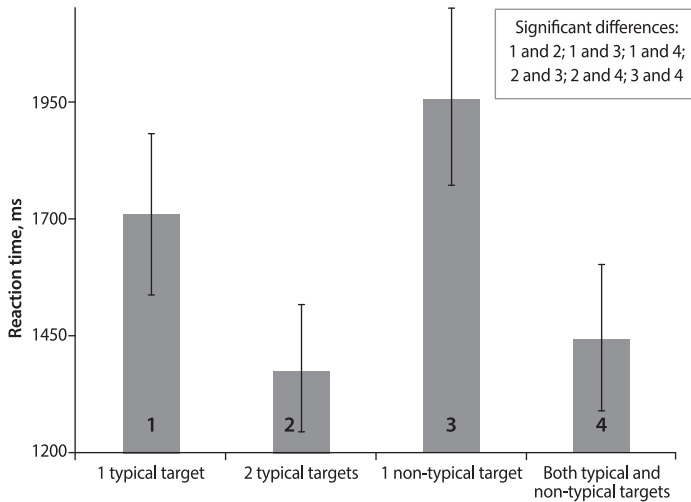


Figure 8. The results of reaction time (first click) analysis for Experiment 2
 Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of pairwise comparisons.

Reaction time (second click)

Repeated measures ANOVA revealed the significant impact of the condition factor: $F(1,27) = 47.033$; $p < .001$; $\eta_p^2 = 0.681$. Pairwise comparisons with Bonferroni-Holm adjustments revealed significant differences between the following conditions: one typical target and two typical targets ($p < .001$), one typical and both typical and non-typical targets in the same task ($p < .001$), two typical and one non-typical target ($p < .001$), two typical and both typical and non-typical targets in the same task ($p < .001$), and one non-typical target and both typical and non-typical targets in the same task ($p < .001$). The results are presented in Figure 9.

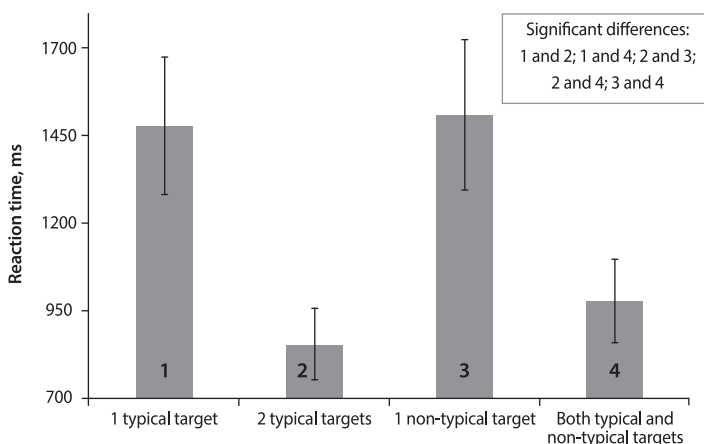


Figure 9. The results of reaction time (second click) analysis for Experiment 2
 Note. Error bars represent 95% confidence intervals. Statistical differences indicate the results of pairwise comparisons.

Discussion

There were no significant differences in accuracy between the baseline experimental condition with one non-typical target and the crucial experimental condition with both typical and non-typical targets in the same task. Therefore, no SSM errors were observed, as in Experiment 1. Interestingly, SSM errors were also not detected for tasks with only typical targets. This can be explained by the effect of high target prevalence (Hout et al., 2015). It is important to note that the targets and distractors belonged to different categories. Therefore, the target-distractor similarity was not large. This could be the major factor leading to the overall reduction of task difficulty, as it is easier to find targets when they are perceptually different from the distractors (Duncan & Humphreys, 1989). In this case, targets were also categorically different, which made the guidance of visual search even easier. As expected, the results for the reaction time showed that it took significantly less time to identify typical targets in comparison to non-typical ones. This further supports the assumption that typicality plays a significant role in the effectiveness of visual search, as typical targets have better representations in working memory. This effect was also observed for non-typical targets that were found after typical ones. In compliance with the categorical perception hypothesis, the search becomes guided by the specific characteristics of the initially found target (e.g., Kristjánsson & Campana, 2010). Finally, the participants were significantly quicker to find the first target in the case of two in-trial present targets, as well as to report the second present target in comparison to reporting its absence. These findings were the same as in Experiment 1.

General discussion

Two visual search paradigms provided different ways of studying the same phenomenon. Incidental findings are defined as targets that do not relate to the primary search goals but are of potential interest to the searcher. The criterion for distinction between incidental findings and the similar effect of subsequent search misses (SSM) was the difference in accuracy between single- and dual-target tasks. Incidental findings can be identified only in the absence of such statistical differences. The main finding of Experiment 1 was the difference between categorical and specific visual search for targets. Categorically defined targets were easier to miss. As initially suggested by Wolfe and colleagues (Wolfe et al., 2017), incidental findings are most closely associated with such targets. Targets that have clear representations are typically found first, so less attentional resources are left for potentially remaining ones. Significantly, there was no decrease in accuracy for finding the second target after the first one. This distinguishes this effect from previously described SSM. Hence, accuracy in this case does not simply depend on the order in which the targets are identified, but rather on the search characteristics themselves. Similarly, no SSM were detected in Experiment 2, although the standard SSM experimental paradigm was used. Notably, though, the search was categorical in this experiment, and the targets differed in typicality. It was shown that the search for typical targets was significantly more accurate, alike to the

search for specific targets in Experiment 1. Taking both findings into consideration, it seems that the major factor is the prevalence effect of the targets. In both experiments, high-prevalence items were found much more efficiently than low-prevalence targets. In both experimental and real-life situations, targets that have the most priority are more likely to be found. This might be one of the most important features of the incidental findings phenomena.

It is significant to note that the results in both experiments ultimately illustrated very similar tendencies, although target-distractor similarity was differed significantly. While in Experiment 2, targets belonged to a completely separate category in relation to distractors, items in Experiment 1 all constituted one category. It would seem, therefore, that the search in the second experiment would be far easier for the participants. However, this did not seem to play such a significant role. Firstly, the hybrid search paradigm in the first experiment is generally harder, since it involves searching from memory. Secondly, irrespective of task difficulty, the findings represented no significant decline in accuracy for finding the second target. Finally, despite the seeming target-distractor similarity distinction in the two experiments, the crucial point might be not categorical, but based on perceptual differences of the stimuli. Even though all items belonged to the same category of food in Experiment 1, they were very different perceptually. These characteristics could potentially be more important, since in real life the search task demands finding items with specific visual features. Such features may prevail over unclear categorical representations and, thus, guide the search for targets. However, there are data suggesting the overall categorical superiority in relation to perceptual phenomena in visual search (e.g., Biggs et. al., 2015). At the same time, this point needs further clarification, particularly with regards to incidental findings. Hence, a potential continuation of this study might be to vary the target-distractor similarity within one experiment in order to reveal the role of this particular factor.

Overall, the study revealed that incidental findings differ from SSM. This effect relates specifically to categorical visual search — a search defined by the category of objects. Additionally, prevalence of the targets plays an important role, since incidental findings relate to less common and less represented targets. These factors should be addressed by the optimal paradigm for studying incidental findings as a separate visual search phenomenon. Regarding the factor of target-distractor similarity, incidental findings seem to be perceptually different from the main targets of search. However, the specific role of perceptual differences should be clarified in further research.

Conclusion

The purpose of this research was to study incidental findings in two separate experimental paradigms of visual search in order to reveal the primary factors specific to this phenomenon. The mixed hybrid search model and subsequent search misses (SSM) paradigm were used in two behavioral visual search experiments. The results revealed similar patterns in terms of participants' accuracy and reaction time. The

most significant factor for incidental findings was concluded to be the target prevalence effect. Targets that were more typically found seemed to create a certain bias towards similar items. However, rare targets that were more categorically distant from the initially identified target were more likely to be missed by the searcher. These results seem to be specific to incidental findings as opposed to SSM. Overall, the findings provide additional information about incidental findings as a separate visual search phenomenon.

Limitations

Both experiments were conducted online due to the COVID-19 pandemic situation, which means that quite a few parameters of the experimental study could not be controlled. Those include the technical characteristics of the computers that varied from one participant to another, the conditions of noise and lighting, and others. Moreover, the display size was significantly reduced, since the majority of the participants had laptops with rather small screens. This implied a higher density of the stimuli on screen. In the case of visual search experiments, this might be an issue as it tends to make the task easier for the participants. However, since both experiments were very similar in technical aspects (e.g., stimuli size, grid parameters), it was possible to adequately compare the results. Moreover, since the critical parameter in both experiments was accuracy, rather than reaction time, and the results illustrated typical behavioral patterns for the described effects, the differences in technical parameters do not seem to have drastically influenced the data. As well as this, it has been argued that web-based experiments are appropriate for collecting such parameters as reaction time, even though they traditionally seem to be quite estimation-sensitive (Chetverikov & Upravitelev, 2015).

Ethics Statement

All experiments reported in this manuscript were carried out in accordance with the Declaration of Helsinki and the existing Russian and international regulations concerning ethics in research. All participants provided written informed consent. We did not seek approval by an institutional review board for the experiments because it is not required for a study of the type reported in this manuscript.

Author Contributions

O.R.: originator of the concept, experimental planning, programming, data collection, data analysis, discussion of the results, manuscript preparation.

E.G.: originator of the concept, experimental planning, discussion of the results, manuscript preparation.

Conflict of Interest

The authors declare no conflict of interest.

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PSYCHOGENETICS

Recognition of Emotional and Neutral Visual Scenes in Carriers of the MAOA, COMT, DRD4, and 5HT2A Gene Polymorphisms

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Background. It is known that some genes regulate neurochemical metabolism, and their polymorphisms affect cognitive performance, including the ability to categorize emotionally significant information.

Objective. The aim of our study was to analyze the recognition of emotional and neutral visual scenes in carriers of different polymorphic variants of the MAOA, COMT, DRD4, and 5HT2A genes.

Design. The study sample consisted of 87 university students (Caucasians, women 63%, average age 20.4±2.6 years). The genotypes of the COMT, 5HT2A, and DRD4 genes were determined by polymerase chain reaction. Agarose gel electrophoresis was used to determine the number of tandem repeats of the MAOA gene. Three hundred sixty (360) photographic images of scenes of different emotional valence (positive, negative, and neutral — 120 images for each category) were used as stimuli. These images were classified by expert assessments. The images were presented in a random sequence. The exposure time was 700 ms. The research participants were asked to determine the emotional valence of each scene.

Results. We found that only the COMT gene genotype affected the recognition of emotional and neutral visual scenes. Carriers of the COMT Val/Val genotype, which causes dopamine to stay in the synaptic space for a shorter time, are better in recognizing and demonstrate higher sensitivity to the emotional content of scenes. Carriers of the Val/Met genotype demonstrated the worst ability to differentiate the emotional valence of visual scenes.

Conclusion. This study has shown that the length of stay of monoamines in the synaptic space regulated by the COMT gene affects the recognition of emotional visual information.

Keywords: Visual scene recognition, MAOA, COMT, DRD4, and 5HT2A genes

Introduction

Visual scene recognition is one of the fundamental operations people use to build an internal model of the world. One of the important semantic characteristics of visual scenes is their emotional valence (You & Li, 2016). The individual features of recognition of emotional scenes affect cognitive processes and are an important personal psychological characteristic (Bush et al., 2015). When a person's ability to recognize emotions is impaired (a condition called alexithymia), his/her ability to perceive negative visual scenes worsens (Wang et al., 2021).

In a study using EEG and fMRI simultaneously while the subjects were viewing visual scenes of pleasant, unpleasant, and neutral content, it was found that affective scenes, depending on their valence, evoked specific neural representations (Bo et al., 2021). The influence of the scene's emotionality on the neuronal response was also shown using evoked potentials (Tebbe et al., 2021; Trujillo et al., 2021). There was also evidence of valence-modulated susceptibility to the image distortions when observing the scenes (Stevenson et al., 2020).

Emotional scene recognition has both universal patterns and individual characteristics, which are determined by the person's genotype. In a study on 233 pairs of twins at the age of 11 years, it was discovered that the children's gaze trajectory during the perception of visual scenes was significantly influenced by genetic factors (Kennedy et al., 2015).

Prior study has demonstrated that recognizing emotionally significant information is greatly influenced by the activity of selective serotonin and noradrenaline reuptake inhibitors (Hamrer, 2012). The organization of these synaptic mechanisms is known to be largely genetically predetermined. In particular, the deletion of the ADRA2B gene that encodes the $\alpha 2b$ -adrenergic receptor has been shown to increase reactivity to emotional stimuli (Li, 2013) and affect emotional memory (Maheu et al., 2004; de Quervain et al., 2007;). However, the more obvious candidates for genes whose polymorphisms affect the perception of emotionally significant information are those of the dopaminergic (DRD4, COMT) and serotonergic (MAOA, HTR2A) systems (Ermakov et al., 2017; Vorobyeva et al., 2020).

The monoamine oxidase A (MAOA) gene is located on the X chromosome and regulates the duration of the dopamine, serotonin, and norepinephrine stay in the synaptic cleft. Carriers of the MAOA gene alleles with two, three, and five repeats in the promoter region have a low-active form of the gene and enzyme that catabolizes neurotransmitters, which leads to a longer stay of dopamine, norepinephrine, and serotonin in the synaptic cleft; carriers of alleles with 3.5, 4, and 3.5/4 repeats have a highly active monoamine oxidase A, which leads to a shorter stay of monoamines in the synaptic cleft (Brady, 2012). Low- and high-activity genotypes for the MAOA-uVNTR are associated with the functioning of the mesolimbic subsystem of the dopamine system, cingulate gyrus, amygdala, nucleus accumbens, hippocampus, and prefrontal cortex. There is also evidence that MAOA-uVNTR gene polymorphism is indirectly associated with the personal traits and processing of stimuli of various valences (Barnett et al., 2011; Williams et al., 2009).

The COMT gene is located on chromosome 22. It encodes the production of the Catechol-O-methyltransferase enzyme, which plays an important role in the breakdown of catecholamines (dopamine, adrenaline, and norepinephrine). The single nucleotide polymorphism rs4860 (Val158Met) can be represented by the G allele encoding the amino acid valine, or the low active A allele encoding the amino acid methionine. Carriers of the A (Met) allele have an increased length of stay of the dopamine in the prefrontal cortex; they also have a higher pain threshold, lower stress resistance, and more efficient cognitive function. Carriers of the G (Val) allele, on the other hand, have decreased length of stay of catecholamines in the synaptic space due to the high activity of the COMT enzyme, as well as an increased sensitivity to pain, higher stress resistance, and a moderate decline in the prefrontal function (Chen et al., 2004; Lotta et al., 1995).

It has been shown that the Val158Met single nucleotide polymorphism of the COMT gene affects individual differences in attention, while insufficient or excessive catecholaminergic activity can each have equally undesirable consequences for attention span (Shalev et al., 2019). Serrano et al. have described the psychological characteristics (mainly related to the stress response) of carriers of different COMT genotypes (Serrano et al., 2019). It has been shown in a Russian sample that the presence of the Val/Val genotype in the COMT gene is associated with a high risk of depression (Gafarov et al., 2021).

The DRD4 gene is located on chromosome 11. It encodes the D4 subtype of the dopamine receptor. The dopamine D4 receptor is involved in transmitting neural signals to the brain's mesolimbic system, which regulates emotions and complex behavior (Wang et al., 2017). The association of single nucleotide polymorphisms (SNPs) of the DRD4 gene with the functioning of working memory and perception was shown in a study on a South American family-based sample (Cervantes-Henriquez et al., 2021).

The HTR2A gene that encodes the 5-HT_{2A} receptor (5-hydroxytryptamine (serotonin) receptor 2A) is localized on the 13q14-q21 chromosome. This gene is involved in the serotonin system and is often of interest to scientists who have been searching for genetic associations of various psychopathologies such as schizophrenia (González-Castro et al., 2013; Mistry et al., 2011; Yan et al., 2021), but the features of its relationship with emotional and cognitive processes in healthy people have not been sufficiently studied.

Based on the above, we assumed that the described genes could be considered factors associated with human emotional reactions. However, in previous years, the relationship of these and a number of other genes with the perception of emotional scenes was studied mainly in connection with the development of pathological processes: affective disorders (Cipriani et al., 2009) or Alzheimer's disease (Cavill, 2017).

The aim of our study was to study the features of recognition of emotionally colored and neutral visual scenes in healthy carriers of the different genotypes of the MAOA, COMT, DRD4, and 5HT_{2A} (HTR2A) genes.

Methods

Participants

Our study involved 87 university students (Caucasians, women 63%) ages 19 to 25 years (average age 20.4 ± 2.6). All participants had normal or normalized vision, and no history of neurological or psychiatric illness. At the initial stage of the process, all participants were informed about the research objectives and procedures, and gave written consent for voluntary participation.

Procedure

Stimuli

Three hundred sixty (360) photographic images of scenes of different emotional valence (positive, negative, and neutral — 120 images for each category) were used as stimuli. The images were obtained from open sources and classified as positive, negative, or neutral by independent experts. Selected scenes are freely available now as a dataset at <https://osf.io/eagyc/>. We aligned the images by average brightness and RMS contrast. The image width was 22.5, and the height was 18 angular degrees.

Procedure

Participants were positioned in a head-chin rest at 60 cm distance from the center of the screen. The images of the scenes were presented in a random sequence. The exposure time was 700 ms. Prior to the experiment, all subjects underwent brief training that helped familiarize them with the procedure and ensured that they understood the task correctly. The training images did not appear in the main experiment. The duration of the main experiment did not exceed 25 minutes, and the experimental task was not tiring. The subjects were tasked to recognize the emotional valence of each scene shown and report their decision by clicking one of the three response options (positive, negative, or neutral). The demonstration of the next stimulus was launched 100 ms after the participant's response.

Genotyping

Genetic analysis was carried out in the “Biological Solutions and Technologies” laboratory (Russian Federation, Moscow). DNA was extracted from buccal cells. To determine the genotypes of the COMT, 5HT2A, and DRD4 genes, the genotyping procedure was carried out by using the real-time PCR method (Real-Time CFX96 Touch cycler, Bio-Rad, USA). An agarose gel electrophoresis procedure was used to determine the number of MAOA tandem repeats.

Statistical data analysis

The number of correct recognitions and “false alarms” for each type of image was determined. Next, the sensitivity index (d') was calculated using the PAL_SDT_1AFC_PHFtoDP function from the Palamedes toolbox (Prins & Kingdom, 2018). The probability of correctly identifying an emotion (hits) was considered as p_H , and the probability of false alarms (fails) was considered as p_F . For example, for a neutral im-

age, pH is equal to the ratio of the number of “neutral” responses to stimuli expressing neutral scenes, to their total number; pF is the ratio of the number of “neutral” responses to positive and negative scenes, to the total number of such stimuli. The calculation comes down to subtracting the normalized pF from the pH for each type of stimulus (Prins & Kingdom, 2018). The overall (general) sensitivity index was calculated as the average d’ for the three types of scenes.

For intergroup comparisons of index sensitivity in carriers of different genotypes of the studied genes, we used the Kruskal-Wallis Test. As a post-hoc procedure, Dunn’s test with Holm’s correction for multiple comparisons was used. Statistical data processing was carried out using an open-sourced JASP Computer software (Version 0.16, 2021).

Results

We have analyzed the following DNA sections: the Val158Met polymorphic locus of the COMT gene (472A>G, rs4680), tandem repeats (VNTR) in the promoter region of the MAOA gene, the HTR2A gene for the 5HT2A serotonin receptor (T102C rs6313, Tr3) and the DRD4 gene for D4 subtype dopamine receptor (\-C-521T, rs1800955).

The following genotypes were found in our sample for the MAOA gene: highly active H genotypes, including 4 tandem repeats (VNTR) of the promoter region of the gene; low-active L genotypes with 5 tandem repeats (VNTR) of the promoter region of the gene; and heterozygous medium active genotypes M, including alleles with 5 and 4 tandem repeats (VNTR) of the promoter region of the gene. The distribution of genotype frequencies of the studied genes is presented in *Table 1* and corresponds to the Hardy-Weinberg equilibrium.).

Table 1

Frequency distribution of MAOA, COMT, DRD4, and 5HT2A gene genotypes in the study sample

Gene polymorphisms	Genotypes and their distribution in the sample (in percents)		
Gene MAOA (VNTR)	H genotypes (4 repeats of the promoter region of the gene) 22%	L genotypes (5 repeats of the promoter region of the gene) 50%	M genotypes (5/4 repeats of the promoter region of the gene) 28%
Gene COMT (Val158Met, rs4680)	Val/Val 16%	Met/Met 29%	Val/Met 55%
Gene DRD4 (C-521T, rs1800955)	T/T 39%	C/T 50%	C/C 11%
Gene 5HT2A (T102C rs6313, Tr3)	C/C 34%	C/T 50%	T/T 16%

We proceeded to the main part of the study after processing the results of the genetic analysis. *Table 2* shows the differences in the accuracy of recognition of the emotional content of visual scenes in carriers of different genotypes of the MAOA, COMT, DRD4, and 5HT2A genes.

Table 2

The results of the Kruskal-Wallis Test for comparing sensitivity to the emotional valence of visual scenes in carriers of different genotypes of the MAOA, COMT, DRD4, and 5HT2A genes (- $p < 0,05$)*

Genes and genotypes		General sensitivity index	Visual scenes		
			Negative	Neutral	Positive
Mean ranks for COMT (Val158Met, rs4680)	Val/Met	38.52	40.29	37.37	39.75
	Met/Met	45.80	43.98	48.22	44.72
	Val/Val	60.91	57.00	60.64	57.77
Kruskal-Wallis test	H	7.548	4.051	9.088	4.782
	p	0.023*	0.132	0.011*	0.092
Mean ranks for 5HT2A (T102C rs6313, Tr3)	C/T	46.67	48.01	44.51	43.42
	C/C	41.34	38.79	42.86	44.90
	T/T	36.83	37.96	41.25	40.42
Kruskal-Wallis test	H	1.795	3.091	0.190	0.274
	p	0.408	0.213	0.909	0.872
Mean ranks for DRD4 (C-521T, rs1800955)	C/T	40.38	41.28	41.01	42.68
	T/T	45.06	43.81	46.89	46.56
	C/C	48.27	48.60	42.73	39.10
Kruskal-Wallis test	H	1.279	0.939	0.991	0.989
	p	0.528	0.625	0,609	0.610
Mean ranks for MAOA (VNTR)	H	37.78	36.13	38.80	37.07
	L	44.83	43.38	45.87	47.37
	M	45.14	49.79	42.00	40.98
Kruskal-Wallis test	H	1.411	3.379	1.252	2.754
	p	0.494	0.185	0.534	0.252

Note. Asterisks indicate statistically significant results.

The Kruskal-Wallis Test showed significant differences in sensitivity to the neutral scenes in carriers of different COMT gene genotypes ($H = 9.1$, $df = 2$, $p = 0.01$). The Dunn's Post Hoc Comparisons showed that carriers of the heterozygous genotype were less successful at recognizing neutral images (*Figure 1*). At the same time, the recognition accuracy of neutral scenes in Val/Met was statistically significantly lower than in Val/Val (VM — VV, $z = -2.798$, $p_{holm} = 0.008$).

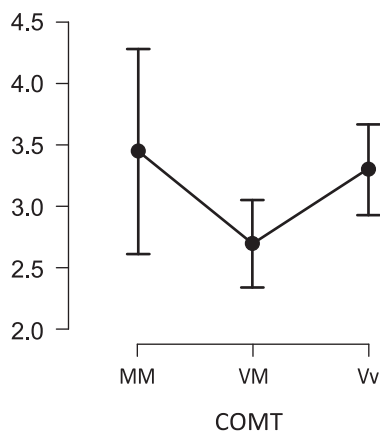


Figure 1. Accuracy of recognition of neutral scenes by carriers of different genotypes of the COMT gene.

Note. Y-axis — sensitivity (d'). The abscissa shows genotypes for the COMT gene: MM (Met/Met), VM (Val/Met), and VV (Val/Val).

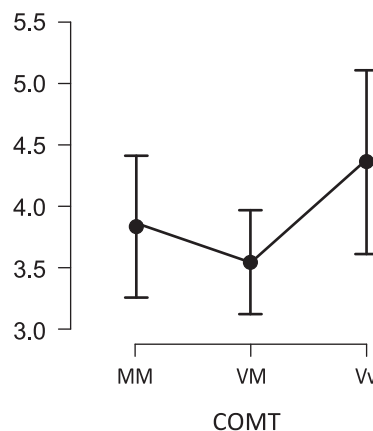


Figure 2. Accuracy of recognition of the emotional valence of scenes by carriers of different genotypes of the COMT gene.

Note. Y-axis — sensitivity (d'). The abscissa shows genotypes for the COMT gene: MM (Met/Met), VM (Val/Met), and VV (Val/Val).

The Kruskal-Wallis Test showed significant differences in sensitivity to the emotional valence of scenes by carriers of different COMT gene genotypes ($H = 7.458$, $df = 2$, $p = 0.02$). Dunn's Post Hoc Comparisons showed that carriers of the Val/Val genotype were generally better than others in recognizing the emotional valence of stimuli (*Figure 2*). At the same time, the accuracy of recognition of the emotional valence of scenes in Val/Val was statistically significantly higher than in Val/Met (VM – VV, $z = -2.692$, $p_{\text{holm}} = 0.011$).

Discussion

Our results show that of the four genes studied, only COMT polymorphism was associated with the perception of emotional visual scenes. Moreover, statistically significant differences were obtained only when comparing the Val/Val and Val/Met groups. It turned out, in particular, that carriers of the Val/Met genotype for the COMT gene were worse in recognizing neutral and emotional scenes than carriers of the Val/Val genotype.

Our finding is consistent with the results of a previous meta-analysis, which showed an association of the Met allele with reduced emotional processing efficiency (Mier et al., 2010). A more recent study discovered that Val/Met heterozygotes retain fewer details of past emotional events than carriers of other genotypes (Tougu et al., 2021). What can explain it? It is possible that the length of stay of monoamines in the synaptic space, which is regulated by the COMT gene, is causing those differences. A number of authors have posited that carriers of the Val/Met COMT genotype have

a longer stay of monoamines in the synaptic space compared to carriers of the Val/Val genotype (Chen et al., 2004; Lotta et al., 1995). Our results indicate that a longer stay of monoamines in the synaptic space is a less preferable factor in tasks for recognizing the emotional valence of visual scenes.

The decline in scene categorization performance in Val/Met carriers may also be associated with increased levels of dopamine in the prefrontal cortex. Analysis of the data presented by Zareyan et al. (2021) indicates that the presence of the Met allele at codon 158 results in higher levels of dopamine in this cortical region than the presence of the Val allele does. It is possible that successful recognition of neutral and emotional visual scenes does not require an increased amount of dopamine in the prefrontal cortex. On the contrary, its increased levels worsen the performance.

Thus, the greater sensitivity of carriers of the Val/Val COMT genotype to the emotional content of visual scenes may be associated with a faster breakdown of monoamines (including dopamine) in the synaptic space, as well as with a relatively low level of dopamine in the prefrontal cortex.

Conclusion

This study, carried out on healthy subjects, made it possible to obtain new data concerning the mechanisms of recognition of emotional visual information and the influence of genes involved in the regulation of neurochemical metabolism on these processes. Our results specify the role of the COMT gene polymorphism in the perception of emotionally significant signals and allow us to draw the following conclusions:

1. Among the examined genes (MAOA, COMT, DRD4, and 5HT2A), only the COMT gene genotype affects the recognition of emotional and neutral visual scenes.
2. Carriers of the COMT Val/Val genotype, which causes dopamine to stay in the synaptic cleft for a shorter time, recognize neutral scenes better and demonstrate a higher sensitivity to the emotional content of scenes.
3. Carriers of the COMT Val/Met genotype are less successful at recognizing the emotional valence of visual scenes.

Limitations

The limitation of our study is related to the unequal number of persons per genotype in the sample. However, such unevenness of genotypes occurs naturally in the human population.

Ethics Statement

All participants were informed about the research objectives and procedures and gave written consent for participation. The study was approved by the local ethics committee and conducted in accordance with the ethical standards of The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Author Contributions

P.E. conceived of the idea and analyzed the results. E.V. conducted a theoretical analysis of the problem and analyzed the results. E.D. managed the data collection, translated, reviewed, and edited the final version of the manuscript. V.B. determined and verified the research methods, and reviewed and edited the final version of the manuscript. E.K. compiled a database of stimuli and participated in the analysis of the results obtained. D.A. compiled a database of stimuli and participated in the data collection. 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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EDUCATIONAL PSYCHOLOGY

Conscious Self-regulation, Motivational Factors, and Personality Traits as Predictors of Students' Academic Performance: A Linear Empirical Model

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Background. The theoretical basis of this study was the resource approach (Morosanova 2014, 2017), in which the conscious self-regulation of learning activity is understood as a meta-resource for students, allowing them to consciously and independently set learning goals and manage their achievement. This approach made it possible to create models of direct and mediate contributions of self-regulation and school engagement not only to academic performance, but also to other motivational and personal competencies.

Objective. Our study aimed to investigate the impact of conscious self-regulation, school engagement, motivation, and personality on academic achievement, while taking into account the effects of mediation.

Design. A quantitative research design was applied, using data collected from more than 1524 students from the 5th to 11th grades in Russian schools and applying Structural Equation Modelling (SEM).

Results. The results allowed us to construct a statistical model of predictors of students' academic achievement. The model was verified on the total sample, as well as samples differing in gender and age. The results show that conscious self-regulation is central to non-cognitive predictors of academic achievement. For the first time, a study has revealed and described the reciprocal relationship between self-regulation, academic motivation, school engagement, and academic performance. The resulting model demonstrates that behavioral and cognitive engagement make a significant contribution to academic performance, while emotional and social engagement do not find significant links with it, although they determine other areas of school life.

Keywords:
Conscious self-regulation (SR), engagement, motivation, personality, academic achievement

Conclusion. Our paper investigates the nature and strength of the effects of major non-cognitive predictors of academic achievement. The study results substantiated the resource role of conscious self-regulation not only for students' academic performance, but also for their academic motivation, school engagement, and attitude toward learning. The predictor model of academic achievement we developed will provide a foundation for combining existing heterogeneous concepts into a single integrated model and clarify the contradictions between them.

Introduction

Conscious self-regulation, school engagement, and academic motivation are considered the most significant factors advancing academic performance (Morosanova, Fomina, & Bondarenko, 2015; Gordeeva, Sychev, Gizhitsky, & Gavrichenkova, 2017; Steinmayr, Weidinger, Schwinger, & Spinath, 2019). The literature suggests that determinants of academic achievement range from personality characteristics (traits, intelligence, engagement, motivation, experience, and attitudes) to school factors (peer and teacher support, autonomy, and available resources) (Petrides, Chamorro-Premuzic, Frederickson, & Furnham, 2005). While priority has previously been given to cognitive characteristics such as intelligence and executive functions (EF) (Deary, Strand, Smith, & Fernandes, 2007; Zelazo, Blair, & Willoughby, 2016), now researchers are increasingly turning to non-cognitive predictors (e.g., Richardson, Abraham, & Bond, 2012).

The evidence that non-cognitive predictors (in particular, self-regulation, motivation, engagement, and emotional attitude toward learning) directly contribute to academic performance has been reliably replicated across samples that differ in age, gender, type of school activity, cultural differences, and so on. However, the specifics of the relationship between the non-cognitive predictors and their joint impact on academic success have not been studied sufficiently, although researchers emphasize the relevance of integrative models of non-cognitive predictors of student academic achievement (for example, Mega, Ronconi, & De Beni, 2014). Constructing comprehensive models allows researchers to take into account the versatile relationship that arises between the variables. So, the present study had as its objective to build structural models of the relationships between conscious self-regulation, motivational factors, and personality traits, and academic success, as well as to assess the moderating and mediating effects of their joint contribution.

Self-Regulated Learning as a Predictor of Academic Achievement

Self-regulated learning (SRL) has been one of the main topics in educational psychology research for several decades. In the general field of scientific research, methods for studying self-regulation have been developed in the frameworks of different approaches, and naturally complement each other. In its most general form, SRL is defined as a complex phenomenon ensuring the maintenance of the cognitive and motivational processes that contribute to the development of conscious behavior to

achieve learning goals (Pandero, 2017). The present study is based on the original approach, which considered conscious self-regulation a reflexive means of setting goals (including educational ones) and managing their achievement. According to this approach, the multicomponent structure of self-regulation determines its general development, which, in turn, serves as a meta-resource for students; it predicts their academic success and also contributes to school engagement and psychological well-being (Morosanova, 2021).

The results of our research are in line with the global trend, according to which the study of self-regulation makes it possible to explain individual differences in students' academic achievements, thereby proving the possibilities of self-regulation in advancing academic performance (e.g., Dent & Koenka, 2016, etc.). High SRL is associated with better academic performance, with high-achieving students using its defining strategies more frequently and effectively than their lower-achieving peers (Zimmerman, 2002).

School Engagement as a Predictor of Academic Achievement

During the last 10 years, researchers have shown great interest in the “school engagement” construct. Following the competent approaches, we consider school engagement to be the sustainable, directed, active participation of students in educational activities and in school life in general, manifested through their behavior, and cognitive and emotional involvement, as well as features of their social interaction in the academic environment (Wang, Degol, & Henry, 2019). It has been shown that students with a high level of school engagement are characterized by having more effective learning strategies, coping more successfully with learning difficulties, and being more likely to achieve their educational goals (Fredricks, Filsecker, & Lawson, 2016). Students who are more engaged in school have been shown to have higher academic performance (Chase et al., 2014).

School engagement is a multifaceted concept. Researchers have identified several components, such as behavioral, emotional, cognitive, social, etc. (Fredricks, Blumenfeld, & Paris, 2004; Wang, Shim, & Wolters, 2017). The effect of student engagement on academic performance varies depending on the components of engagement that are examined. According to some studies, highly significant relationships are found between academic achievement and a student's general level of school engagement (Fomina et al., 2020), as well as its particular components: cognitive and behavioral engagement (Fredricks et al., 2004).

Motivation as a Predictor of Academic Achievement

Different motivational theories and constructs have been put forward to try to understand how and why students are motivated for academic achievement (Pintrich, 2003). The problem of learning motivation's impact on academic success is widely represented in studies (Olivier et al., 2019; Schnitzler, Holzberger, & Seidel, 2021). According to meta-analyses, intrinsic academic motivation is the strongest predictor of academic achievement: students with intrinsic motivation have significantly high-

er levels of academic achievement and engagement than those with predominantly extrinsic motivation (Richardson et al., 2012).

In this article, we focus on the motivational constructs that appear to be mainly associated with SRL and play an essential role in supporting academic performance: cognitive motivation, attitude towards learning, and achievement motivation. Our study used the Ryan and Deci approach (self-determination theory, or SDT), which identifies the mechanisms of the functioning of extrinsic and intrinsic motivation (Ryan & Deci, 2012). Intrinsic motivation is associated with engagement in the educational process and higher achievement. It occurs when a person does something simply because this activity gives him pleasure; external reinforcement is not needed. At the same time, extrinsic and intrinsic motivation do not exist separately from each other; there are mutual transitions between them.

Personality as a Predictor of Academic Achievement

The personality traits included in the Big Five are most often considered to be intrapersonal predictors of academic success. To date, a lot of data has been accumulated in this domain, which has been systematized and summarized in the framework of meta-analyses (e.g., O'Connor & Paunonen, 2007).

Among the Big Five, Conscientiousness has the closest relationship with academic performance (Dumfart & Neubauer, 2016). This is the only trait whose impact on academic performance is comparable to (and according to some data, even exceeds) that of cognitive abilities (Richardson et al., 2012). The research on Extraversion's effect on academic performance shows ambiguous results. The relationship between Neuroticism and academic achievement is usually negative. Openness to Experience has a strong relationship with intelligence and is therefore positively associated with learning success. Most studies show no significant relationship between Agreeableness and academic performance (according to the meta-analysis of O'Connor & Paunonen, 2007). It has been demonstrated that there are regulatory bases for the personality dispositions, while conscious self-regulation has stable links with Conscientiousness, which, with a high development of SR, ensures high academic performance and compensates for the multidirectional influence of Extraversion and Neuroticism (Morosanova, 2021).

All the phenomena discussed above have been well studied in terms of their impact on academic achievement, but their mutual influence on each other has not been adequately considered. This creates the need for developing structural models and verifying them empirically.

Essentially, the current study aims to provide the answers to the following questions:

- RQ 1: What is the nature of the relationship between conscious self-regulation, school engagement, motivation, and personality traits as predictors of students' academic achievement?
- RQ 2: What is the specificity of these predictors in determining students' academic achievement?

In this regard, the following hypotheses were tested:

Hypothesis H1: There is a significant relationship between self-regulation, academic motivation, and school engagement. It is expected that this relationship is reciprocal in nature.

As shown above, there are some specifics in the joint influence of self-regulation, academic motivation, school engagement, and attitude toward learning on academic performance. We designed another group of hypotheses to uncover this specificity.

Hypothesis H2a: Personality traits are expected to show a positive linear relationship with school engagement and self-regulation, as well as a predictive effect for academic achievement;

Hypothesis H2b: School engagement is expected to mediate the relationship between self-regulation and academic achievement;

Hypothesis H2c: A student's emotional-motivational attitude toward learning is expected to positively correlate with school engagement and positively contribute to academic achievement.

Schematically, these hypotheses are presented in *Figure 1*.

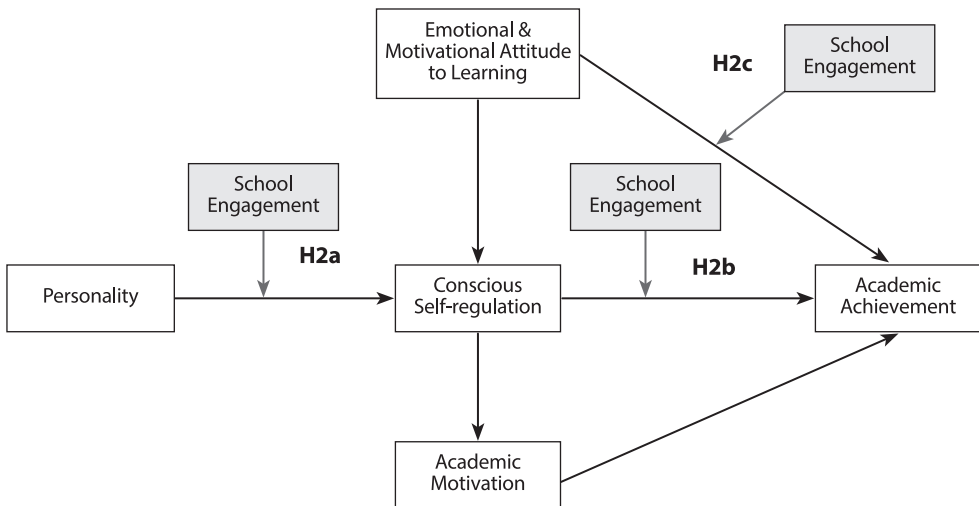


Figure 1. Theoretical framework (mediating effects of school engagement)

Methods

Participants

To test the proposed hypotheses and provide answers to the research questions, the current study adopted a quantitative research design; data was collected in surveys which were conducted with the help of self-administered questionnaires. Respondents were students in the 5th to 11th grades (N = 1524) from Moscow and the Moscow region.

Procedure

Self-Regulated Learning

For assessment of the students' conscious self-regulation development the "Self-Regulation Profile of Learning Activity Questionnaire — SRPLAQ" was used (Morosanova & Bondarenko, 2017). It includes 67 statements describing typical situations of achieving educational goals. These generate 10 scales corresponding to the structural components of the conscious self-regulation:

1. Planning (e.g., "I often try to set a certain amount of time needed to complete the learning task");
2. Modeling (e.g., "Unexpected changes in the timetable throw me off my stride");
3. Programming (e.g., "When preparing for a test (exam), I usually think over the order of studying the material");
4. Results evaluation (e.g., "Even when I'm tired, I tend to study until I'm satisfied with the result");
5. Flexibility (e.g., "If I need to get prepared for a lesson, I can work even in an uncomfortable and unfamiliar situation");
6. Independence (e.g., "I use every opportunity to make reports in class");
7. Reliability (e.g., "I do not postpone preparing for the lessons even if I'm tired or feel sick");
8. Responsibility (e.g., "I do not give up preparing for the lessons even if I have to choose between studying and spending time with my peers");
9. Social desirability (e.g., "I always admit my mistakes"); and
10. The general level of self-regulation (total score for all scales).

The SRPLAQ was previously validated in a sample of 14 to 18-year-old students (N = 702). The validation study demonstrated that the coefficients of internal consistency of items for each scale ranged from 0.58 to 0.76, indicating an overall reasonable homogeneity of the items in each scale. The subscales were significantly correlated with each other ($r = 0.22-0.66$, $p < 0.001$). Each statement is rated on a 4-point scale (Yes — Probably Yes — Probably No — No). The responses are then reduced to only "yes" and "no," by counting "probably yes/probably no" as "yes/no" respectively. The "yes" responses are then added up (items are reversed if necessary), so that high scores (maximum 9 for each scale) denote high self-regulation.

Academic motivation

Participants completed the Scales of Academic Motivation in School-Age Children (Gordeeva et al., 2017). The Russian edition was developed on the basis of The Academic Motivation Scale (AMS-C), which has its theoretical foundation in self-determination theory and its sub-theory of intrinsic and extrinsic motivation. The questionnaire contains 32 statements, including three scales for assessing intrinsic learning motivation (cognitive motivation, achievement motivation, self-development motivation); four scales for assessing extrinsic motivation (external motivation (parents), external motivation (general), introjected motivation, self-respect

motivation); and amotivation. The responses for all statements were measured with a 5-point Likert scale ranging from 1 (“Strongly Disagree”) to 5 (“Strongly Agree”).

The attitudes toward learning in middle and high school were identified by means of the Spielberger’s “State-Trait Personality Inventory, STPI” as modified by Bondarenko (Bondarenko et al., 2018). We used three Spielberger’s subscales: anxiety, anger, and curiosity. The depression scale was replaced by the achievement motivation scale. The Russian edition of the inventory includes 40 statements generating four scales and is designed to diagnose a student’s emotional and motivational attitude toward learning. Responses for the variables are measured with a 5-point Likert scale ranging from 1 (“Strongly Disagree”) to 5 (“Strongly Agree”). It results in an overall score called the general level of attitude toward learning (AL).

School Engagement

School engagement has been assessed by means of the Multidimensional School Engagement Scale (Wang et al., 2019, Russian adaptation by Fomina & Morosanova, 2020). The questionnaire evaluates behavioral, cognitive, emotional, and social components of school engagement/disengagement. It includes eight scales and contains 37 statements, which are evaluated by subjects on a 5-point Likert scale, with answers ranging from 1 (“Not like me at all”) to 5 (“Very similar to me”). The scales have acceptable reliability (Cronbach’s alpha from 0.63 to 0.90). Confirmatory factor analysis confirmed the preservation of the original bifactorial structure of the questionnaire with the identification of two global factors of engagement and disengagement. In the context of the research objectives, an integral scale of school engagement was used.

Personality

We assessed personality traits by means of the Russian version of the “Big Five Questionnaire — Children (BFQ-C)” (Malykh, Tikhomirova, & Vasin, 2015). The questionnaire contains 62 statements. Items rated on a 5-point scale, with response options ranging from 1 (“Strongly Disagree”) to 5 (“Strongly Agree”), and measures five personality factors: Extraversion, Openness, Agreeableness, Neuroticism (or Emotional Stability as a positive pole), and Conscientiousness.

Academic achievement

The average score of annual grades in Russian language and Mathematics was used as an indicator of academic performance.

SPSS 26.0 (SPSS Inc.) was used to obtain descriptive statistics for the study variables and bivariate associations. We performed SEM in AMOS 23 to verify our hypotheses.

Results

The Pearson correlations, means, and σ coefficients of the variables under study are reported in *Table 1*.

Table 1
Descriptive Statistics and Inter-scale Correlations (N = 1524)

	M±σ	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Academic Achievement	4.06±0.7	1												
2 Self-regulation	27.80±8.9	.20	1											
3 Emotional Attitude to Learning	0.00±13.5	.24	.64	1										
4 Motivation	3.61±0.9	.25	.53	.61	1									
5 Extraversion	45.10±8.3	.10	.32	.46	.35	1								
6 Agreeableness	46.54±8.5	.13	.37	.50	.44	.63	1							
7 Conscientiousness	43.38±8.3	.17	.59	.60	.54	.54	.67	1						
8 Neuroticism	31.44±9.6	-.12	-.47	-.58	-.30	-.14	-.21	-.32	1					
9 Openness	45.95±7.8	.29	.50	.58	.57	.56	.58	.67	-.2	1				
10 Engagement (Overall score)	68.05±13.4	.18	.55	.64	.63	.54	.61	.63	-.3	.59	1			
11 Behaviour Engagement	13.66±3.4	.21	.49	.54	.55	.41	.47	.55	-.2	.56	.81	1		
12 Cognitive Engagement	18.17±4.2	.21	.56	.56	.55	.37	.46	.62	-.3	.52	.77	.60	1	
13 Emotional Engagement	18.09±4.3	.10	.38	.52	.56	.43	.49	.48	-.3	.43	.85	.57	.52	1
14 Social Engagement	18.13±4.5	.10	.38	.47	.41	.55	.57	.44	-.2	.45	.83	.56	.46	.65

Note. $p < 0.01$.

Path analysis was undertaken through AMOS, and the structural model was constructed to show the overall measures of main factors (Figure 2).

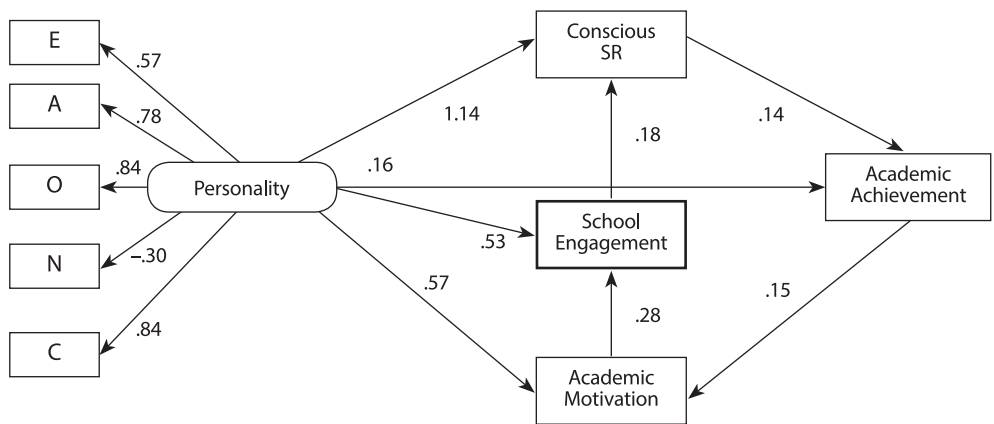


Figure 2. Path Diagram of the Proposed Model of the Present Study (Overall Scores). Model 1
 Note. E = Extraversion, O = Openness, A = Agreeableness, N = Neuroticism, C = Conscientiousness.

Model 1, made for the integral indicators, is shown in Figure 2. It has good statistical agreement with the theoretical model ($\chi^2/df = 2.57, p = .00, CFI = .99, GFI = .99, RMSEA = .037, PCLOSE = .94$). It demonstrated that SR makes a direct significant contribution to academic achievement. In addition, the positive impact of SR on academic achievement was enhanced by engagement and academic motivation. The contribution of academic motivation to academic achievement was mediative in nature, through school engagement and self-regulation. Finally, the achieved results (grades) supported and enhanced the adolescents' motivation to learn. In addition, all personality traits contributed positively to self-regulation, engagement, motivation, and academic achievement. Thus, Model 1 has confirmed the H1 hypothesis that there is a significant relationship between self-regulation, academic motivation, and school engagement. It also showed that this relationship is reciprocal in nature.

The second model (Model 2) shows particular components of school engagement. In addition, it is complemented with an indicator of the student's emotional and motivational attitude toward learning in order to identify the role of emotional engagement in the determination of academic performance.

The path diagram for the whole sample, along with standardized path coefficients of direct effects, is presented in Figure 3. It shows a very good fit to the data ($\chi^2/df = 1.90, p = .00, CFI = .99, GFI = .99, RMSEA = .029, PCLOSE = .99$). Our expectation that personality traits would show a positive linear relationship with school engagement and self-regulation, as well as a predictive effect on academic achievement, was confirmed completely (Hypothesis H2a).

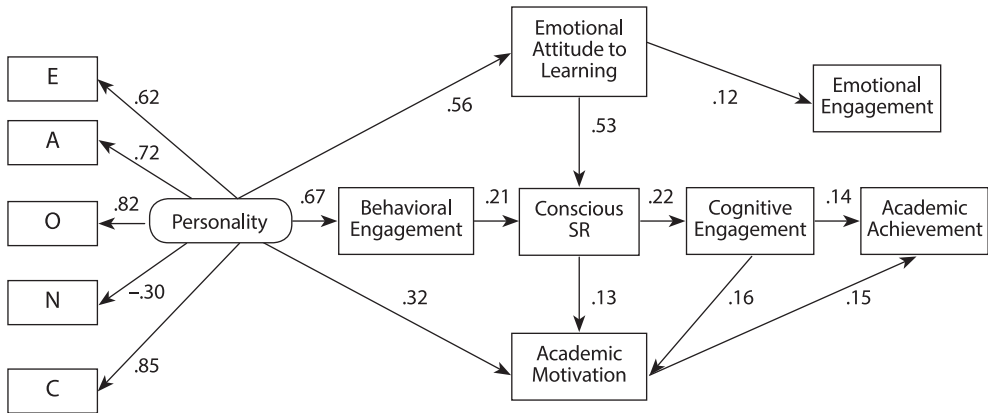


Figure 3. Path Diagram of the Proposed Model of the Present Study. Model 2.
 Note. E = Extraversion, O = Openness, A = Agreeableness, N = Neuroticism, C = Conscientiousness.

Model 2 demonstrates that SR's contribution to academic achievement is mediated by the cognitive engagement, which fully confirms the hypothesis of its mediator role in the relationship between self-regulation and academic achievement (Hypothesis H2b). Thus, conscious self-regulation, combining the influence of personality traits, the emotional and motivational attitude toward learning, and behavioral engagement, acts as a "stabilizing" resource for academic achievement, compensating

for negative intrapersonal and emotional influences. It supports cognitive motivation and is enhanced by cognitive engagement.

The assumption that a student’s emotional-motivational attitude toward learning positively correlates with school engagement and makes a positive contribution to academic achievement was only partially confirmed. Indeed, an emotional-motivational attitude toward learning makes a positive contribution to emotional engagement, but emotional engagement itself does not make a significant positive contribution to academic achievement.

Thus, the model has revealed that the construct of school engagement is not holistic. However, its positive impact is included in the contribution of each of its significant success factors. Detailed information on the path coefficients and significance levels for the considered achievement factors is given in *Table 2*.

Table 2
Path coefficients and significance level

Path	R ²	p value	Conclusion
Self-regulation → Academic motivation → School engagement → Academic achievement	0.27	0.000	H1 is supported
Personality → Behavior engagement → Self-regulation → Cognitive engagement → Academic achievement	0.32	0.000	H2a is supported
Self-regulation → Academic achievement (Cognitive engagement as mediator)	0.27	0.000	H2b is supported
Emotional Attitude to education → Academic Achievement (Emotional engagement as mediator)	0.24	0.000	H2c is partially supported

Modifications of the general model for boys and girls and for different classes

Verification of the model on samples of students of different ages and gender demonstrated its invariant character (See *Table 3*); its components and the relationships between them were preserved for the subjects from the 5th to the 10th grade. In the 9th and 11th grades, the scores of the fit indices slightly decreased due to the reduced contribution of cognitive engagement to academic performance. This is due to the students’ preparation for passing the Unified State Examination (at the ends of grades 9 and 11), when children have to repeat the material already studied.

Structural modeling allowed us to assess the contribution of conscious self-regulation to cognitive engagement (average $\beta = .20$). At the same time, cognitive engagement resulted in adding an average of 14% to the determination of academic achievement. In the 9th and 11th grades, due to the reason cited above, its contribution was reduced to 5%. Thus, the study results demonstrated the great importance of maintaining school engagement as a mediator that makes a significant contribution to academic performance in “quiet” periods of schooling.

Table 3*Correspondence indices of models made for groups of students differing in gender and age*

Model	N	χ^2 / df	P	GFI	CFI	RMSEA	PCLOSE
Model 1 (grade 5)	187	1.43	.057	.96	.99	.048	.540
Model 2 (grade 6)	103	1.06	.693	.95	.99	.000	.916
Model 3 (grade 7)	105	.92	.584	.96	1,00	.000	.856
Model 4 (grade 8)	265	1.13	.273	.97	.99	.023	.928
Model 5 (grade 9)	151	1.83	.008	.95	.99	.074	.122
Model 6 (grade 10)	237	1.28	.42	.98	.99	.034	.776
Model 7 (grade 11)	39	1.78	.83	.91	.92	.143	.014
Model _F (girls)	471	1.05	.76	.99	1.00	.011	.992
Model _M (boys)	615	1.4	.12	.99	.99	.026	.965

The structural models built separately for boys and girls, on the whole, did not detect gender specificity in the determination of academic performance by the regulatory, motivational, and personal predictors. However, in female samples, researchers have traditionally recorded higher values for the contribution of self-regulation to engagement and engagement to academic performance. Girls are more organized, manage their time better, and use metacognitive strategies (Ruffing et al., 2015), consistent with the fact that girls tend to perform better during adolescence. Also, for girls, the predictive value of intrinsic motivation is higher at all levels of education, while for boys, the effects of external regulation are stronger (Vecchione et al., 2014). Boys are more likely than girls to demonstrate their indifference and ostentatious disregard for school norms and rules, while girls are more likely to transfer this to the emotional sphere (Kessels et al., 2014).

Discussion

The novelty of the integrative model of non-cognitive predictors of academic performance constructed and verified in this study is not only determined by the composition of the considered predictors. Our study also provided new data on more complex patterns in the relationship between non-cognitive and academic performance compared to previous studies. Based on the data obtained, conscious self-regulation can be considered a core component of academic success, making not only a direct contribution to academic performance, but also supporting factors that contribute to the achievement of educational goals.

For the first time, a study has established the reciprocal nature of the relationship between self-regulation (SR), academic motivation, school engagement, and academic achievement (Hypothesis H1). Previously, some researchers showed a reciprocal relationship between SR and engagement (Karabenick & Zusho, 2015), while

other researchers noted that these concepts are closely interrelated and complementary to each other (Cleary & Zimmerman, 2012). The present study has unambiguously confirmed its existence. This result allows us to speak about the resource role of conscious SR in relation to other significant predictors of academic success.

The reciprocal nature of the relationship between school engagement and self-regulation was also confirmed by the longitudinal research data: depending on the age of students, either self-regulation predicted higher levels of engagement, or vice versa (e.g., Fomina et al., 2021; Stefansson et al., 2018). Thus, in adolescence, self-regulation compensated for the lack of engagement and motivation of students, maintaining optimal levels of academic achievement (Bakracevic Vukman, & Licardo, 2010). On the other hand, the higher the students' engagement, the higher their need to achieve educational goals. Thus, for the first time, it has been clearly shown that engagement in this case is a means of maintaining and developing self-regulation which eventually lays the foundation for successful learning. At the same time, it was shown that self-regulation was positively associated with productive forms of intrinsic motivation in all age groups: the more motivated a student was, the more effective his self-regulation (Rheinberg, Vollmeyer, & Rollett, 2000).

Hypothesis H2a, which asserted that personality traits will show a positive linear relationship with school engagement and self-regulation, thus influencing academic performance, has also been confirmed. School engagement in this case was represented by behavioral and cognitive components. On the whole, little is known about the relationship between personality characteristics and school engagement (Moreira et al., 2021). Most of the research in this direction has been carried out with the samples of older age (students and adults). Thus, it has now been shown that agreeableness and conscientiousness are reliable predictors of cognitive engagement; extraversion, agreeableness, conscientiousness, and openness predict behavioral engagement; and agreeableness is predictive of emotional engagement (Qureshi et al., 2016).

As for the relationship between self-regulation and personality characteristics, this issue has been well studied. Students with a high level of self-regulation development have certain personality structures: low neuroticism combined with high openness to experience, high extraversion, agreeableness, and conscientiousness (e.g., Dörrenbächer & Perels, 2016). According to the data from previous studies, conscious self-regulation compensates for personality traits that hinder high performance (Morosanova, 2021). Studies have also shown that increasing the level of conscious self-regulation development helps to compensate for extreme expressions of personality characteristics. Thus, for example, introverts with a higher level of SR development have higher levels of openness to new experience. In this way, conscious self-regulation is actually a direct determining factor in academic performance, while personality features determine some individual peculiarities of students' academic behavior. This issue needs further research.

Hypothesis H2b, which concerned the mediating role of cognitive school engagement in the relationship between self-regulation and academic achievement, has been confirmed. The conceptual contiguity of self-regulation and cognitive engage-

ment is emphasized by a number of researchers (e.g., Ben-Eliyahu et al., 2018). Our data clearly indicate that conscious self-regulation is a resource for not only academic achievement, but also for school engagement. Indeed, progressing toward one's internal goal (consciously relevant to one's true needs and motivations) encourages students to be more engaged in the educational activities (Vasalampi et al., 2009). In general education schools, significant relationships are found between all types of school engagement and self-regulation (Wang, Deng, & Du, 2018). Longitudinal data show a reciprocal relationship between self-regulation and engagement in high school as well (Stefansson et al., 2018).

Hypothesis H2c, which posited that the emotional-motivational attitude toward learning is positively correlated with school engagement and makes a positive contribution to academic performance, found only partial confirmation in this study. Indeed, some factors of the emotional-motivational attitude toward learning, such as cognitive activity, achievement motivation, and negative emotions of anger and anxiety, make but little contribution to emotional engagement. However, contrary to the hypothesis, emotional engagement itself is not significantly associated with academic performance.

At present, the issue of including emotional factors in multifactorial models of academic success still remains under discussion. Researchers pay great attention to the regulation of emotions, especially maintaining their positive and negative balance at an optimal level (McRae & Gross, 2020). Thus, the ambiguous contribution of positive emotions to academic performance is known (for example, Pekrun et al., 2017). It is noted that the high intensity of positive emotions can act as one of the factors hindering the achievement of learning goals (Sallquist et al., 2009) due to a decrease in volitional control and the emergence of behavioral problems. It is possible to conclude that emotional engagement will probably make a significant contribution to another important indicator of schooling - the subjective well-being of students. But this hypothesis requires further testing.

Conclusion

The research results allowed us to construct a new integrative model of predictors of students' academic achievement. The data generated by this model show that conscious self-regulation is central to non-cognitive predictors of academic performance. The resource role of SR is thus substantiated, not only in determining academic performance, but also in relation to motivation, engagement, and attitude toward learning. For the first time, a reciprocal relationship between conscious self-regulation, academic motivation, school engagement, and academic performance has been described. It has been shown that behavioral and cognitive engagement make a significant contribution to academic performance, while emotional and social engagement did not have significant links with it, although they determine other areas of school life.

The theoretical contribution of the present study to the research topic lies in its possible clarification of the nature of the components of school engagement. The

research results demonstrated that the school engagement construct is not holistic. Thus, its behavioral component is more of a personality formation, while the cognitive one is closer to regulatory-cognitive properties. The model of non-cognitive predictors of academic performance obtained in the study has demonstrated its invariant nature; it could be reproduced on samples that differed in gender and age. This model has revealed the role and place of conscious self-regulation as a key resource for academic success, regulating the activation of its other predictors.

The data obtained in this study provides essential results for pedagogical practice, psychological counseling, and psychoprophylactic work at school in the direction of advancing students' academic performance. The resource role of conscious self-regulation is emphasized as both a direct predictor of academic performance and a factor regulating the positive impact of such achievement predictors as motivation, school engagement, and the emotional attitude toward learning.

Limitations

The limitation of this study is the model's lack of an intelligence indicator. Analysis of academic performance, as a rule, provides for an assessment of the impact of intelligence. The results of numerous studies have shown that its impact varies widely and on average explains up to 25% of the variance of the annual score. We did not include intelligence in this study because we aimed to investigate the impact of so-called non-cognitive predictors of academic achievement (conscious self-regulation, school engagement, motivation, and personality), taking into account the effects of mediation. In followup, we plan to include intelligence indicators in the model.

Ethics Statement

All subjects gave their informed consent for inclusion before they participated in the study. 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 (if the participants were minors)

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.

Author Contributions

I.B., T.F., and V.M. were involved in the conceptualization; V.M. was involved in methodology; I.B. and T.F. were involved in validation; I.B. was involved in formal analysis; I.B. and T.F. were involved in the investigation; I.B. and T.F. were involved in data

curation; I.B and T.F. were involved in writing-review and editing; V.M. was involved in supervision; and I.B was involved in project administration.

Conflict of Interest

The authors declare no conflict of interest

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BIBLIOMETRICS

A Bibliometric Analysis of Scientific Publications on Cultural-Historical Psychology from 2010 to 2020: Dynamics, Geography, and Key Ideas

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Background. This paper presents the results of a study into the breadth, dynamics, and diversity of the interdisciplinary branch of cultural-historical psychology. The scatter of thematic areas within the cultural-historical approach indicates the urgent need to continue a systematic and holistic analysis of research related to cultural-historical topics in the context of its various directions and research groups.

Design. A bibliometric analysis of scientific publications indexed by the Web of Science CC was carried out for the 2010–2020 period. Our previous bibliographic study (Rubtsov et al., 2019) revealed that the number of publications on cultural-historical psychology and citations of them, has recently increased, although unevenly.

Results. According to our results, the number of publications on cultural-historical psychology is growing unevenly; publications from Russia and the United States made up almost equal shares of the sample, and third place was taken by England, followed by Finland and Sweden. The top 10 journals fell into two subject areas: Psychology and Education and Educational Research. With regard to the geographical location of the publishing houses of the top 10 journals, the highest number was taken by England and Russia. The dominant areas of research were teacher education, university education, and learning activity.

Conclusion. The most frequently used terms were Vygotsky, activity approach, CHAT, CHP, ZPD, and learning activity.

Keywords:

Scientometric analysis, cultural-historical psychology, activity approach, L.S. Vygotsky, Web of Science, scientometrics

Introduction

The theoretical and methodological views of L.S. Vygotsky and his closest associates form a significant part of the foundation of scientific discourse and retain great heuristic power in modern psychology. In many ways, Vygotsky's revolutionary thoughts modified the ideas about the unit of analysis at different stages of the formation of such directions in cultural-historical psychology as the theory of activity (Meshcheryakov & Ponomarev, 2018; Sannino & Engeström, 2018). But the perception of Vygotsky's theory in the international academic communities varies a lot. In his critical analysis Dafermos (2016) noted that there are at least three widespread theoretical frameworks of interpretation of Vygotsky's theory: cognitivism, culturalism, and cultural-historical activity theory. Many researchers emphasize significant differences in the traditions of developing ideas of cultural-historical psychology, in particular, between Russian and non-Russian authors (Bakhurst, 2016; Dafermos, 2016; Miller, 2011).

In modern works, three approaches (paradigms) are often described, compared, and partially juxtaposed (Ellis, Edwards, & Smagorinsky, 2010, Ch. 1, Introduction): 1) the cultural-historical, which has its roots primarily in Soviet-Russian psychology and philosophy; 2) the social-cultural, associated primarily with a number of famous North American and British psychologists, as well as Spanish authors (Valsiner, & Rosa, 2007, Editors' Introduction); and 3) cultural-historical activity theory (CHAT), which is closely related to the school of activity theory in Helsinki, Finland (Sannino & Engeström, 2018).

Within this framework, it is interesting to look at the scientific mapping of the spread of Vygotsky's ideas. This can be achieved through bibliometric research methods with focus on visualizing the structure and dynamics of the research field. We can use statistical methods to identify the outcomes of individuals or research groups, institutions and countries, and national and international networks, and map the development of the field of cultural-historical psychology. But there is a very small number of such bibliometric studies in the research field of cultural-historical psychology.

J. Valsiner pioneered measuring the annual frequency of citation of various works of Vygotsky in English-language publications and started with the 1969 to 1984 period. His focus was on analyzing differences in the citations of Vygotsky's works, but he also recognized that "efforts to popularize Vygotsky's name among English-speaking psychologists have succeeded to a great extent" (Valsiner, 1988, p. 156). W.M. Roth and Y.L. Lee (2007) demonstrated that the 1975–2005 period was marked by an impressive growth in citations and an increase in search results for the keyword "theory of activity."

In terms of specific research fields, the bibliometric analysis has shown that Vygotsky's ideas represent modern trends in educational research, specifically the use of dialogic teaching methods (Song et al., 2019), learning English as a second language (Zhang, 2020), creativity and education (Hernández-Torrano, & Ibrayeva, 2020), educational games (Liu et al., 2020), special education, disability, and inclusion (Bal et al., 2020). Another significant direction that has shown up in bibliometric analysis is the application of Vygotsky's ideas to the study of human-computer interaction and

digital technologies. T. Clemmensen, V. Kaptelinin, and B. Nardi found that there are different ways of using, adapting, and developing activity theory for different purposes. They refer to analyzing theory and developing new questions about it; defining requirements for new tools and supporting empirical analysis; and providing practical recommendations (Clemmensen et al., 2016). Using the bibliometric method, S. Karanasios, B. Nardi, C. Spinuzzi, and J. Malaurent pointed to the role of activity theory in the study of human-technology relations and such digital technologies as social media, smartphones, blockchain, artificial intelligence, and algorithmic decision-making (Karanasios et al., 2021).

In terms of applying the specific concepts of the cultural-historical approach, an increase in publications can be also seen; for example, between 2000 and 2019 the number of publications on the “zone of proximal development” (ZPD) grew (Margolis, 2020). A bibliometric mapping analysis of publications from Indonesia for the 2011-2020 period found that the keyword “activity theory” was among the six most-used keywords on the topic of Educational Technology (Darmawansah, 2021).

But it is important to understand that it is not always possible to trace the trajectory of the movement of scientific ideas, possible dead ends, or breakthrough directions from separate scientific publications. V. Zaretskii uses the image of a tree as Vygotsky sometimes did to illustrate his ideas. Publications are fruits, or finished products (Zaretskii & Nikolaevskaya, 2019). But can they always be used to reconstruct the process of obtaining them, or to identify the tree on which they grew, or the gardeners who tended them?

We need to look at the interconnections within the scientific schools. Authorial collaborations in scientific publications can give us an idea of the invisible colleges of scientific thought. An invisible college is a group of interacting scholars or scholars who share similar research interests in a subject area, who frequently produce publications related to that subject, and who communicate formally and informally with each other to achieve important goals on the subject, even though they may belong to geographically dispersed research affiliates (Zuccala, 2006).

Background

The scatter of thematic areas within the cultural-historical approach indicates the urgent need to continue a systematic and holistic analysis of research related to cultural-historical topics in the broad context of its various directions and research groups.

Our previous bibliographic study (Rubtsov et al., 2019) revealed that the number of publications on cultural-historical psychology and their citations, has recently increased, although unevenly. The study’s total sample accounted for 5,669 works (published within 2009-2019 period) and included 1,817 publications from the Web of Science Core Collection and 2,838 from the RSCI database (Russian Science Citation Index). The sample consisted of publications containing the following Author Keywords: cultural-historical psychology (CHP sample) and Vygotsky (Vygotsky sample). The CHP sample embraced 181 publications, which included 161 scientific articles (88%). Most of these papers were in Russian (87% of the total). The total number of citations in these publications was 457; the h-index of the sample was 12. The Vygotsky sample appeared in 1,636 publications, of which 1,278 (78%) were

scientific articles. Publications in Russian accounted for 10% of the total. The total number of citations for all works in the Vygotsky sample reached 7,850, and the h-index of the sample was 40. Let us look at this sample in greater detail.

The Vygotsky sample revealed that most publications included the keywords Activity (436 publications, or 32% of the total number in the sample), Tool (241 or 15%), and Zone of Proximal Development (226 or 14%). The analysis of the representation of publications in the Vygotsky sample by year showed that for Activity, the maximum number of publications was 72 in 2016; for Zone of Proximal Development, 32 and 33 (2015 and 2017, respectively); and for Tool, 40 publications (2017). The analysis of the geographical distribution of the groups of authors in this sample revealed that the United States had the largest number of publications, with 305 (18.64%), followed by Russia with 221 (13.51%), and Brazil with 162 (9.90%).

Our analysis of the terms used in the titles and abstracts of the publications in the Vygotsky sample identified four clusters of terms, which were classified by us: Cultural-Historical Psychology (1), Education (2), Development (3), and Zone of Proximal Development (4). Each had a different set of links between the terms. In cluster 1, the strongest links were between the following terms: psychology, L.S. Vygotsky, cultural-historical psychology, thinking, consciousness, speech, emotions, art, and personality; in cluster 2, learner/student, teacher, skills, tutor, case analysis, class, application, resource, and mathematics; in cluster 3, young child, parent, motive, early childhood education, self-regulation, family, speech, emotions, art, and literacy; in cluster 4, learner, scaffolding, developmental delay, language learning, and dynamic assessment.

In addition, the study presented the citation dynamics of various works and publications of L.S. Vygotsky for the 1999-2019 period based on a sample of 1,014 publications from Google Scholar. The dynamics of the number of citations of Vygotsky's work showed an increase, with the peak in 2017, when it reached 24,226 citations per year. At the beginning of the analyzed period in 1999, a total of 2,724 citations were shown per year; in 2009 it was 12,396, and in 2018 it was 21,078. If we turn to the most cited works, we note that the five most-cited Vygotsky works included publications in English (two), Portuguese (one), and Russian (two). All the publications were books.

Method

Aim

This study was aimed at analyzing the thematic diversity of publication activity within the framework of the modern branch of cultural-historical psychology in the period from 2010 to 2020, taking into account certain bibliographic variables (year of publication, country, journal, university, and research field).

The following research questions were investigated through bibliometric mapping analysis:

RQ1: What were the dynamics of publications in cultural-historical psychology?

RQ2: Which countries, organizations, and journals have contributed to cultural-historical psychology-related research?

RQ3: What were the most-used keywords in the abstract sections of journals on cultural-historical psychology from 2010 to 2020?

RQ4: What was the semantic similarity of publications in different countries, universities, and journals on cultural-historical psychology from 2010 to 2020?

Sample

The Web of Science Core Collection (hereinafter WOS CC) was the empirical base of the present study. Web of Science was selected as the scientific publication source in the study due to it having the largest research database.

Data collection

The study sample consisted of scientific publications included in the WOS CC for the period of 2010-2020 (see *Table 1*).

Table 1

Sampling of publications in Web of Science Core Collection

N	Sample	Sampling
1	n = 105	Advanced search in the Web of Science Core Collection by the field AK=Author Keywords: Cultural-historical psychology with specification for compliance with the cultural-historical approach. Articles that directly indicate cultural-historical psychology formed the core (core sample records) of the publication for this study. The query formulation in the Web of Science Core Collection advanced search: AK=(("Cultur* Histor* Psychol*") or ("Cultur* Histor* Activ* Theor*")) and PY=(2010-2019).
2	n = 526	Analysis of the Web of Science Core Collection citation report, followed by a transition to an array of publications citing core sample records (n=105). Selection of publications that do not belong to the core sample.
3	n = 446	An expert assessment of the sample of publications citing the core with confirmation of the relevance of this sample to the subject of cultural-historical psychology and the activity approach.
4	n = 551	Combination of the core samples with the publications citing the core. Thus, a combined sample of core+ was obtained. The conducted analysis covered the publications for the 11-year period (2010-2020).

Data analysis

The methodology of the present study primarily involved a bibliographic analysis across scientific publications to test the study hypothesis about the thematic heterogeneity of cultural-historical psychology and the activity approach.

Bibliometric analysis of publications involved the tools of the Web of Science platform. Bibliometric analysis of publications of the core and the core+ was carried out according to the following parameters: year of publication, country, source of publication, scientific organization, and research field.

The thematic diversity of the content of the core+ sample was analyzed on the basis of the Author Keywords. The Author Keywords are indicated in the articles in the relevant section of the publication. For the analysis, the Author Keywords were used in their original version (without changes). A free software VOSviewer v.1.6.13 was used to process the information, received in the Web of Science through co-word analysis of the text, and to visualize the relationships among the Author Keywords. To combine expressions that were close in meaning, a VosViewer Thesaurus File was used, which takes into account the synonymy of the Author Keywords and unifies the representation of the plural and singular (analysis of co-occurrence). When creating a visual map of terms, a threshold for frequency of occurrence was set at 5, which corresponds to 61 keywords (Figure 2).

For quantitative analysis of the frequency profiles (distributions) of terms, the following mathematical statistical methods were used (SPSS Statistics 23.0): calculation of matrices of linear correlation coefficients r (Pearson product-moment method); and then, for comparison, calculation of distances by formula: $d = 10(1 - r)$. If $d = 0$, we can say that the frequency profiles of the terms were completely similar (with $r = +1$); the possible maximum value is 20 (if $r = -1$), but in the overwhelming majority of cases, d did not exceed 10 units. Terms are semantic units. The distances were calculated between the frequency distributions of these terms (semantic units). These distances will be referred to as semantic distances.

The use of hierarchical cluster analysis (distances were also estimated on the basis of correlation) made it possible to quantitatively and visually assess the degree of semantic similarity or the distance of the compared samples.

In order to clarify the conclusions based on cluster analysis, factor analysis (principal component analysis) was also carried out by orthogonal Varimax rotation using Kaiser normalization. Here, it should be noted that the described method of analysis did not constitute a variant of co-word analysis (Callon, Courtial, & Laville, 1991), since it was not based on estimates of the strength of links in pairs of keywords co-occurring in publications, and its units of analysis were frequency profiles of terms in specially organized subsamples of publications.

Results and Discussion

The thematic diversity analysis of cultural-historical psychology and activity approach was carried out in two directions: analysis of the frequency distributions of publications in two samples (core and core+) in relation to the year of publication, countries, and journals; and analysis of the thematic diversity of publications related to the core+ sample in relation to the countries, journals, organizations, and scientific fields.

Frequency distribution analysis

RQ1: What were the dynamics of publications in cultural-historical psychology?

In order to explore the development of interest in cultural-historical issues in terms of its sporadic or uniform character, we examined how many articles related

to the topic were published annually in editions indexed by the Web of Science Core Collection from 2010 onwards. The publication dynamics of the core and core+ samples were evaluated separately.

The dynamics of the publication activity of the core+ are presented below (*Figure 1*).

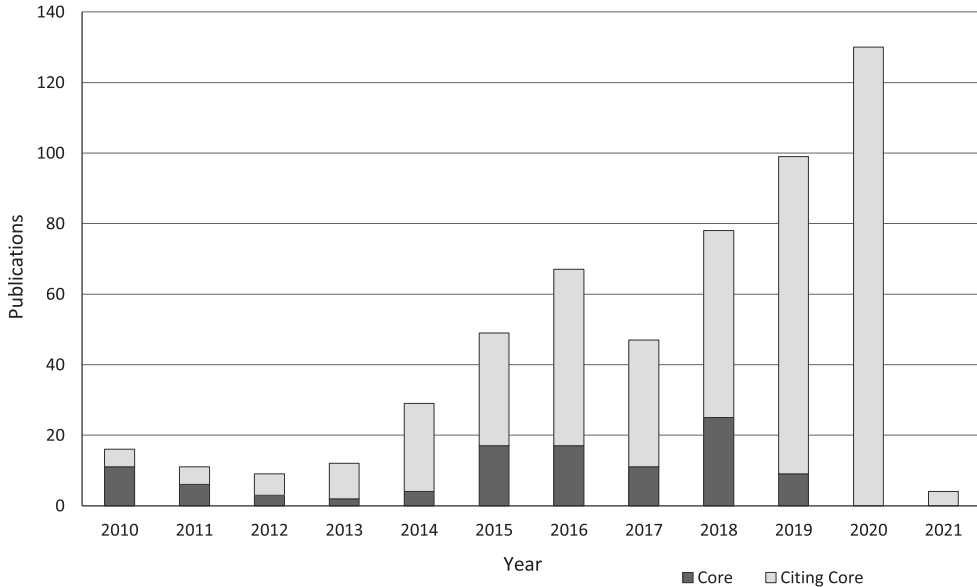


Figure 1. Distribution by year of publications in the core+ sample ($n = 551$, according to the Web of Science Core Collection): publications related to the core sample ($n = 105$, according to the Web of Science Core Collection), publications citing core sample ($n = 446$, according to the Web of Science Core Collection).

The sporadic nature of publication activity can be identified in terms of frequency distribution of core publications by year, with the largest number of publications (24%) appearing in 2018. More broadly, the lowest publication activity is observed from 2011 to 2014 (14%), while the period 2015–2019 accounts for the majority of publications (75%).

The nature of the distribution of publications in the core+ sample, including publications of the core and core+ sets, corresponds to the overall pattern of publication and citation in the social sciences: in general, articles started to be actively cited around three to four years after their publication. In this connection, there was an annual increase in the number of publications constituting the core+ sample: the highest number of publication citations appeared in 2020 ($n = 130$), while the lowest number was in 2012 ($n = 9$). The data for 2021 are not included in this analysis since 2021 has not yet ended, and some works are yet to be published.

Therefore, it can be seen that the number of publications on the cultural-historical psychology is growing unevenly. The annual number of core publications increased by 2.5 times, and the number of core+ by more than eight times.

RQ2: Which countries and journals have contributed to cultural-historical psychology related research?

Analysis of the affiliation of the authors by sample showed the geographical spread of the cultural-historical approach in terms of the 10 top countries in which the research was carried out. *Table 2* demonstrates the frequency distribution of publications in the core+ sample by the authors' country affiliations.

Table 2

Top 10 countries by number of publications included in the core+ sample (n=551, according to Web of Science Core Collection)

	Countries	Number of publications	Number of publications (% of 551)
1	Russia	96	17.42
2	USA	95	17.24
3	England	52	9.44
4	Spain	33	5.99
5	Australia	27	4.90
6	Canada	26	4.72
7	Brazil	24	4.36
8	Finland	22	3.99
9	Norway	22	3.99
10	Sweden	21	3.81

Almost equal shares of the core+ sample are taken by publications from Russia and the United States (17.42% and 17.24%, respectively). The third place is taken by the group of authors affiliated with England (9.44%). Finland and Sweden entered the top 10 in terms of the number of publications in the core+, while Germany and Bulgaria failed to meet the threshold (see *Table 2*).

It is interesting to look at the specific academic journals which published works on cultural-historical topic (see *Table 3*).

Analysis of the periodicals publishing articles of the core+ sample showed that 10 journals were responsible for more than 25% of publications. Among these, the leader in terms of the number of publications was the *Cultural-Historical Psychology* journal (7.26%); second place was shared by the journals *Educational Studies in Mathematics* and *Issues of Psychology* (2.9% each). Third place in terms of the share of publications was taken by the *Learning Culture and Social Interaction* journal (2.72%). The top 10 journals pertained to two subject areas: Psychology (six journals) and Education & Educational Research (four journals). These journals are published by Springer (Netherlands), Taylor & Francis (England), and MSUPE (Russia) (2 journals each). With regard to the geographical location of publishing houses of the top 10 journals, the largest numbers were in England and Russia (four and three journals, respectively).

Table 3

Top 10 journals by number of publications included in the core+ sample (n=551, according to Web of Science Core Collection)

	Journal Title ISSN, Publisher, Country, research field in WoS CC	Number of publications	Number of publications (% of 551)
1	Cultural-Historical Psychology ISSN: 1816-5435, MSUPE, Russia (Psychology)	40	7.26
2	Educational Studies in Mathematics ISSN: 0013-1954, Springer, Netherlands (Education & Educational Research)	16	2.90
3	Issues of Psychology (Voprosy psikhologii) ISSN: 0042-8841, International Book, Russia (Psychology)	16	2.90
4	Learning Culture and Social Interaction ISSN: 2210-6561, Elsevier, England (Education & Educational Research)	15	2.72
5	Mind, Culture and Activity ISSN: 1074-9039, Taylor & Francis, England (Education & Educational Research)	12	2.18
6	Psychological Science and Education ISSN: 1814-2052, MSUPE, Russia (Psychology)	10	1.82
7	Theory & Psychology ISSN: 0959-3543, Sage, England (Psychology)	10	1.82
8	ZDM Mathematics Education ISSN: 1863-9690, Springer, Germany (Education & Educational Research)	10	1.82
9	Frontiers in Psychology ISSN: 1664-1078, Frontiers Media, Switzerland (Psychology)	7	1.27
10	Infancia y Aprendizaje ISSN: 0210-3702, Taylor & Francis, England (Psychology)	7	1.27

Thus, in the first part of the analysis of our research results, we distinguished the groups of countries and academic journals having the largest number of publications in cultural-historical psychology, and determined the yearly frequency of these publications.

RQ3: What were the most-used keywords in the abstract sections in journals on cultural-historical psychology from 2010 to 2020?

The frequencies of the representation of Author Keywords in the sample were calculated in order to analyze the content of publications related to cultural-historical psychology. A semantic analysis of the 1,742 words and phrases (author keywords) contained in the sample was carried out. Keywords that were close in meaning were combined; these were those which might differ in singular or plural, presence or absence of articles, spelling errors, or they may contain synonyms. Among the Author Keywords there were unspecific terms for cultural-historical psychology. By referring in the same publication to terms related to the field of cultural-historical psychology (CHP) or to the cultural-historical activity theory (CHAT), they showed the intensity of work in a particular field of cultural-historical research. Semantic analysis resulted in a sample of 1,532 keywords.

Table 4

Top 20 terms (keywords) by frequency of occurrence (according to the Web of Science Core Collection)

	Term (Examples of variants it encodes)	Frequency of occurrence of the term
1	CHP (cultural-historical psychology, Vygotsky’s theory, cultural-historical scientific school, historical-cultural psychology, cultural-historical approach)	86
2	activity approach (activity principle, activity theory, theory of activity)	55
3	CHAT (cultural-historical activity theory)	50
4	Vygotsky (Vygotski, Lev Semenovich Vygotsky, etc.)	38
5	teacher education	24
6	ASD (autism spectrum disorders, autism spectrum condition, autism, etc.)	19
7	ZPD (zone of proximal development, proximal development zone, etc.)	18
8	learning activity	16
9	education	14
10	development	13
11	university education	12
12	perezhivanie (feeling, experiencing)	12
13	subjectivity (subjektividad)	11
14	contradictions	11
15	methodology	10
16	reflection (reflexivity)	10
17	double stimulation	10
18	identity	10
19	sociocultural theory (sociocultural approach, sociocultural perspective)	9
20	social interaction	9

Table 4 shows that of the 20 most frequent terms, the first three places are occupied by: CHP — 86 articles; activity approach — 55; and CHAT — 50. The keywords indicated the following research fields to be prevalent: teacher education, university education, and learning activity. Development, subjectivity, reflection, and identity were among them, as well as specific terms in cultural-historical psychology — ZPD, perezhivanie, and double stimulation.

The representation of the core+ keywords can be visualized using VosViewer tools. The size of a term on the map of keywords below (Fig. 2) is determined by the frequency of the keyword use. The density of keywords placement depends on the number and intensity of links between them. On this keyword map, the lighter the area around a keyword, the higher the frequency of its use. The density of placement of keywords depends on the number and strength of links between them.



Figure 2. Map of relationships between Author Keywords in publications of the core+ sample (n = 551, according to the Web of Science Core Collection)

As shown in Figure 2, such Author Keywords as CHP ($o = 86$; $ls = 138$), Activity approach ($o = 55$; $ls = 63$), CHAT ($o = 50$; $ls = 51$), and Vygotsky ($o = 38$; $ls = 69$) were the most represented for the core + sample in terms of the number of uses (weight<occurrences>, o hereafter) and the total weight of the links (weight<total_link_strength>, ls hereafter). Also the top 10 of the most used keywords included Teacher Education ($o = 24$; $ls = 33$); ZPD ($o = 18$; $ls = 43$); Autism Spectrum Disorders (ASD) ($o = 19$; $ls = 15$); Learning Activity ($o = 16$; $ls = 24$); Development ($o = 13$; $ls = 39$); and Education ($o = 14$; $ls = 32$).

Unfortunately, not all publications included in the analysis of thematic diversity contained complete bibliographic data (according to the Web of Science Core Collection). For example, Author Keywords might have been missed in some publications. For this reason, our analysis omitted publications in one of the most significant scientific journals, *Mind, Culture, and Activity*.

Since many of the 1,532 samples were not specific to a particular scientific field, and 78% had a low frequency of occurrence ($=1$), the next step was to select an abbreviated list of terms for subsequent analysis. The selected Author Keywords were contained in a sample of those articles where “Cultural-historical psychology” and “Cultural-historical activity theory” (that is, core publications) were used among the full list of the Author Keywords. Thus, the sample consisted of 368 keywords (Shvedovskaya, 2021).

RQ4: What was the semantic similarity of publications on cultural-historical psychology in different countries, universities, journals from 2010 to 2020?

This study analyzes the semantic distances between different samples of publications, differentiated by a number of variables: country, university, journal, and research field. Semantic proximity is understood as the distance between frequency distributions of terms in the publications.

Subsequent analysis involved the top 20 most frequently used keywords (see Table 4) to identify the relationship (semantic distances) between the most productive countries (n = 10), organizations (n = 10), sources (n = 10), and subject areas (n = 10) in publications where they were used.

Table 5 and Figure 3 present a matrix of the distances between the samples of publications, grouped by country. In total, the analysis included samples from 10 countries in Europe, Australia, and North and South America. The average semantic distance between all countries was 6.98.

Table 5

Semantic distances between the samples of publications according to the geographic affiliation of the authors, and their distances from the core (CHP_105) and core+ (CHP_551) samples

Country	Brazil	Australia	USA	Spain	Canada	England	Norway	Sweden	Finland	CHP_551	CHP_105
Russia	3.86	4.85	7.02	5.66	8.17	8.33	9.72	7.86	9.01	1.97	1.41
Brazil		6.56	8.28	5.74	8.73	9.40	9.16	8.67	9.73	4.11	3.52
Australia			5.02	6.49	5.08	6.54	8.06	8.01	8.01	3.43	4.25
USA				6.04	3.95	3.24	4.85	6.87	6.62	2.86	4.55
Spain					7.46	8.00	7.94	8.25	7.93	4.00	4.99
Canada						5.25	5.70	7.78	8.07	4.77	5.70
England							5.15	5.08	6.80	4.21	6.53
Norway								6.60	8.54	6.16	6.79
Sweden									5.92	5.43	7.12
Finland										6.40	8.56

As can be seen from Figure 3, the analysis of semantic distances of terms by geographical affiliation of the authors showed that the closest to each other were the United States and England (d = 3.24); Russia and Brazil (d = 3.86); and the United States and Canada (d = 3.95) (see Table 5). On the other hand, the greatest distances were between Brazil and Finland (d = 9.73); Russia and Norway (d = 9.72); and Brazil and England (d = 9.40).

The dendrogram (Figure 3) obtained for countries with a cut close to the root clearly shows two large clusters. The first of these clusters includes Russia, Brazil, Australia, and Spain (average d between them = 5.53). The second cluster includes the countries of North America, as well as England and the Scandinavian countries (average d in the second cluster = 6.03). It should be noted that the geographical proximity of countries does not correlate with their thematic proximity. For example,

HIERARCHICAL CLUSTER ANALYSIS

Dendrogram using Average Linkage (Between Groups)

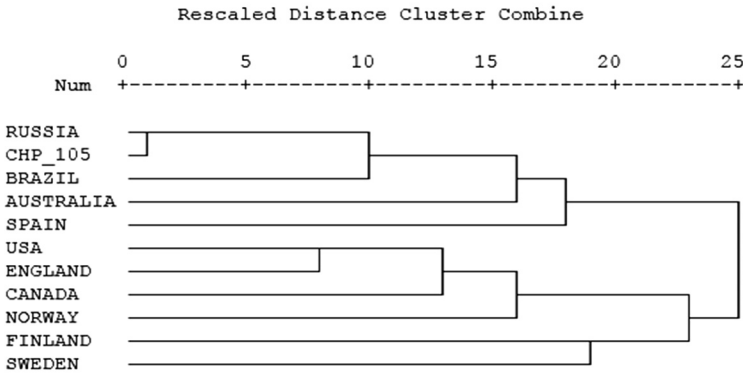


Figure 3. Dendrogram for samples of publications in different countries

neighboring Scandinavian countries differed thematically from each other much more markedly than the pair Russia-Brazil or the pair United States-England (see Table 5).

On the other hand, the same dendrogram, cut at a height of 20, depicts a differentiation of three clusters: the first remains the same, while the second includes the United States, England, Canada, and Norway (average distance = 4.69), and the third includes publications by Finnish and Swedish authors (distance = 5.92).

In order to confirm the correct selection of clusters, a factor analysis was carried out with a factor loading refinement of less than $|0.25|$. The analysis confirmed the presence of three components with eigenvalues (Ev) greater than 1: $Ev_1 = 4.46$; $Ev_2 = 1.92$; $Ev_3 = 1.06$. Factor 1 included countries with the following factor loadings: Russia — 0.905; Brazil — 0.824; Spain — 0.610; Australia — 0.578; United States — 0.287. Factor 2: Australia — 0.466; Canada — 0.805; United States — 0.795; Norway — 0.728; England — 0.713. The core had factor loadings of 0.864 for factor 1 and 0.352 for factor 2. Factor 3: England — 0.430; Finland — 0.818; Sweden — 0.782. If a country is included in several components, it is assigned to a greater factor loading. Rotation transformed in four iterations.

We note that three terms were common to all groups of countries: activity approach, teacher education, and CHAT (see Table 6). Five more terms common to paired country groupings were CHP, Vygotsky, ZPD, contradictions, and university education. The first group of countries was responsible for 50.0% of repeated terms, the second group 66.7%, and the third 41.7%. Of course, this indicates a significant conceptual overlap with publications in different groups of countries. Without even knowing which countries are included in each group, the semantic analysis of the terms indicates that the first and third groups are associated with the Russian and Finnish schools of thought, respectively. These are united by three general terms, which are common to all three groups. Thus, it turns out that the middle group has the greatest number of overlaps with both the Russian school (six) and the Finnish school (five), which could be interpreted as its mixed character.

Table 6
Most common terms in publications by country group

Russia, Brazil, Spain, Australia	Canada, USA, Norway, England	Finland, Sweden
CHP	CHAT	activity approach
activity approach	activity approach	double stimulation
Vygotsky	Vygotsky	intervention research
subjectivity	teacher education	computer-based training
ZPD	ASD	formative interventions
education	ZPD	CHAT
perezhivanie	identity	teacher education
development	sociocultural theory	contradictions
reflection	contradictions	University education
reflective-activity approach	CHP	methodology
teacher education	play	collaboration
CHAT	University education	Clinic of Activity

Table 7
Semantic distances between samples according to the authors' affiliation to different universities, and their distances from the complete and core samples

Universities	Lomonosov Moscow State University	University of Crete	Monash University	University of Barcelona	University of Manchester	University of Toronto	University of Helsinki	University of MÜNICH	CHP_551	CHP_105
Moscow State University of Psychology and Education (MSUPE)	3.36	5.01	5.41	7.04	9.23	8.22	9.33	9.44	2.47	2.12
Lomonosov Moscow State University (LMSU)		5.20	6.02	7.11	9.67	8.50	10.00	10.27	3.90	2.74
University of Crete (Uni_CRETE)			5.26	7.91	7.17	6.45	8.40	8.62	3.45	3.63
Monash University (Uni_MONASH)				8.48	6.55	4.84	8.87	9.48	4.25	4.56
University of Barcelona (Uni_BARCEL)					9.55	9.71	10.09	10.08	5.82	6.09
University of Manchester (Uni_MANCH)						8.42	8.82	9.25	6.04	7.31
University of Toronto (TORONTO)							10.13	9.60	7.35	7.52
University of Helsinki (Uni_HELSINKI)								9.89	7.05	8.73
University of MÜNICH (Uni_MÜNICH)									8.07	9.00

Next, let us consider the distance matrices (see Table 7) and dendrogram (Figure 4) for the samples of publications differentiated by the authors' affiliation to universities. The average distance between all universities was 8.09.

As can be seen from Figure 4, the analysis of the semantic distances of terms according to the authors' affiliation to different universities showed that the following universities are the closest to each other: Moscow State University of Psychology and Education and Lomonosov Moscow State University ($d = 3.36$); Monash University and the University of Toronto ($d = 4.84$); Moscow State University of Psychology and Education and the University of Crete ($d = 5.01$) (see Table 7). On the other hand, the largest distances were between Lomonosov Moscow State University and the University of Munich ($d = 10.27$); the University of Toronto and the University of Helsinki ($d = 10.13$); and the University of Barcelona and the University of Helsinki ($d = 10.09$).

HIERARCHICAL CLUSTER ANALYSIS

Dendrogram using Average Linkage (Between Groups)

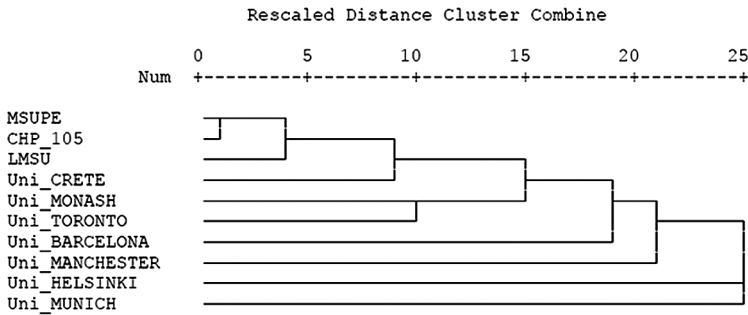


Figure 4. Dendrogram for samples of publications by the authors' affiliation to different universities

The dendrogram shows that publications by authors affiliated with the University of Helsinki and Ludwig Maximilian University of Munich hold a special place among the publications of all university affiliations. The other seven universities form one large cluster (together with the core): Moscow State University of Psychology and Education (MSUPE), Lomonosov Moscow State University (LMSU), the University of Crete, Monash University, the University of Barcelona, the University of Toronto, and the University of Manchester (average d within the cluster = 7.10). Although the average distance between the publications of the University of Helsinki and all other universities was 9.44 (with the University of Munich — 9.58), they are also separated from each other by a significant semantic distance of 9.89.

These results also provide a basis for identifying at least three thematic groups within the analyzed sample of publications. This is consistent with the results of factor analysis with a factor loading refinement of less than $|0.25|$. The analysis confirmed the presence of three components with eigenvalues (E_v) greater than 1: $E_{v1} = 3.70$; $E_{v2} = 1.35$; $E_{v3} = 1.05$. Factor 1 included organizations with the following factor loadings: Moscow State University of Psychology and Education — 0.845; Lomonosov

Moscow State University — 0.842; the University of Barcelona — 0.582; the University of Crete — 0.563; Monash University — 0.386. Factor 2: the University of Crete — 0.459; the University of Toronto — 0.853; Monash University — 0.728; the University of Manchester — 0.464. The core had factor loadings of 0.863 for factor 1 and 0.301 for factor 2. Factor 3: the University of Crete — 0.304; the University of Helsinki — 0.802; the University of Manchester — 0.518; the University of München — 0.390. If an organization was included in several components, it was assigned to a greater factor loading. Rotation converged in four iterations.

If the university samples of publications are grouped according to the factors having the highest loadings, then the first group will include two Moscow universities (MSUPE, LMSU) and the universities of Barcelona and Crete, and the second group will comprise the University of Toronto and Monash University, while the third group will be made up of the universities of Helsinki, Manchester and Munich.

The thematic diversity and at the same time the overlap of factorized groups of publications, are illustrated in the table of the most frequently used terms in each group (see Table 8). All groups of universities have one common term (Vygotsky), while six terms are common for two groups of universities (CHP, development, ZPD, identity, dialectics, and contradictions).

Table 8

Most common terms in publications of universities

MSUPE, LMSU, Universities of Barcelona and Crete	University of Toronto, Monash University	Universities of Munich, Manchester and Helsinki
CHP	Vygotsky	double stimulation
Vygotsky	CHP	CHAT
activity approach	perezhivanie	activity approach
development	ZPD	ASD
reflective-activity approach	AR Luria	social interaction
reflection	early childhood	identity
education	emotions	Vygotsky
ZPD	development	intervention research
multivector model of ZPD	CHAT	dialectics
teacher education	dialectics	contradictions
social situation of development	double stimulation	leading activity
mediation	collaboration	formative interventions

Table 8 shows that groups of organizations are semantically similar to groups of countries (see Table 6). This is because the parameters “organization” and “country” are related, as they are attributes of the authors of publications in the same sample.

We note that the term Vygotsky was used by all three groups of universities. CHP, Development, and ZPD were included in two groups: “MSUPE, LMSU, Universities of Barcelona and Crete” and “University of Toronto, Monash University.” Activity approach was used by “MSUPE, LMSU, Universities of Barcelona and Crete” and

“Universities of Munich, Manchester and Helsinki.” CHAT was used by “University of Toronto, Monash University” and “Universities of Munich, Manchester, and Helsinki.” The remaining terms fell into one group only (see *Table 8*).

Let us analyze the data on the samples of publications corresponding to different journals (see *Table 9* and *Figure 5*). The average distance between all pairs of samples amounted to 8.34.

Table 9

Semantic distances between the samples of publications corresponding to the top 10 journals

Journals	Issues of Psychology	Psychological Science and Education	Theory & Psychology	Infancia y Aprendizaje	Educational Studies in Mathematics	ZDM Mathematics Education (Zdm)	Frontiers in Psychology	Learning Culture and Social Interaction	CHP_551	CHP_105
Cultural-Historical Psychology (CULT_HIST_PS)	2.84	3.72	7.44	6.99	8.72	10.32	9.86	8.09	2.26	1.71
Issues of Psychology (VOPR_PS)		5.05	8.52	7.15	9.59	9.8	9.85	9.4	3.97	2.58
Psychological Science and Education (PS_NAUKA_OBRAZ)			6.82	6.78	7.76	9.58	8.92	8.98	2.42	2.99
Theory & Psychology (THEORY_PS)				9.21	6.35	8.86	9.7	6.78	5.33	6.17
Infancia y Aprendizaje (INFACIA_APREND)					8.63	10.25	9.96	10.05	6.32	6.39
Educational Studies in Mathematics (EDUC_STUDIES_MATH)						6.53	9.76	8.35	4.99	6.72
ZDM Mathematics Education (Zdm MATH_MATH)							10.32	9.64	7.72	7.91
Frontiers in Psychology (FRONTIER_PS)								9.7	9.96	8.23
Learning Culture and Social Interaction (LEARN_CULTURE_SOC)									7.02	8.39

As can be seen from *Table 9*, the analysis of semantic distances by journals with publications included in the core+ sample showed that the following journals were the closest to each other: *Cultural-Historical Psychology* and *Issues of Psychology* ($d = 2.84$); *Cultural-Historical Psychology* and *Psychological Science and Education*

($d = 3.72$); *Issues of Psychology* and *Psychological Science and Education* ($d = 5.05$). On the other hand, the largest distances were between *Cultural-Historical Psychology* and *ZDM Mathematics Education* ($d = 10.32$); *ZDM Mathematics Education* and *Frontiers in Psychology* ($d = 10.32$); *Infancia y Aprendizaje* and *ZDM Mathematics Education* ($d = 10.25$).

HIERARCHICAL CLUSTER ANALYSIS

Dendrogram using Average Linkage (Between Groups)

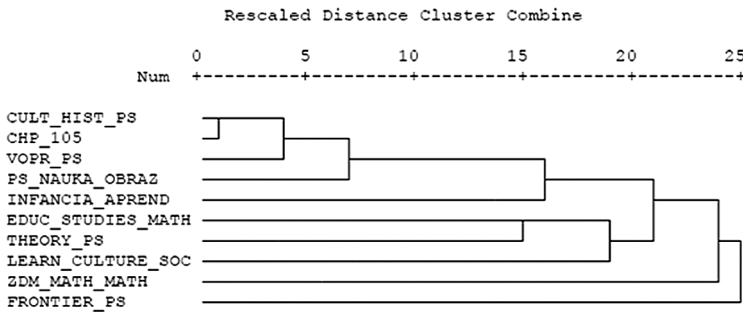


Figure 5. Dendrogram for samples of publications in different journals

The dendrogram in Fig. 5, cut at a height of 20 or so, is divided into two non-single clusters (four and three journals each) and two single journals. The first cluster with an average distance ($d = 5.42$) included three Russian journals (*Cultural-Historical Psychology*, *Issues of Psychology*, *Psychological Science and Education*), and a Spanish journal (*Infancia y Aprendizaje*). Another cluster (average $d = 7.16$) included *Educational Studies in Mathematics* (EDUC_STUDIES_MATH), *Learning Culture and Social Interaction* (LEARN_CULTURE_SOC_INT), and *Theory & Psychology* (THEORY_PS). Although the journals *ZDM Mathematics Education* (ZDM_MATH_EDUC) and *Frontiers in Psychology* (FRONTIERS_PS) have a specific thematic content, they were very semantically distant from each other ($d = 10.32$).

The results of clustering were consistent with the results of factor analysis with a factor loading refinement of less than $|0.25|$. The analysis confirmed the presence of three components with eigenvalues (Ev) greater than 1: $Ev_1 = 3.54$; $Ev_2 = 1.52$; $Ev_3 = 1.09$. Factor 1 included journals with the following factor loadings: *Cultural-Historical Psychology* — 0.882; *Issues of Psychology* — 0.848; *Psychological Science and Education* — 0.766; *Infancia y Aprendizaje* — 0.528; Factor 2: *ZDM Mathematics Education* — 0.812; *Educational Studies in Mathematics* — 0.770; *Theory & Psychology* — 0.389. The core has factor loadings of 0.897 for factor 1 and 0.259 for factor 2. Factor 3: *Learning Culture and Social Interaction* — 0.786; *Theory & Psychology* — 0.634; *Frontiers in Psychology* — 0.376. If a journal was included in several components, it was assigned to a greater factor loading. Rotation transformed in four iterations.

Table 10 shows the most common terms corresponding to three groups of journals. Two terms were included in all three groups of journals (activity approach, Vygotsky), while five more terms were common for pairs of groups of journals (ZPD, Development, learning activity, Teacher education, and CHAT).

Table 10*Most common terms in publications of three groups of journals*

Cultural-Historical Psychology, Issues of Psychology, Psychological Science and Education, Infancia y Aprendizaje	ZDM Mathematics Education, Educational Studies in Mathematics	Learning Culture and Social Interaction, Theory & Psychology, Frontiers in Psychology
CHP	CHAT	double stimulation
activity approach	teacher education	Vygotsky
Vygotsky	review of the literature	CHAT
ZPD	identity	activity approach
Development	activity approach	ASD
education	Vygotsky	practice
reflection	methodology	play
reflective-activity approach	activity	dialectics
learning activity	leading activity	learning activity
teacher education	development	formative interventions
joint activity	discourse	intervention research
AR Luria	contradictions	ZPD

Analysis of the table showing the most frequent terms in these three groups of journals reveals a somewhat similar picture to that of the previous two analyses (for countries and universities): the first group has four common terms with the second group and three with the third; the second and third groups have three common terms. Therefore, we can again highlight the mixed character of the middle group and the difference in scientific schools in the first and third groups.

Finally, let us analyze the data on distances and clusters within the samples of publications, distributed by so-called “subject areas” (see *Table 11* and *Fig. 6*). Here, the average distance between all pairs of samples was 7.87.

As can be seen from *Figure 6*, the analysis of semantic term distances by the thematic directions to which publications in the Web of Science Core Collection were assigned, showed that the following areas were the closest to each other: Psychology, Multidisciplinary and Psychology, Educational ($d = 2.86$); Psychology, Educational and Psychology, Developmental ($d = 4.43$); Psychology, Multidisciplinary and Social Sciences, Interdisciplinary ($d = 4.70$) (see *Table 11*). On the other hand, the greatest distances were between Psychology, Developmental and Philosophy ($d = 10.15$); Linguistics and Philosophy ($d = 10.15$); Psychology, Clinical and Psychology, Experimental ($d = 10.40$).

If we cut the dendrogram (*Fig. 6*) slightly above level 20, we obtain a structure consisting of three clusters. The first cluster includes six subject areas (average $d = 6.32$) and a core sample; the second cluster includes three areas (average $d = 7.07$). The third cluster includes the thematic area of Philosophy almost equidistantly from the other two clusters (average d from the first cluster = 9.18; from the second, $d = 9.20$).

Table 11

Semantic distances between samples differentiated by subject areas and their distances from the total and core samples

Subject areas	Psychology, Educational	Psychology, Clinical	Education & Educational Research	Social Sciences, Interdisciplinary	Linguistics	Psychology, Developmental	Education, Scientific Disciplines	Psychology, Experimental	Philosophy	CHP_551	CHP_105
Psychology, Multidisciplinary (PS_MULTIDISCIPLINARY)	2.86	4.72	6.51	4.70	5.55	6.57	9.43	8.29	8.08	1.22	1.21
Psychology, Educational (PS_EDUC)		5.82	7.75	6.06	6.94	4.43	9.94	9.83	9.02	3.22	2.53
Psychology, Clinical (PS_CLINICAL)			9.53	7.46	8.49	8.19	9.63	10.40	9.17	5.70	4.92
Education & Educational Research (EDUC_RESEARCH)				7.25	6.30	7.07	5.92	6.76	8.73	2.79	4.94
Social Sciences, Interdisciplinary (SOC_SCIEN_INTERDISC)					7.10	6.88	9.91	7.46	8.48	4.45	5.07
Linguistics (LINGUISTICS)						8.99	9.02	8.21	10.15	4.76	5.59
Psychology, Developmental (PS_DEV)							9.95	8.94	10.15	5.69	6.24
Education, Scientific Disciplines (EDUC_SC_DISCIPLINES)								8.53	8.73	7.48	8.00
Psychology, Experimental (PS_EXPER)									10.13	6.83	8.08
Philosophy (PHILOSOPHY)										8.04	8.69

The results of factor analysis with a factor loading refinement less than $|0.25|$ provide a basis for identifying a three-factor structure. The analysis confirmed the presence of three components with eigenvalues (Ev) greater than 1: $Ev_1 = 4.05$; $Ev_2 = 1.52$; $Ev_3 = 1.11$. Factor 1 included subject areas with the following factor loadings: Psychology, Multidisciplinary — 0.884; Psychology, Educational — 0.869; Psychology, Clinical — 0.661; Social Sciences Interdisciplinary — 0.589; Psychology, Developmental — 0.557; Education & Educational Research — 0.258; Linguistics — 0.403.

HIERARCHICAL CLUSTER ANALYSIS

Dendrogram using Average Linkage (Between Groups)

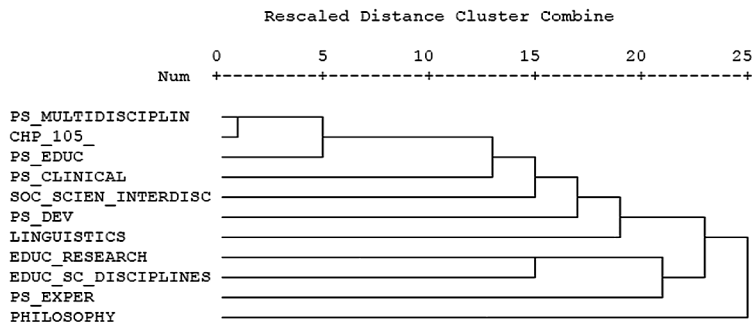


Figure 6. Dendrogram for samples of publications pertaining to different subject areas

Factor 2: Social Sciences Interdisciplinary — 0.283; Education & Educational Research — 0.756; Linguistics — 0.463; Education, Scientific Disciplines — 0.515. The core has factor loadings of 0.884 for factor 1 and 0.307 for factor 2. Factor 3: Psychology, Developmental — 0.266; Philosophy — 0.778; Education, Scientific Disciplines — 0.581. If a subject area was included in several components, it was assigned to a greater factor loading. Rotation transformed in six iterations.

Table 12

Most common terms in publications of three groups of subject areas

Psychology, Multidisciplinary; Psychology, Educational; Psychology, Clinical; Social Sciences Interdisciplinary; Psychology, Developmental	Education & Educational Research; Linguistics; Psychology, Experimental	Education, Scientific Disciplines; Philosophy
CHP	CHAT	CHAT
Vygotsky	activity approach	Vygotsky
activity approach	Teacher education	Identity
ZPD	Vygotsky	peer assisted learning
education	CHP	University education
ASD	University education	sociocultural theory
Development	Sociocultural theory	learning activity
subjectivity	contradictions	Activity systems analysis
CHAT	learning activity	Practice-based learning
reflective-activity approach	perezhivanie	Scientific literacy
Practical knowledge	early childhood education	Context-based learning
learning activity	double stimulation	epistemology

Table 12 shows the most common terms corresponding to the groups of areas, differentiated by factors. Three terms were common to all areas (Vygotsky, CHAT,

and learning activity), while four additional terms combined pairs of groups of areas (CHP, activity approach, university education, and sociocultural theory).

Semantic analysis of the distributions of terms in the three groups of areas (see Table 12) does not reveal a clear ideological commitment to a particular school. Here, the apparent theoretical and methodological confusion between all subject areas is quite understandable since the grouping of samples of publications by subject areas or year was not appropriate for solving our task of determining the diversity of theoretical and methodological approaches. To a greater extent, however, this task correlated with the samples distributed by countries and universities. Thus, for the correct interpretation of the results, it is essential that not only that all analyses (except for distributions by years) reveal a three-cluster and three-factor structure, but also that the semantic analysis of terms (keywords) is common and distinctive for different groups of publications.

In all our terminological comparisons, we can see that some terms are included in all triads of groups or in their pairs (on average, about 20%).

The most frequent common terms are Vygotsky, activity approach, CHAT, CHP, ZPD, and learning activity. For this group of six terms, our additional analysis of the dynamics of their use as keywords was not limited to the framework of the sample that served as the basis of our study. Fig. 7 depicts the dynamics of their use over an 11-year period.

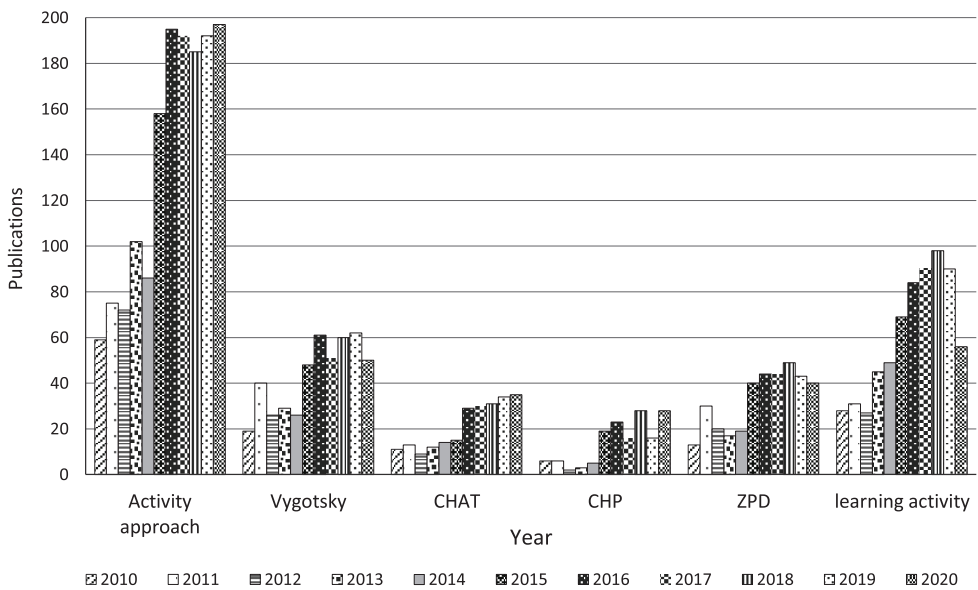


Figure 7. Dynamics of the use of the terms (keywords) in publications by year (according to Web of Science Core Collection)

If we divide this period (2010-2020) into two approximately equal sub-periods, then it is quite clear that the search terms were all used much more often in the second period than in the first one. At the same time, the undisputed leader is activity approach (the total number of publications is 1,513, peaking at 197 in 2020), followed by the learning activity (the total number of publications is 667, with the peak at 98

in 2018), and Vygotsky (the total number of publications is 472, max. 61 in 2016). The terms CHAT, CHP, and ZPD are found in less than 60 publications per year. Interestingly, the peak of the ZPD term was in 2011, while the peaks of CHAT and CHP overlap in 2016 and 2018.

Conclusion

The present community of active cultural researchers and practitioners was formed about 40 years ago. In this context, we can observe an increase in the number of both its participants and scientific publications. This growth would have been impossible without a common cultural and historical foundation of ideas, concepts, and theories — not only psychological, but also philosophical, linguistic, semiotic, philological, pedagogical, biological, etc. (Cole, 1996; Cole, 1997; Toomela, 2016; Dafermos, 2016).

In this article, bibliometric analysis was applied to the scientific output in cultural-historical psychology. Based on journal publications from 2010 to 2020, we obtained a comprehensive overview of cultural-historical psychology-related research. Hierarchical cluster analysis and factor analysis (Principal Component Analysis) of the publications provided answers to a number of research questions, which we summarize here:

RQ1: What were the dynamics of publications in cultural-historical psychology?

The number of publications on cultural-historical psychology was established to be growing, although unevenly. The largest number of publications appeared in 2018. The minimum activity was observed from 2011 to 2014, whereas the bulk of publications came in the period from 2015 to 2019. The annual number of core publications increased 2.5 times, and the number of core+ went up more than eight times.

RQ2: Which countries, organizations and journals have contributed to cultural-historical psychology-related research?

Almost equal shares of the core+ sample were taken by publications from Russia and the United States (17.42% and 17.24%, respectively). Third place was taken by the group of authors affiliated with England (9.44%). Finland and Sweden entered the top 10 in terms of the number of publications in the core+, while Germany and Bulgaria remained below the threshold.

Analysis of periodicals with publications of the core+ showed that more than 25% of the publications appeared in 10 journals. The leader in terms of the number of publications was the journal *Cultural-Historical Psychology* (7.26%); second place was shared by the journals *Educational Studies in Mathematics* and *Issues of Psychology* (Voprosy psikhologii) (2.9% each). Third place was taken by the *Learning Culture and Social Interaction* journal (2.72%). The top 10 journals pertained to two subject areas — Psychology (six journals) and Education & Educational Research (four journals). These journals are published by Springer (Netherlands), Taylor & Francis (England), and MSUPE (Russia) (two journals each). With regard to the geographical locations of the publishing houses of the top 10 journals, the bulk were located in England and Russia (four and three journals, respectively).

RQ3: What were the most-used keywords in the abstract section in journals on cultural-historical psychology from 2010 to 2020?

The most-used keywords reflected the prevailing areas of research such as teacher education, university education, and learning activity. Development, subjectivity,

reflection, and identity were also among them, as well as ones specific to cultural-historical psychology — ZPD, perezhivanie, and double stimulation.

RQ4: What was the semantic similarity of publications from 2010 to 2020 in different countries, universities, and journals on cultural-historical psychology?

Analysis of the semantic distances of the publications in the core+ sample by the authors' geographical affiliation showed that the following countries were the closest to each other: the United States and England; Russia and Brazil; the United States and Canada. On the other hand, the greatest distances were between Brazil and Finland; Russia and Norway; Brazil and England.

Analysis of the semantic distances between universities showed that the following universities were the closest to each other: Moscow State University of Psychology and Education and Lomonosov Moscow State University; Monash University and the University of Toronto; Moscow State University of Psychology and Education and the University of Crete. On the other hand, the largest distances were between Lomonosov Moscow State University and the University of Munich; the University of Toronto and the University of Helsinki; the University of Barcelona and the University of Helsinki.

Analysis of the semantic distances between the journals showed that the following journals were the closest to each other: *Cultural-Historical Psychology* and *Issues of Psychology*; *Cultural-Historical Psychology* and *Psychological Science and Education*; *Issues of Psychology* and *Psychological Science and Education*. On the other hand, the largest distances were between *Cultural-Historical Psychology* and *ZDM Mathematics Education*; *ZDM Mathematics Education* and *Frontiers in Psychology*; *Infancia y Aprendizaje* and *ZDM Mathematics Education*.

The most frequently used terms in all semantic groups were Vygotsky, activity approach, CHAT, CHP, ZPD, and learning activity. At the same time, the absolute leader was activity approach, followed by learning activity and Vygotsky.

In terms of further research, B.G. Meshcheryakov began work on a chronotope of cultural-historical psychology as a generalized and topological (non-metric) schematic representing the development process, similar to a genealogical tree. The units of chronotope analysis are not versions (varieties) of theory, but larger units — theoretical-methodological paradigms, and scientific schools somewhat comparable to them (Meshcheryakov, 2021). This study may provide the basis for further research.

Supplementary Materials

To view supplementary material for this article, please visit <https://doi.org/10.25449/ruspsydata.14914872.v1>

Limitations

To our knowledge, there has been no systematic analysis of the state and evolution of cultural-historical psychology using bibliometric and scientometric methods up to now. The method used in this study could help identify the historical and future development trends of research frontiers in the field of cultural-historical psychology. However, there are also some limitations in this study that can be overcome in future research.

First, we only collected data from the Web of Science Core Collection Database. Furthermore, in order to get a complete and in-depth analysis, it is preferable to significantly expand the analyzed sample of publications. Future studies can extend the search to include other databases such as Scopus.

Second, we did not differentiate the keywords according to their theoretical and methodological relevance, although it is quite obvious that keywords often include terms related to the objects of research or intervention (for example, play, education, learning, etc.). In future studies, it is possible to use different approaches to the problem of keyword selection in the bibliometric analysis, in particular, the application of the co-word method (Chen and Xiao, 2016). It should be taken into account that the results of a search query in the Web of Science Core Collection Database depend on individual user access restrictions (users may get access to data of different time periods).

Authors' Contributions

All authors have agreed on the final version and met at least one of the following criteria [recommended by the COPE (<https://publicationethics.org/authorship>): substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content.

Conflict of Interest

The authors have no conflicts of interest to declare.

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The publication comes out in memory of B. Meshcheryakov (1953 - 2021)

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