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Metacognitive Determination of Effective Parameters in Programmers' Activity

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Abstract

Introduction. Currently, information-related activity studies based on computer technologies and the identification and explanation of its cognitive and metacognitive determinants are of particular relevance. In this respect, it is objectively necessary to converge research in two important areas – metacognitivism and the psychology of professional information-related activity. This study is the first to identify and interpret the fundamental patterns of the deterministic influence of metacognitive factors on the effective parameters of information-related activity, including the optimum type dependency between metacognitive factors and efficiency. **Methods**. The sample (n = 210) consisted of programmers of various profiles and levels working in Yaroslavl, Moscow, and Rybinsk. The study used psychodiagnostic procedures, including the Complex Inventory of Metacognitive Potential (CIMP) developed by the authors and methods developed in metacognitivism. **Results**. The findings indicated that the deterministic influence of metacognitive potential on the effective parameters of programmers' activity was essentially diverse in terms of degree and direction. It synthesized both positive and negative characteristics, ultimately determining the complex and nonlinear nature of this influence and the presence of the optimum type dependency between the severity of metacognitive potential and efficiency. **Discussion**. The results are interpreted from the perspectives of metacognitivism and the basic perspectives of the psychology of information-related professional activity. Finally, the conclusion was that the negative influence of metacognitive factors on effective parameters of activity is determined by a combination of their direct and indirect impacts on the implementation of activity and particular functions to ensure their performance.

Keywords: metacognitive qualities, metacognitive potential, programmers' activity, reflexivity, information activity, voluntary regulation, activity quality, performance, efficiency

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Introduction

The subjective determinants of professional activity are one of the most important and traditional, i.e. classical problems in psychology, especially applied psychology. During its development, significant results have been obtained, and many explanation concepts have been formulated that reveal and explain the patterns of influence of these determinants and the individual psychological qualities of the subject on the main parameters of professional activity. However, like other 'classical' problems, this problem retains a long-term relevance, gains a new sound in each historical period, presents itself in a new light, and reveals additional aspects. This is very typical of this problem. The fact is that the 'world of professions' is dynamic and its changes lead to the emergence of a new type and class of fundamental professional activity. At the present stage of development, these transformations in the world of professions, referred to the phylogenesis of activity (Karpov & Len'kov, 2006), have led to the formation of a new class of activity – the *subject-information* type of activity. The future is that it raises the issue of its priority study and in particular question of identifying the specific characteristics of its subjective determinants.

Moreover, ideas about the category of subjective determinants of activity are being developed and expanded, and their new types and classes are explained. Therefore, as the complexity of an activity increases, relatively complex subjective factors in general and individual characteristics in particular play an increasingly decisive role in ensuring its final results. These include such qualities that are still insufficiently studied in the context of professional activity research and, especially information-related professional activity – subjective determinants of metacognitive nature. Therefore, the need to include new categories of subjective factors (personal metacognitive characteristics) and to reveal their functional roles in the implementation of professional activity becomes increasingly urgent. It is particularly important for types of activity that are relatively complex and cognitively saturated. This is first and foremost manifested in actions belonging to the class of subject-information, which are implemented on the basis of computer technology. Therefore, the mutual orientation of two important trends is clearly explicated – the development of forms and types of activity and the need to reveal the most complex determinants of activity itself, not only cognitive, but also metacognitive.

Nevertheless, the implementation of this objective logic (the gradual convergence of the two directions indicated) is still in the early stages and its synthesis is a task that has not yet been solved, rather than a reality that has already taken place. The most general characteristics of the current state of the problem are as follows. *Firstly*, the subjective determinants of the professional activity are well studied in detail and in accordance with various paradigms, in terms of many kinds and types of this activity. For example, there are paradigms such as the approach of professionally important qualities, competence-based approach, paradigm of knowledge, skills, and abilities, structure-level approach, etc.

Secondly, these approaches, although of course, to varying degrees, are also applied to activities in the IT sphere. Thus, we should note in this regard the work on the professionography of IT activities and the implementation of competent approaches to specific information-related activity

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(Karpov, 2021; Plotkina, 2010). Other important personal and professional qualities of IT specialists, particularly programmers, have also been studied (Demidenko & Eratina, 2021; Zhurina, 2019; Orel, 2007). Consequently, the main cognitive properties of this profession have been identified: hyperconcentration, a high level of code immersion, introversion, low socialization, formalization and thinking schematization (Leksunin, 2012). In addition, the following skills necessary to develop programmers' thinking have been differentiated (Demidenko, 2021; Bakunovich & Stankevich, 2018): the ability to establish an analogy between familiar and new; the ability to focus on long-term tasks; the ability to use developments efficiently; the ability to predict various scenarios for the development of events; the search for refactoring; concentration; introversion; rationality; perfectionism; gadgetmania.

In addition, the concept of soft skills as important subjective determinants of information activity has been developed in accordance with the competency-based approach. At the same time, their relatively constant sets are differentiated, including the following components: communication skills, social intelligence, teamwork, critical thinking, customer-oriented thinking, self-regulation, decision-making, time management, emotional intelligence, work under uncertain conditions, introspection, and self-reflection. At the same time, these approaches are generally not sufficiently implemented in relation to the IT sphere and programmers' activity.

Thirdly, this also includes the class of metacognitive personality characteristics, which has already been partially studied in relation to certain types of activity, but has not yet been implemented to a lesser extent in relation to IT activity, not only in professional activity, but also in the educational field. Therefore, it has been studied in terms of leadership and organizational activity (Karpov, 2018), certain health professions (Welch, Young, Johnson, & Lindsay, 2018), certain military disciplines (Fedorishin, 2020) and university education (Abdelrahman, 2020; Allon, Gutkin, & Bruning, 1994). At the same time, if we systematize and generalize recent studies on professional groups, it turns out that they are more often conducted with representatives of subject-specific professions – teachers, doctors, managers, etc. (see, for example, Gutierrez de Blume & Montoya, 2021).

Research on the metacognitive determination of professional activity for professions of object-related and especially information-related types is relatively rare and very fragmentary. For example, some studies involve so-called 'novice programmers' (e.g., Rum & Ismail, 2016), but actually college or university students studying an information-oriented specialty (e.g., 'computer science') and a programming course. For example, Prather et al. (2018) provides a short overview of such studies. These include metacognitive knowledge, declarative knowledge, procedural knowledge, conditional knowledge, metacognitive regulation strategies (Borkowski & Muthukrishna, 1992), information management strategies, understanding monitoring, metacognitive participation in activity, and self-assessment strategies (Flavell & Miller, 1993). In general, in relation to the field of IT, we can say more categorically that these studies are thus far isolated and severely fragmented (Dori, Mevarech, & Baker, 2018; Mariano, Figliano, & Dozier, 2017; Card, Moran, & Newell, 1983; Craig, Hale, Grainger, & Stewart, 2020).

Furthermore, we should note that all these studies are mainly conducted within the framework of the broad theoretical framework, in line with modern metacognitivism in general and one of its most important problems related the explication of its content and definition of its boundaries. In this regard, the most important concepts have been developed, revealing the content and organization of the metacognitivism subject area. First of all, we should note among them the

hierarchical model of metacognitive processes by M. Ferrari (Ferrari & McBride, 2011); the theory of cognitive metaoperators by D. Dörner (Dörner, 1978); the concept of cognitive monitoring by L. Nelson and L. Narens (Nelson, 1996); the concept of metaregulatory functions by M. Lefebvre-Pinard (Lefebvre-Pinard, 1983); the concept of the structure of metacognitive experience by M. A. Kholodnaya (Kholodnaya, 2012); and the theory of metaarchitectonics of consciousness by E. Blacky and S. Spence (Yzerbyt et al., 1998). More specific concepts related to the study of a specific metacognitive process are also presented (A. Brown, J. Borkowski, J. Flavell, R. Kluve, J. Metcalf, R. Paris, E. Madigan, E. Tulving, etc.) (Anderson, 1985; Borkowski & Muthukrishna, 1992; Flavell & Miller, 1993; Kluwe, 1982; Metcalfe & Eich, 2019; Tulving, 1985; Splichal, Oshima, & Oshima, 2018).

At the same time, because of the significant theoretical results obtained in these fields, the role of metacognitive factors in the organization of activity is less obvious. Of course, this situation must be overcome and the task of investigating personal metacognitive qualities as subjective factors influencing the activity of the IT industry should be a priority. Therefore, this task was the main objective of the study, aimed at identifying and explaining the role of metacognitive determinants in the effective parameters of programmers' activity as the main representatives of the IT sphere.

Methods

Examination and measurement procedure

To achieve this objective, we need to obtain two main empirical data sets – (a) data on individual measures of the severity of the main metacognitive qualities as subjective factors determining activity and (b) data on indicators of highly effective activity parameters, including quality and performance parameters, i.e. their accuracy and quantitative characteristics. At the same time, considerable methodological and conceptual difficulties have already been encountered in collecting empirical data. Thus, when solving the first of these tasks, there is a complex and still unresolved problem of determining the most representative metacognitive characteristics in terms of their determined role in activity. Furthermore, the problem is to determine these qualities that need to be investigated. The problem of transitioning from determining their summarizing and complex influence on activity to identifying their integrated influence is also important.

Therefore, as a major diagnostic tool to determine the overall metacognitive determinants, this study used a technique that examines the totality of metacognitive determinants in their complexity and structure – **Comprehensive Inventory of Metacognitive Potential (CIMP)**. We have previously developed this inventory to be applied in the field of IT activity. We described its detailed characteristics (Karpov, 2021; Karpov & Karpov, 2022); its main characteristics are as follows. Firstly, it enables the diagnosis of a wide range of basic personal metacognitive qualities, taken precisely in its entirety. Secondly, it helps identify the complexes in which they are synthesized according to the principle of similarity in their functional roles (subsystems). These subsystems include, in particular, subsystems that provide metacognitive monitoring, metaregulatory control, metacognitive organization of declarative and procedural knowledge, metacognitive control of emotional and motivating factors, and communication determinants of activity (eight basic subsystems). Consequently, they form the most integrated regulatory structure – the metacognitive sphere of personality. We emphasize in particular that the methodology applied is not only complex in terms of the extensive coverage of a large number of individual metacognitive qualities,

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but also in terms of the complexity of other methods used in its development, i.e. those that demonstrate the greatest validity and are considered to be the most reliable. These methods are used to diagnose the following qualities: individual measures of metamemory according to Metamemory in Adults, MIA, inventory by R. Dixon and D. Hultsch (Dixon & Hultsch, 1983); level of meta-planning according to D. Everson (Tobias & Everson, 2002); degree of metacognitive behavior development according to La Cost inventory (in A. V. Karpov, 2015); level and type of knowledge metacognitive monitoring according to the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994); processes of metacognitive inhibition, which aim at minimizing metacognitive monitoring (Karpov, 2018).

Furthermore, considerable difficulties in the operation and determination of the main effective parameters of the activity (quality and performance, i.e., accuracy and speed parameters) must be taken into account and overcome. In fact, because of the specificity of this activity, it is fundamentally difficult to implement it in the IT field as a whole and one of its main activities – programmers' activity. Finally, they are determined by the ambiguity and uncertainty of the concepts of the result of this activity and, more importantly, of *what* must be considered as its quality indicators and efficiency indicators. Moreover, in the IT sphere itself, the problem is not clearly resolved, nor is the problem of their relations with each other. This difficulty is also due to the lack of a clear content definition of these parameters. However, they are even less accessible for operationalization and therefore to quantitative explanations. Finally, it is also important that the boundaries between these activities are conditional and mobile. For example, it is known that the high initial quality of the code, which practically eliminates errors and ensures that there is no need for improvement, is at the same time not only a quality parameter but also an activity speed parameter, as it reduces the actual time spent on the entire activity. In addition, the ability to meet the time parameters of the sprint (i.e., the time limits for performing tasks) is not only a realistic time parameter for activity effectiveness, but also a quality indicator. In this activity, the known conflicts between accuracy and speed parameters are largely reduced, making the relationships between them more complex and indirect.

Despite the need to implement all these concepts, the following methodological technique has been developed and implemented in this study. It is the synthesis of the traditional method of expert assessment and the technique of expert checklist, which dates back to research conducted in line with Scandinavian activity theory and in the context of HCI (Engeström, Miettinen, & Punamäki, 1999; Bødker & Klokmose 2011); its essence is as follows. On the basis of preliminary pilot studies and the implementation of focused interviews and activity sounding methods (Karpov, 2015), the basic indicators of the qualitative and quantitative parameters of activity were identified. Then, we differentiated the indicators in which they were explicated and, accordingly, could be diagnosed. Finally, we formulated questions to facilitate this process and synthesized them into a questionnaire-type inventory. Finally, according to the psychology of professional activity, the most universal and integral effective parameter is efficiency, which, as a derivative of the first two parameters, is not their simple superposition, but a more complex phenomenon.

Thus, the inventory consists of three groups, aimed at determining quality and performance parameters and the efficiency of programmers' activity. Annex 1 provides the text of the inventory.

In addition, given that the most difficult task was to determine the effectiveness of programmers' activity (which was further strengthened by the lack of methodological tools), the study used one of the few existing methods – a questionnaire by A. Nikitin (2010).

On the one hand, the heads of the departments where the surveyed programmers worked, played the role of operational experts, which was a prerequisite for the validity of the export procedure. On the other hand, employees of the same status as the persons examined also acted as experts. At the same time, an important but not always consumed circumstance should be realized - as pointed out (Kolb, Kolb, & McIntryre, 1984), the degree of adequacy and accuracy of employees' qualifications assessment by their closest colleagues is generally very high and can reach 90-95 %. Each employee was evaluated by three experts, and the results were averaged.

Study sample

The sample (n = 210; 149 men, 61 women) consisted of programmers of different profiles and levels (application programmers, system programmers, graphic programmers, database engineers, quality assurance specialists, front-end developers, back-end developers, full-stack developers, desktop developers, 1C developers, web developers) from three Russian cities (Yaroslavl, Moscow, and Rybinsk) aged 21-64 years: < 31 years old – n = 92 (43.80 %), 31-45 years old – n = 86 (40.91 %), > 45 years old – n = 32 (15.23 %). Besides, the sample included the heads of services and departments in which the surveyed programmers worked (n = 51, aged 39-55 years).

Results

Table 1 shows the results of the assessment of the parameters of quality and performance of activity and its integrated efficiency indicator, depending on individual levels of the development of meta-cognitive potential (MP).

Table 1

The result of evaluating the activity parameters

Level of MP	Low (L)	Below average (BA)	Above average (AA)	High (H)
Quality evaluation	20.12 (5.67)	35.77 (5.70)	40.02 (7.74)	37.43 (5.23)
Performance evaluation	40.09 (6.20)	47.00 (7.73)	25.11 (6.94)	23.01 (6.01)
Efficiency evaluation	35.03 (4.10)	60.21 (7.11)	75.43 (5.80)	65.67 (5.82)

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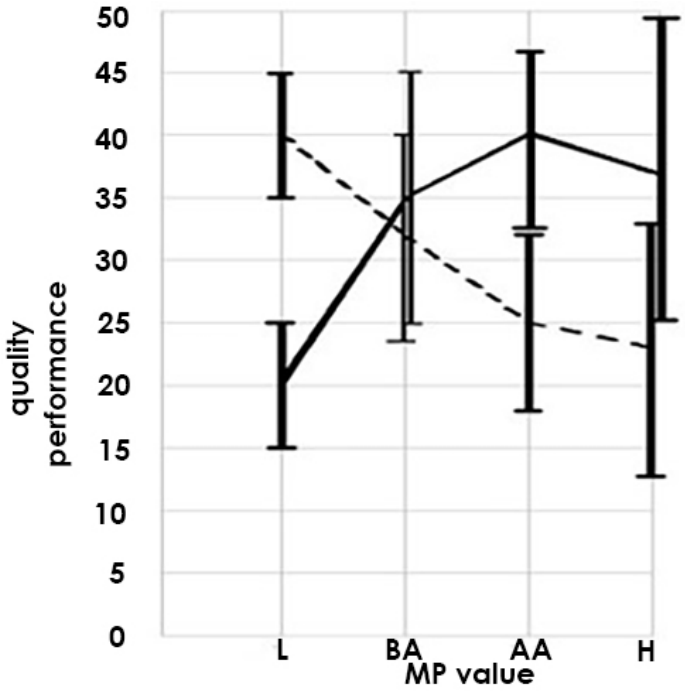
In the subsequent processing, the one-way analysis of variance (one-way ANOVA) was used, and the following subgroups were identified based on the levels of MP development, which corresponded to different values of the severity of the metacognitive potential: low (< 180 points), below average (180-280 points), above average (280-380 points), and high (> 380 points). At the same time, each subgroup contains approximately 25 % of the subjects of the group considered. The Games-Howell test was used to perform several comparisons which did not require equal subgroup sizes and variances; the Kruskal-Wallis test was used to construct graphic dependencies. Furthermore, we presented all these data graphically. Therefore, Figures 1 and 2 show the dependency of performance and activity quality values, as well as activity efficiency on individual level of MP severity, respectively.

Figure 1

Dependency of the quality (solid line) and performance (dotted line) of activity on the value of MP

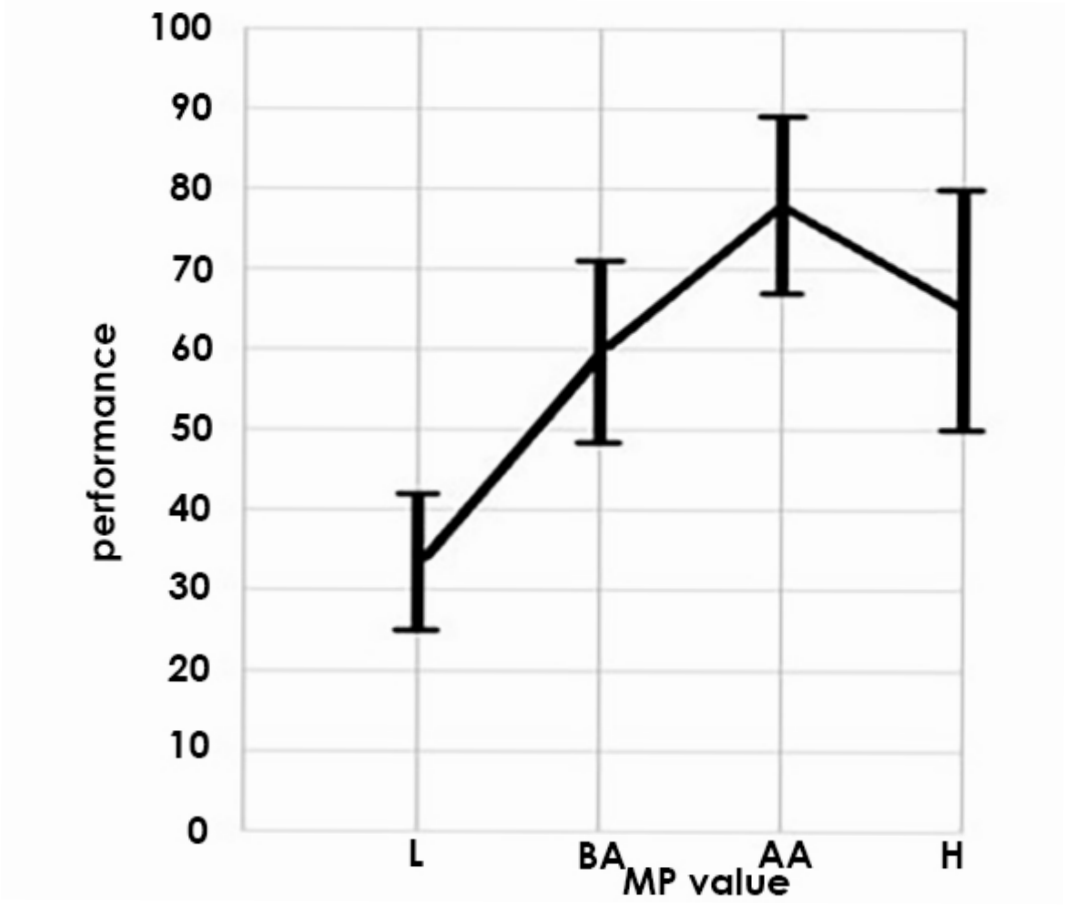


Note. The ordinate axis shows the values of the expert assessment methodology

The analysis of the results shown can clarify the following facts. First, in terms of quality and performance parameters, a scenario of the most general plan is revealed, in which there are in fact certain relationships between them and the individual levels of MP severity. Secondly, these dependencies are generally nonlinear, which indicates their complex nature, albeit indirectly. Thirdly, these dependencies are largely opposite. If the first one explicates positive dynamics, the second one explicates negative dynamics more generally.

Figure 2

Dependency of the efficiency of activity on the value of MP



Note. MP value: L – low, BA – below average, AA – above average, H – high.

These results enable us to clarify another important fact. The highest values of the efficiency parameter are associated with relatively high MP (in the subgroup with above average values of MP), not with minimum or maximum MP values. Therefore, the greatest efficiency is achieved in individuals with some intermediate, although, we repeat, quite well-developed MP level. Therefore, not only a low level of MP severity is associated with relatively low efficiency (which is quite understandable), but the highest level also causes a decrease in efficiency (which is less clear and requires a special explanation). This proves that there is a dependency of an optimum type, rather than a maximum type between the variables, as we previously predicted.

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Discussion

The results presented above enabled us to establish the following main features and regularities.

First, the circumstance that was stated above as a general assumption as an initial one was confirmed with a sufficiently high degree of clarity. It is based on the fact that there are quite natural connections and dependencies between the individual measure of the severity of MP and the two main effective parameters of activity (quality and performance). In the most general and fundamental terms, this indicates that the metacognitive qualities themselves, as well as their integrative effect – a measure of the severity of MP, are indeed significant determinants of effective parameters of activity.

Secondly, these two dependencies are characterized by fundamental commonality and even more obvious differences. On the one hand, their commonality is that both are usually not directly proportional, but nonlinear, which shows their complex and indirect nature. However, the differences in the dependent variables identified are more obvious: if the first variable is positive, the second one explicates the negative dependency dynamics. At the same time, we should note that, in general, both are well in line with the similar dependency established in the psychology of professional activity regarding the two main effective parameters – performance and quality. Furthermore, their overall interpretation should be similar to that previously made. The dynamics identified is not as pronounced as previously discovered, so they are unique in terms of characteristics of many other types of activity. Furthermore, with regard to quality parameters, it slightly changes its general form, changing from a maximum type dependency to an optimum type dependency. Overall, however, when comparing them, we revealed the most general circumstance, i.e., between these two parameters, there is a reciprocal relationship, which manifests itself in the dynamics of mutually opposite transformation.

Thirdly, synthesizing all these results, as well as supplementing them with the data presented in Fig. 2, we should explicate the circumstance of the generalized plan. This is the result of a very clear relationship between the individual level of MP severity and the most common integral effective parameter (efficiency). Furthermore, contrary to the a priori prediction and theoretical expectations, it is not the maximum type dependency, but the dependency of the *optimum* type with the characteristics of the reverse U-shaped curve. As mentioned above, this means that the maximum efficiency of activity is associated with an intermediate MP value. Not only low (natural), but also high (less obvious) severity of MP is the reason for a decrease in the effectiveness of this kind of professional activity.

High MP values are objectively associated with significant reflexivity. In addition to the direct negative effects – inhibitors – and even blocking the cognitive functions (especially the key characteristics of creativity, independency, and constructiveness in decision-making), it has a unique indirect influence. Thus, reflexivity is 'related' to many of these individual qualities which are 'contraindications' of many kinds of professional activity, especially complex and cognitively saturated (especially neuroticism, sensitivity, rigidity, development of psychological defenses, etc.). Similar dependencies were found in the previous study of the effectiveness of the most important professional activity, the leadership activity, associated with the intelligence level (Ghiselli curve, (Ghiselli 1963)).

In the same context, we should mention such functionally similar phenomena as the effect of the metacognitive loop (Metcalfe, 2019); the phenomenon of paralysis-by-analysis (Kolb et al., 1984); the phenomenon of 'metacognitive perfectionism' (Kluwe, 1982); the phenomenon of a moratorium of reflexivity (Karpov, 2021), the effect of hypercontrol (Karpov, 2022); and

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the phenomenon of metacognitive blockade, etc. They indicate that the metacognitive control of activity functions, being generally positive over a sufficiently large interval of its measure, can, however, be transformed into its opposite. In fact, the situation is similar to the concept of 'double-function operation mode' (Karpov, 1980). In general, the implementation of activity functions and cognitive functions is guaranteed in particular in parallel with the metacognitive functions behind this implementation and in some cases comes first. This situation requires the redistribution of common cognitive resources to implement metacognitive control and has a negative impact on the implementation of the main activities and tasks. Furthermore, we have found that the relationship between the level of MP and the important cognitive processes such as thought depends on the type of optimality (Karpov, 2021). Thus, not only low MP values but also high ones are counterproductive, especially under very severe conditions of professional activity.

Obviously, the main and fundamental reason for all these similar patterns is the fact that the deterministic influence of metacognitive factors in general, and in particular the impact of reflection on performance parameters, structural components and processes supporting them, is not only complex, but also internal contradiction. It is ambivalent in its direction. On the one hand, it has a positive facilitating effect, which leads to the extension of the functional abilities of the subject and the realization of its resource functions. This is exactly what occurs when the MP values are average and above average (see Fig. 2). On the other hand, it can also have the opposite effect – negative effect that inhibits the functional ability of the subject. This is associated with high MP values. In other words, its impact is essentially *diversified* depending on its specific measure of severity and its degree of representation in the situation. As this measure increases, it changes from positive to negative.

Fourthly, it should be taken into account that we have previously established an overall similar dependency of the optimum type with respect to another main type of professional activity – management (which, in addition, belongs to another type of activity – subject-subject). In addition, it is also explicated in relation to a number of other types of activities – in particular, education, operator activities, etc. It is therefore of a very general nature, as Karpov demonstrated (2015). Here are two important conclusions. On the other hand, the discovery of a new type of activity – information-related activity – increases the extent of its generalization and consequent importance, as a fundamental invariant regularity in the organization of activity as a whole. On the other hand, its establishment in relation to itself is an additional new result that extends the general idea of metacognitive regulation of information activity. At the same time, through this prism, a deep commonality of basic means and mechanisms for organizing fundamentally different kinds and even types of activity is revealed, which are means of their metacognitive regulation and are therefore conscious and arbitrarily controlled. It is also important that they are precisely located at the consciousness and therefore the highest level of their organization, which is crucial for their effective parameters in general and especially efficiency.

Fifthly, when interpreting the data obtained, it is also necessary to take into account the most important and specific features of computer technology. A closer examination reveals a kind of non-reflexive specificity of such a technology, the computer technology, which manifests itself in many important aspects. Firstly, the specificity of this activity lies in its highly pronounced algorithmic characteristics, which is largely contrary to the variability in the organization and behavior of the activity itself.

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All of this leads to the 'machine-like' and formalized nature of this activity, which is antagonistic to reflection as a 'purely human' quality. The specific characteristics of this activity include not only large amounts of information, but also high dynamic characteristics, which require processing speeds, content changes and rapid implementations. This in turn results in the objective removal of the possibility of reflection breaks and successive metacognitive monitoring. Moreover, it began to act here, even negatively, as it prevented the execution of major functions of activity. In this respect, there is even a work rule established empirically – 'consciously accelerate' – which is equivalent to the same arbitrary minimization of the phenomenon of reflexive control and non-reflexive. In this regard, it is necessary to point out one of the important means of its organization established and interpreted in modern cognitive psychology – the so-called cognitive control blockade heuristics (Anderson, 1985; Metcalfe & Eich, 2019).

However, this type of blockade can be implemented not only in 'primary' cognitive processes, but also in secondary (metacognitive) ones and in a much more pronounced and subjectively distinct form. The essence of such a 'secondary', i.e., a metacognitive 'blockade', is that the metacognitive processes themselves act as a means of inhibition or even 'rejection' of the correct means of reflection. Finally, the direct interaction between the subject and object in the process of activity takes place almost entirely with a 'non-animate' entity – the computer. This stimulates the development of professional deformations, including isolation and introversion in IT specialists, and reduction of communication contacts. In this respect, Zakhur stated that "programmers have incorporated a distant metaposition to everything" (Zakhur, 2018).

Conclusions

The following main *conclusions* can be drawn by summarizing the results of the analysis above. *Firstly*, metacognitive qualities are indeed important and complex factors in the effective parameters of programmers' activity and should therefore be interpreted as important factors that form the general composition of their subjective determinants.

Secondly, there are certain correlations between the individual MP severity measure and the main resulting parameters of this activity (quality and performance), which explicates the invariant nature of the determinative role of metacognitive factors. These are the opposite directions of the two main parameters. With regard to quality parameters, this dependency is usually direct; with regard to performance, it is opposite.

Thirdly, there is a dependency between individual measures of MP severity and the most generalized effective parameter (efficiency) that have optimum type characteristics. This means that the maximum efficiency of activity is associated with a sufficiently high but average MP value.

Fourthly, the deterministic influence of MP on the effective parameters of programmers' activity is fundamentally different - not only in degree, but also in direction and character. The combination of positive and negative characteristics ultimately determines the complexity and nonlinear nature of this influence and the content and type of the most common dependency – the efficiency of activity depends on the degree of its development.

Fifthly, there is a fundamental commonality not only in the nature of the dependency in specific activity, which occurs not only in other types but also in other kinds of activity, but also in the basic causes and factors underlying them, and thus explaining them.

Sixthly, the negative effect of metacognitive factors on the effective parameters of activity depends on a combination of their direct and indirect impact on the implementation of activity

and certain functions supporting it. The direct effect is that these functions are generally and particularly inhibited, and this manifests itself in the phenomenon of cognitive and metacognitive blockade. The indirect effect is to facilitate the negative impact of several other important factors. This explicates not only the internally contradictory but also complex nature of its determinative impact on the main effective parameters of the activity.

Conclusion

Metacognitive qualities have a significant and complex effect on the resulting parameters of information activity. Individual metacognitive potential measures and the main effective parameters of information-related activity – quality, performance, and efficiency – are closely related. The main regularity of the correlation between metacognitive potential and effective parameters of activity is the optimum type dependency, based on a combination of facilitating and inhibitory effects of the subject's metacognitive potential on the implementation of activity.

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Annex 1

	Inventory items	1	2	3	4	5
1	He/she is characterized by the ability to clearly formulate goals					
2	He/she performs tasks faster than most other employees					
3	He/she performs tasks better than most other employees					

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	Inventory items	1	2	3	4	5
4	His/her code quality is characterized by adequate implicit expectation					
5	He/she often fails to meet deadlines for tasks					
6	He/she is capable of non-standard solutions and finds new ways to perform tasks					
7	He/she adequately assesses the complexity of tasks					
8	He/she requests more time for tasks					
9	He/she has extraordinary results in work					
10	He/she responds constructively to blocking processes that affect the 'health' of the product					
11	He/she rarely performs tasks in time					
12	His/her colleagues often seek advice from him					
13	He/she performs almost all tasks at the average level of effort					
14	He/she adequately estimates deadlines, completes tasks in time					

	Inventory items	1	2	3	4	5
15	He/she systematically assumes leadership roles in a team					
16	His/her products have few features that have been rejected or returned for revision					
17	He/she achieves goals through overtime work					
18	He/she knows how to make right decisions					
19	He/she worked a long time in the company					
20	He/she knows how to manage time and give proper priority to complete work in time					
21	He/she has a long IT product uptime					
22	He/she is characterized by a small number of defects found during the product operation					
23	He/she is characterized by a rapid meeting deadlines					
24	His/her colleagues highly appreciate him/her as a specialist					
25	He/she possesses perseverance and discipline					
26	He/she makes mistakes due to failure to meet deadlines					
27	He/she maintains high quality even when tasks become more complex					

	Inventory items	1	2	3	4	5
28	He/she can understand the code of someone else					
29	He/she is characterized by a large number of tasks completed per working day/hour					
30	He/she has great learning abilities; quickly absorbs new knowledge					

The experts worked in accordance with the following instructions: "Please evaluate whether the following statements correspond to the employee. The more fair it is, the greater the evaluation should be. Evaluating options: 1 – it does not seem to correspond at all; 2 – it is more likely not corresponding; 3 - I cannot say for sure; 4 – it is rather corresponding than not corresponding; 5 – it is fully corresponding. Items 1, 4, 7, etc. assess quality; items 2, 5, 8, etc. assess performance; items 3, 6, 9 assess efficiency. Items 5, 8, 11, 23 and 26 are reversed.

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Author Contribution

Anatolii Viktorovich Karpov developed the research concept and supervised the study on the basis of metacognitive methodology for the development of the issues of information-related activity, contributed to theoretical generalization of the results.
Aleksandr Anatol'evich Karpov developed the research concept using the methodology of metacognitivism, processed data, and interpreted the results.
Yuliya Vladimirovna Filippova contributed to the experimental design of the study, carried out the empirical study using the Complex Inventory on Metacognitive Potential, collected the data, and interpreted the results.

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Conflict of Interest Information

The authors have no conflicts of interest to declare.