

Theoretical paradigms of multitasking research: from classical models to an integrative approach

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Abstract: Problem. Digitalization of the professional environment necessitates the simultaneous or alternating execution of multiple heterogeneous tasks under time constraints, which brings the scientific understanding of the phenomenon of multitasking to the forefront. Despite a significant volume of research, there is no unified theoretical framework in this area, which integrates the achievements of various scientific disciplines. **Aim.** To systematize the main theoretical paradigms of multitasking research and analyze the psychological structure of multitasking activity. **Methods.** The methodological basis was a theoretical review of the literature, including peer-reviewed empirical and theoretical works indexed in the Web of Science, Scopus, PubMed, and RSCI databases, with an emphasis on recent studies and classical works that laid the foundation for the study of multitasking. **Results.** Five key paradigms were identified: the successive paradigm, which reveals the mechanisms of sequential information processing; the simultaneous paradigm, which emphasizes the possibilities of parallelism; the resource paradigm, which interprets attention as a distributable resource; the neurocognitive paradigm, which identifies brain mechanisms; and the ecological paradigm, which considers multitasking as an adaptive mechanism. **Conclusions.** It was established that the psychological structure of multitasking activity includes three interrelated levels: the micro-level of switching operations, the macro-level of coordination strategies, and the meta-level of self-regulation. The prospects of integrating ideas from different paradigms within a multilevel approach are shown, taking into account both the objective limitations of the cognitive architecture and the possibilities of overcoming them through automation, strategic organization of activity, and metacognitive regulation.

Keywords: multitasking; task switching; executive functions; working memory; cognitive flexibility; attention; cognitive resources; metacognition

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INTRODUCTION

The modern professional environment is characterized by an unprecedented level of complexity, dynamism, and information saturation. Rapid digitalization, the penetration of information and communication technologies into all spheres of work, and the globalization of economic processes are radically transforming the nature and content of professional labor [1; 2]. The contemporary worker exists under conditions of a constant information flow, where the boundaries between work and personal space are becoming increasingly blurred, and the demands for data processing speed and decision-making are steadily rising.

One of the key features of professional activity in the 21st century is the growing phenomenon of multitasking – the need for simultaneous or alternating execution of multiple diverse tasks under conditions of acute time pressure [3]. High event density, frequent interruptions, and constant switching between diverse activity contexts are turning from an exception into the norm of professional life [4]. Moreover, after an interruption, a worker typically requires a significant amount of time to restore fully concentration on the original task.

At the same time, numerous studies convincingly demonstrate the existence of a fundamental contradiction between the environmental demands for multitasking functioning and the objective limitations of the human cognitive system [5; 6]. Human attention, working memory, and executive functions have limited capacity, which makes truly parallel processing of complex information impossible [7]. Attempts to perform multiple cognitively demanding tasks simultaneously inevitably lead to switching costs, an increase in the number of errors, and a decrease in the quality of work [8].

The issue of multitasking is actively being developed within various psychological frameworks. General theoretical approaches to understanding multitasking as a specific mode of cognitive functioning are presented in the classical works of D.E. Broadbent [9], D. Kahneman [10], H. Pashler [5], as well as in modern integrative models by D.D. Salvucci and N.A. Taatgen [11], and C.D. Wickens [12]. In recent years, special attention has been paid to the neurocognitive mechanisms of cognitive flexibility [13; 14], the influence of media multitasking on cognitive control [15; 16], and the development

of training programs for enhancing multitasking competencies [17; 18]. In Russian psychology, the problem of multitasking is being developed mainly in the context of research on attention, activity, and adaptation [19].

At the same time, the analysis of the literature indicates the presence of significant gaps in the theoretical understanding of the phenomenon of multitasking. Most existing models focus on individual aspects of the problem, failing to offer an integrative view of their interaction. The predominance of laboratory studies with artificial tasks limits the ecological validity of the obtained results [4; 20].

The aim of this review is to systematize the main theoretical paradigms of multitasking research and analyze the psychological structure of multitasking activity in order to identify possibilities for integrating different approaches.

METHODS

The present study is a theoretical review of the literature. The search for publications was carried out in the Web of Science, Scopus, PubMed, and RSCI databases using the key terms: multitasking, task switching, executive functions, working memory, cognitive flexibility, attention, and their Russian-language equivalents. The review includes both recent studies (2020-2026) reflecting the current state of discussions in this field and fundamental classical works that laid the foundation for the study of multitasking and are necessary for understanding the evolution of theoretical approaches. The review included peer-reviewed theoretical and empirical works on the cognitive mechanisms of multitasking, meta-analyses, as well as review articles systematizing the accumulated data. The analysis involved the systematization of theoretical paradigms, comparative analysis of concepts, and synthesis of an integrative understanding of the phenomenon.

RESULTS

1. Main theoretical paradigms of multitasking research

A systematic analysis of the scientific literature allowed revealing five main theoretical paradigms within which the phenomenon of multitasking is conceptualized: the successive (sequential), simultaneous (parallel), resource, neurocognitive, and ecological paradigms. Each offers its own explanation of the nature, mechanisms and limitations of parallel information processing.

Successive paradigm

The successive paradigm is historically one of the first theoretical frameworks for understanding multitasking. Its central thesis is that the human cognitive system can only process one stimulus at any given moment, and the apparent simultaneity of performing several tasks is actually the result of rapid sequential switching of attention between them.

The filter model proposed by D.E. Broadbent in his work “Perception and Communication” represents a model

of sequential processing with a limited channel capacity [9]. According to this model, all incoming sensory signals are initially processed in parallel at a peripheral level; however, only some of them, selected by a selective filter based on physical characteristics (source location, voice pitch, volume), are admitted into the limited-capacity perceptual channel for further semantic recognition.

The successive paradigm was significantly developed in the works of H. Pashler [5], who formulated the “bottleneck hypothesis”. According to this concept, the key limitations of multitasking are localised not at the peripheral sensory stages, but at the central stages of cognitive processing – in decision-making and response selection processes. H. Pashler experimentally demonstrated the phenomenon of the psychological refractory period – the minimum time interval between the end of one response and the possibility of initiating the next. This period is necessary for reconfiguring the cognitive system to meet the demands of a new task, and its magnitude directly depends on the complexity of both tasks and the degree of their automation.

Contemporary research develops these ideas, showing that switch costs scale with the conceptual distance between tasks: the greater the difference between task representations, the higher the cognitive cost of switching [21]. This aligns with the notion of tasks as cognitive maps, where the magnitude of costs reflects the “distance” between representations in psychological space.

For all its explanatory power, the successive paradigm has several significant limitations. First of all, it underestimates the possibilities of parallel information processing at early sensory stages. Furthermore, this approach does not fully account for the role of skill automation: regular practice in performing related tasks leads to the formation of automated coordination schemes, significantly reducing switch costs [9; 18].

Simultaneous paradigm

As an alternative to the successive approach, the simultaneous paradigm emerged in cognitive psychology, postulating the possibility of truly parallel processing of multiple stimuli, at least in the early stages of information processing.

A. Treisman made a key contribution to the development of this direction through a series of dichotic listening experiments [22]. The results showed that, although semantic analysis did require switching between channels, low-level physical characteristics of the signal (speaker’s gender, voice timbre, intonation) were processed in parallel. Based on this data, A. Treisman formulated the concept of sensory “feature dictionaries” – relatively autonomous modules for processing basic perceptual characteristics, functioning in a simultaneous mode [23].

According to the constructivist interpretation of perception, parallel processing of sensory signals serves as the basis for the formation of perceptual schemas and anticipations. The limitations of multitasking are associated not so much with the sequential nature of processing, but with the capacity of the attention and working memory system, and practice and skill automation can significantly expand the possibilities of performing tasks in parallel.

The simultaneous paradigm allows understanding how a person can simultaneously monitor multiple environmental parameters, integrating multimodal information into a coherent picture of a situation. However, this approach insufficiently accounts for the "bottlenecks" at the central processing stages related to decision-making, planning, and action coordination [6].

Resource paradigm

Resource models offer a kind of compromise between the successive and simultaneous paradigms, treating attention as a limited but distributable resource. In this view, the success of multitasking in this perspective is determined by the balance between task demands and available cognitive resources.

D. Kahneman made a fundamental contribution to the development of the resource approach in his monograph "Attention and Effort" [10]. The central construct of his theory is the concept of cognitive effort – a limited resource expended during mental operations. D. Kahneman draws a fundamental distinction between automatic processes, which occur quickly, without effort, and without interference with each other, and controlled processes that require conscious attention, are subject to capacity limitations, and are susceptible to mutual interference.

The resource approach was significantly developed in the works of C.D. Wickens [12], who proposed the concept of multiple resources. Unlike D. Kahneman's unitary model [10], C.D. Wickens posits the existence of several relatively independent pools of information processing. He identifies three dimensions of resources: modality of input (visual / auditory), stages of processing (perception / cognition / motor response), and codes of representation (spatial / verbal) [12]. According to this model, tasks that differ in at least one of these dimensions will create less mutual interference and are easier to perform simultaneously.

Contemporary research confirms the practical significance of the resource approach. For instance, it has been shown that multitasking significantly increases demands on the attention control system, particularly in aspects of sustained attention and switching [24]. Meta-analyses demonstrate that frequent media multitasking is associated with a moderate negative effect on cognitive control, especially inhibitory control and working memory [15].

Resource models have high practical relevance for workplace design and workload distribution. However, the construct of "resource" remains largely speculative: there are no reliable methods for independently measuring its capacity and distribution.

Neurocognitive paradigm

The development of neuroimaging methods opened up opportunities for studying the brain mechanisms of multitasking, leading to the formation of the neurocognitive paradigm. This approach focuses on identifying the neural networks and structures that support attention distribution and coordination of parallel processes.

Contemporary neuroimaging studies have identified the key role of the frontoparietal network (FPN) and

the dorsal attention network (DAN) in providing cognitive flexibility and task switching [13; 25]. A review of task-switching research shows that the left inferior frontal junction, intraparietal sulcus, and pre-supplementary motor area are key regions activated during switching [13]. Meanwhile, the dorsolateral prefrontal cortex (DLPFC) plays a critical role in representing task rules and coordinating switching [26; 27].

Of particular interest are data on the functional connections between cognitive control networks and the default mode network (DMN). Research shows that antagonistic relationships between these networks mediate task switching and the maintenance of task engagement [13]. An imbalance between networks may underlie individual differences in multitasking ability.

Neurocognitive models allow uncovering the biological mechanisms of multitasking and identify neural correlates of individual differences. A limitation of this approach remains the predominantly laboratory-based nature of the research, which is not always relevant to the complex dynamics of real professional contexts.

Ecological paradigm

The ecological approach offers a fundamentally different perspective for analysing multitasking, considering it not as a laboratory phenomenon, but as an evolutionarily formed adaptive mechanism for human functioning in an information-saturated environment.

From the standpoint of the ecological approach, "natural" multitasking is not reducible to discrete switching between competing tasks but represents a continuous process of attention distribution and coordination of actions of different scales and time perspectives [28]. Multitasking in real-world conditions is inextricably linked to the ability for goal-setting, planning, prioritizing, and forming intentions for the future. A person proactively organizes their activity, integrating many goals of varying urgency and significance into a coherent behavioral trajectory. Thus, multitasking acts as an adaptive meta-skill.

Contemporary research within the ecological framework focuses on the work environment and employee well-being. It has been shown that multitasking indirectly affects subjective productivity by reducing the flow state and changing the appraisal of tasks as less challenging [29].

The ecological approach has high validity for understanding natural multitasking; however, it sometimes underestimates the objective limits of parallel information processing. As research [30] shows, chronic intensive multitasking is associated with significant cognitive costs that cannot be fully compensated by adaptive strategies.

2. Psychological structure of multitasking activity

A significant limitation of the reviewed paradigms is their primary focus on cognitive mechanisms, with insufficient attention paid to the psychological structure of multitasking activity as an integral system. Meanwhile, understanding the organization of multitasking activity at various levels opens up possibilities for identifying points of application for developmental interventions.

Micro-level: switching mechanisms

At the micro-level, the key issue is switching between competing tasks. According to the classical model of J.S. Rubinstein, D.E. Meyer, and J.E. Evans, this process includes three sequential stages [24]. The first stage – preparation to terminate the current task – involves completing or postponing unfinished cognitive and motor operations. The second stage – switching itself – represents the reorientation of attention to the stimuli and demands of the new task. The third stage – configuration – means adjusting the cognitive system to perform the new task.

Each of these processes requires time and resources, leading to characteristic switch costs manifested in increased reaction time and a rise in the number of errors [8]. Moreover, residual interference from the previous task can persist for several tens of seconds or even minutes [9].

Contemporary research shows that the level of cognitive flexibility (the magnitude of switch costs) is not fixed but adaptively changes depending on the context [14]. Two key factors modulating switch costs are the frequency of switching and the prospect of reward. People adapt their readiness to switch to changing circumstances through learning mechanisms.

The concept of the psychological refractory period [5] – the minimum time interval required for reconfiguring the cognitive system – is closely related to the switching phenomenon. It is important to note that practice in performing related tasks can significantly reduce both switching time and the duration of the refractory period [30]. The improvement mechanism is associated with the optimization of task coordination skills and more efficient loading of information about task components into working memory [18].

Macro-level: activity coordination strategies

At the macro-level, the phenomenon of multitasking appears as the organization of an integral system of activity, involving the parallel development of many tasks of different types and scales.

Researchers identify four key multitasking strategies: simultaneously performing several tasks that allow parallel processing; rapid switching between tasks in a quasi-parallel mode; processing tasks in sequential blocks, allowing relatively long periods of concentration; and flexible combination of these modes depending on situational demands [4].

The choice of strategy is determined both by objective task characteristics and by individual preferences – activity styles. Two polar types are distinguished – monoactive (orientation towards sequential task solving) and polyactive (tendency towards parallel handling of many affairs) [20].

Productivity in a multitasking environment is determined by the effectiveness of overall activity coordination, which involves constant situation monitoring, flexible change of priorities, and balancing resources between competing tasks [3]. Research on work interruptions shows that the perception of interruptions as more stressful depends on the complexity of the interrupted primary task: interrupting more complex tasks creates greater cognitive load [31].

Meta-level: self-regulation and reflection

The meta-level of organizing multitasking activity is associated with the management and reflection of one's own modes of operation. Research shows that successful "multitaskers" are distinguished both by developed executive functions and by pronounced metacognitive skills. They plan the structure of their activity better, more often evaluate its progress relative to set goals, and notice errors and adjust strategies more quickly.

A special role is played by prospective metamemory – the ability to accurately assess one's own capacity for retaining intentions and plans for future activities. The capacity of "memory for the future" acts as an important limiting factor in multitasking activity, determining the number of goals and subtasks a person can effectively coordinate.

Metacognitive planning skills include the ability to anticipate potential difficulties, allocate time between tasks, and set realistic deadlines. Monitoring skills ensure continuous tracking of activity progress and detection of deviations. Control skills are aimed at correcting strategies and reallocating resources.

Contemporary research emphasizes that metacognitive regulation includes continuous monitoring of cognitive processes, evaluation of their results, and corresponding adjustment of cognitive behavior [32]. Metacognitive abilities enhance the advantages of cognitive reserve for cognitive performance during the aging process, acting as a mediator.

DISCUSSION

Comparative analysis of theoretical approaches

The conducted analysis allows stating that the modern understanding of multitasking relies on several key theoretical paradigms, each possessing certain heuristic possibilities and limitations.

The successive paradigm convincingly reveals the structural limitations of the human cognitive system. The filter model and the "bottleneck" hypothesis explain the phenomena of interference and switch costs well. The strength of this approach is its experimental validity and the possibility of quantitatively assessing cognitive costs. At the same time, successive models underestimate the possibilities of parallel processing and the role of skill automation.

The simultaneous paradigm focuses attention on the possibilities of truly parallel stimulus processing and emphasizes the importance of practice in expanding the possibilities of parallelism. However, simultaneous models do not always account for the "bottlenecks" at the central stages of cognitive processing.

Resource models offer an integrative view of multitasking, linking its effectiveness to the balance of demands and available resources. C.D. Wickens's concept of multiple resources [12] is particularly valuable for understanding the compatibility of different task combinations. At the same time, the "resource" metaphor does not always allow considering the qualitative uniqueness of cognitive strategies.

Neurocognitive models reveal the brain mechanisms of flexible attention distribution and provide a neurobio-

logical foundation for understanding multitasking. The limitation remains the predominantly laboratory nature of the research.

The ecological approach embeds multitasking into the real context of life and activity, emphasizing its functional significance and adaptive potential. However, it sometimes underestimates the objective limits of parallel information processing.

Prospects for paradigm integration

Analysis of contemporary literature indicates a pronounced trend towards integrating ideas from different paradigms. The theory of the multitasking mind by D.D. Salvucci and N.A. Taatgen [11] combines notions of resource limitations with ideas about the multilevel organization of cognitive processes.

In our view, the integration of ideas from different paradigms within a multilevel approach appears most productive. Such an approach should account for both the objective limitations of the cognitive architecture (contribution of the successive and resource paradigms) and the possibilities of overcoming them through automation, strategic organization of activity, and metacognitive regulation (contribution of the simultaneous and ecological paradigms). At the same time, neurocognitive data allow verifying theoretical constructs.

Productive functioning in multitasking environments requires the simultaneous operation of processes at different scales: at the micro-level – switching operations and interference management; at the macro-level – strategies for coordinating integral activity; at the meta-level – processes of conscious self-regulation. Such a multilevel perspective allows overcoming the limitations of partial models.

Limitations of existing research

Despite the significant volume of accumulated data, the field of multitasking research is characterized by several substantial limitations.

The first limitation is associated with the predominance of laboratory studies over ecologically valid ones. Most classical experiments were conducted under strictly controlled conditions using simple stimuli [5; 8]. Although this approach ensures high internal validity, its results are not always transferable to the complex dynamics of real professional activity [4].

The second limitation is due to the ambiguity in operationalizing key constructs. The concept of "multitasking" is used to denote heterogeneous phenomena – from simultaneously performing two simple laboratory tasks to coordinating multiple professional projects [4; 11]. This complicates the comparison of results from different studies.

The third limitation is related to the deficit of longitudinal studies on the development of multitasking competencies. Most works are cross-sectional in nature, which does not allow revealing the dynamics of multitasking skill formation and the role of professional experience in their development.

Prospects for future research

The identified limitations determine several priority directions for further research.

The development of integrative models considering the interaction of factors at different levels appears to be a primary task. Research is needed to reveal the mechanisms of interaction between cognitive abilities, metacognitive strategies, and personal-motivational characteristics in the process of adaptation to multitasking.

Increasing the ecological validity of research requires the development of methods for studying multitasking in natural professional contexts. Diary methods, experience-sampling studies, and analysis of digital traces of activity open up prospects for overcoming the limitations of laboratory paradigms.

Research on training programs for developing multitasking competencies holds particular promise. Meta-analyses show that dual-task training can significantly improve both cognitive functions (global cognition, executive functions) and physical indicators in various groups [17]. Moreover, programs combining cognitive and motor load prove to be the most effective.

Longitudinal studies of the trajectories of multitasking competency development will allow understanding how effective multitasking skills are formed during the professional career, and what role is played by targeted training and practical experience.

CONCLUSIONS

Multitasking represents a complex, multilevel phenomenon that requires the integration of various theoretical approaches for a comprehensive understanding. Reducing multitasking to any single level of analysis inevitably leads to a simplified understanding of this phenomenon.

Contemporary theoretical paradigms reveal different aspects of multitasking, yet none of them is exhaustive. The successive paradigm captures the limitations of sequential processing, the simultaneous paradigm addresses the possibilities of parallelism, the resource paradigm focuses on the balance of demands and capabilities, the neurocognitive paradigm explores the brain mechanisms, and the ecological paradigm highlights the adaptive significance in real-world contexts. A synthesis of ideas from different paradigms appears productive.

The psychological structure of multitasking activity includes three interrelated levels: the micro-level of elementary operations of switching and reconfiguration of the cognitive system; the macro-level of strategies for coordinating integral activity; and the meta-level of processes of conscious self-regulation, reflection, and planning.

A promising direction is the development of integrative models that combine ideas from different paradigms within a multilevel approach, considering both the objective limitations of the cognitive architecture and the possibilities of overcoming them through automation, strategic organization of activity, and metacognitive regulation.

Priority tasks for further research include increasing ecological validity by studying natural multitasking; conducting longitudinal studies on the development of multitasking competencies; and developing a unified conceptual framework and methods for operationalizing key constructs.

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Теоретические парадигмы исследования многозадачности: от классических моделей к интегративному подходу

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Аннотация: Проблема. Цифровизация профессиональной среды обуславливает необходимость одновременного или попеременного решения множества разнородных задач в условиях дефицита времени, что актуализирует научное осмысление феномена многозадачности. Несмотря на значительный объем исследований, в данной области отсутствует единая теоретическая рамка, интегрирующая достижения различных научных направлений. Цель. Систематизация основных теоретических парадигм исследования многозадачности и анализ психологического строения многозадачной деятельности. Методы. Методологическую основу составил теоретический обзор литературы, включающий рецензируемые эмпирические и теоретические работы, представленные в базах данных Web of Science, Scopus, PubMed и РИНЦ, с акцентом на исследования последних лет и классические труды, заложившие основу изучения многозадачности. Результаты. Выявлены пять ключевых парадигм: сукцессивная, раскрывающая механизмы последовательной обработки информации; симультанная, акцентирующая возможности параллелизма; ресурсная, трактующая внимание как распределяемый ресурс; нейрокогнитивная, идентифицирующая мозговые механизмы; экологическая, рассматривающая многозадачность как адаптивный механизм. Выводы. Установлено, что психологическое строение многозадачной деятельности включает три взаимосвязанных уровня: микроуровень операций переключения, макроуровень стратегий координации и метауровень саморегуляции. Показана перспективность интеграции идей различных парадигм в рамках многоуровневого подхода, учитывающего как объективные ограничения когнитивной архитектуры, так и возможности их преодоления посредством автоматизации, стратегической организации деятельности и метакогнитивной регуляции.

Ключевые слова: многозадачность; переключение задач; исполнительные функции; рабочая память; когнитивная гибкость; внимание; когнитивные ресурсы; метакогниция

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