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# WHAT IS A PROBLEM IN THE PSYCHOLOGY OF THINKING AND WHY IS IT NEEDED

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## Что такое задача в психологии мышления и почему она нужна

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**Abstract**

This paper is focused on the problem as the main tool for modeling of thinking and creativity. It traces the history of using problems in the psychology of thinking and analyzes how classical works in this field describe the relationship between a problem, a task, a problem situation, etc. Problem complexity is treated as the key property that allows researchers to study patterns of the solution process. Two main methods of complexity manipulation are facilitation and

**Резюме**

В статье рассматривается задача как основной инструмент моделирования мышления и творчества. Прослеживается история использования задачи в психологии мышления и анализируются позиции авторов классических работ о соотношении задачи, проблемной ситуации и других сходных терминов. Сложность задачи рассматривается в качестве ключевого свойства, позволяющего изучать закономерности процесса решения. В качестве основных направлений манипуляции сложностью рассматриваются фасилитация и ингибиция.

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inhibition. Each may be external or internal in relation to the problem. Studies of external facilitation look at series of similar problems with a gradual increase in complexity, while internal facilitation involves the reduction of sources of difficulty using a hint. External inhibition studies analyze the role of past experience or social pressure, while internal inhibition entails "reverse hints" that lead the participants away from the correct solution path. This article discusses the following issues: which part of the solution should be complicated to further the theories of problem solving? Can the complication of a problem turn it into a qualitatively more complex problem? Internal problem structure is found to be stable, since all experimental manipulations affect the solution process but leave the essence of the problem intact.

*Keywords:* problem, hint, facilitation, inhibition, complication, distractor, insight, creative problem, psychology of thinking.

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Каждая из них может быть внешним и внутренним по отношению к задаче. Исследования внешней фасилитации рассматривают серии схожих задач с постепенным увеличением сложности, в то время как исследования внутренней фасилитации используют редукцию основных источников сложностей задачи при помощи подсказки. Исследования внешней ингибиции анализируют роль прошлого опыта или социального давления, тогда как исследования внутренней ингибиции привлекают «подсказки наоборот», уводящие испытуемых от верного пути решения. В этой статье обсуждаются следующие вопросы: усложнение какой части решения принесет пользу для развития теорий решения задач? Может ли усложнение задачи превратить ее в качественно более сложную? Внутренняя структура задачи оказывается устойчивой, так как все экспериментальные манипуляции влияют на процесс решения, но не затрагивают суть задачи.

*Ключевые слова:* задача, подсказка, фасилитация, ингибиция, усложнение, дистрактор, инсайт, творческая задача, психология мышления.

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In the psychology of thinking, the problem is the main object of research, a model of thinking and creativity, and a unit of measurement. Today the dominant paradigm in this field is problem solving. It implies that thinking is studied through problem solving and it explains only the choice of the problem type for a certain study. But what is the definition of a problem? How did the problem become the main research material in the psychology of thinking and creativity? How effective are manipulations with problem complexity? What are the highest and lowest degrees of complexity for a certain problem? This paper focuses on ways of changing problem complexity, leaving the theories of problem solving out of scope, since their comparison calls for a separate publication.

## Problem

The problem was first used for the study of thinking by the Würzburg school researchers. In particular, H.J. Watt provided a definition, which was closer to *understanding* rather than *thinking* in modern terms (Petukhov, 1987). With the advent of Gestalt psychology, the problem became the main method for the study of thinking (Wertheimer, 1987; Duncker, 1945). Petukhov defines thinking in the narrow sense as a process of problem solving (Petukhov, 1987, p. 6). Brushlinsky provides a milder wording for the same idea: Thinking is most clearly manifested in the course of setting and solving a problem (Brushlinsky, 1970, p. 52). Ponomarev writes that an artificially created problem is a simplified model of thinking that is convenient for laboratory use, and that the essential analysis of solution—without reference to specific problem content — makes it possible to reveal the psychological mechanism of thinking (Ponomarev, 1999). Ohlsson postulated that in experiments that study creativity participants are given problems which require original solutions, and that the choice of an appropriate problem is key for designing such an experiment (Ohlsson, 2011). The first part of this paper references the founders of the experimental psychology of thinking and creativity in an attempt to pinpoint the moment when the problem itself was still discussed in academic literature.

### *Origins of the Problem*

Brushlinsky writes that the problem first appeared in practical activities, when human beings faced difficulties and obstacles, and later extended to theoretical exercises as well (Brushlinsky, 1970). The tradition of using problems in association with thinking is quite venerable and goes back to the cultural practice of riddles, which transmit the values and relationships of a community.

### *Problem Definitions and Properties*

There are several definitions of *a problem* and a number of similar terms — a task, problem situation, problem space, etc. According to Brushlinsky, a problem situation is a vague impression that arises when one encounters an obstacle to performing an activity, while a problem presents a clearer division between the setting

and the solution (Brushlinsky, 1970). Duncker believes that the problem arises when it is impossible to achieve the desired goal (Duncker, 1945). Ball (Ball, 1990) analyzed the term "problem" in several studies and identified three different meanings: (1) synonymous with "goal", (2) the goal plus requirements for achieving it, (3) a verbal description of a situation. This paper focuses on the second meaning and refers to the type of problems used in psychological experiments. For category (2), Ball provides a sequence of definitions:

1. A problem is a situation that requires some action.

2. A cognitive problem is a situation that requires action to find the unknown, utilizing its connection with the known.

3. A problem is a situation that requires action to find the unknown, utilizing its connection with the known, while the solver does not have a method (algorithm) for this action (cited by Fridman, 1977). This hierarchy is surprisingly modern, especially when the third paragraph is applied to insight problems.

Leontiev concisely defines a problem as "a goal given in certain conditions" (Leontiev, 1965). Spiridonov (2014) notes that this definition leaves out an important characteristic of a problem: opportunities. The solver uses the opportunities inherent in a problem by forming secondary values of the key aspects of the problem, linking the problem situation to the goal. Another important property of both the problem and its solution is conventionality. According to Spiridonov, a problem in cognitive psychology is a certain kind of trap (specially created or arising spontaneously), which reveals the incompleteness, inaccuracy or inadequacy of the human thinking that falls into it... A problem is an intentional formation that encourages the solver to perform activities aimed at identifying these opportunities. The presence of a goal encourages such activity. These are not random [opportunities], but precisely those that can be found under given circumstances. In the absence of a goal, a cognitive problem turns into a parody of itself and, strictly speaking, is no longer a problem (Spiridonov, 2014, pp. 99–100). Thus, most researchers agree that a problem contains a goal, certain conditions (requirements) and an obstacle to achieving the goal.

According to Gestaltists, a problem contains a conflict between what needs to be found and the impossibility of doing it. Therefore, to solve a problem is to understand this conflict and resolve it. Wertheimer (Wertheimer, 1987) analyzes many cases of solving non-trivial problems to formulate his understanding of productive thinking. Wertheimer describes problem solving as follows: the problem structure may offer an incorrect solution path and lead away the solver, who might reach one or more impasses and come to the correct answer in a roundabout way. The initial problem state can narrow the solver' focus so that they overlook a simple way to bypass the main difficulty, or leave out components when unifying them into a single system, or connect insufficiently large pieces. It is not uncommon for two opposite directions of solution to be present simultaneously: from the parts to the whole and from the whole to the parts.

Newell and Simon view the problem as an object of computer modeling of thinking. According to them, a problem creates a mental representation that contains an initial problem state, a set of operators (methods of influencing the problem) and a

goal (what it means to solve the problem). These components define the problem space, i.e., the space of possible solutions. The problem is solved by applying operators to the problem space, therefore connecting the initial and the target problem states (Newell & Simon, 1972; Ohlsson, 2011).

Today it seems rational to analyze not only those problem components that stem from the definitions of the problem, but also the dependent and independent variables described in academic studies. Some examples are the solution time, the accompanying emotions and facial patterns, the solution rate, the possibility of applying heuristics, the number of impasses and hypotheses, etc.

An important problem parameter is its difficulty, or complexity. In this article these two terms are used as synonyms, but there are other points of view. It has been observed both in laboratory conditions and in everyday life that the degree of difficulty of a problem may vary for different people, but the problem can also be difficult for the same person in different ways. Tikhomirov writes that neither the idea nor the problem form act as a decisive determinant of the difficulties of its solution (Tikhomirov, 1984, p. 13). Below we will focus on the complication and simplification of problem solving.

### *Problem Section Summary*

It is difficult to give a universal definition of the problem, since it largely depends on the problem scope, the chosen methods of analysis of thought, and the theoretical concept. Most researchers talk about an obstacle, some kind of difficulty or a mismatch that triggers mental activity aimed at finding a solution; some include the participant and their intention to solve the problem, because the obstacle *per se* does not make up a problem — one also needs the intention to remove it; others distinguish the given and the goal as constituent parts of a problem. Based on the similarity of definitions, we hope that the researchers mean the same thing by the problem, and readers correctly understand their texts.

This section further discusses obstacles that trigger thinking. An obstacle becomes a problem-forming factor when the solver does not know how to overcome it. An obstacle without a way to overcome it – an obstacle that makes it hard to overcome the obstacle – might be what makes up an *insight* problem as it is commonly understood.

The abundance of experiments with hints emphasize the importance of an obstacle for a problem. This leaves researchers with a question: does the reduction of an obstacle destroy the essence of a problem? The next section reviews possible ways of problem simplification.

## Facilitation

This section explores how facilitating conditions and hints provide a glimpse into the essence of thinking and problem solving. It also attempts to establish to what extent the problem solution might be simplified and whether it can become so simple that the problem loses its main properties, turning into an instruction.

### *Definitions*

Researchers who facilitate problem solving often use the term "hint", i.e. an event that increases the probability of a solution and/or makes it faster (Lapteva & Valueva, 2011). This article uses the broader term "facilitating conditions" to address any factors or conditions that make it easier to solve a problem. All studies with problem facilitation can be divided into two large categories based on the facilitation type:

1. External facilitation. A study uses something that simplifies the problem solution process, but doesn't change the problem itself. This includes solving a series of similar problems, emotional and emotional-cognitive influences, the application of various cognitive factors, such as the impact on working memory (WM).

2. Internal facilitation. Such experiments use conventional hints. The problem solution process is simplified by changing the problem itself: reducing some of the problem conflicts, hinting at the answer.

### *External Facilitation Conditions*

Studies of external facilitation begin with Gestaltists. Their "theories of the third factor" do not reveal the relationship between the problem description and requirements, but highlight the positive influence of the third, external, variable (Petukhov, 1987). Certain qualities of the solver provide an example of external conditions that facilitate the solution. A non-exhaustive list includes intellectual abilities and personality traits, for example, anxiousness, which in creative problem solving expands the search area for unusual features of objects (Ibid.), creativity (Lapteva & Valueva, 2011), the amount of WM (Ash & Wiley, 2006), various situational factors, e.g., motivation (Petukhov, 1987). The more dramatic studies explored the positive role of praise (Vinogradov, 1972); used a preliminary task aimed at increasing self-esteem (Wen et al., 2013); one study even showed how wearing a lab coat decreased the participants' ability to solve insight problems (DeCaro, 2014).

**Skill transfer.** Another way of facilitation is transferring a solving skill from one problem to another. When talking about the effectiveness of hints, many researchers emphasize the depth of information processing (e.g., Ponomarev, 1999). To increase it, a researcher will allow a participant to tease out the features of the problem independently rather than resort to a prescriptive hint (Sekei, 1965). An example of this kind of facilitation is a series of similar problems with gradual complication. The assumption is that solving a simple problem within a series enables the participant to pinpoint the main difficulty, so the solution of a more complex problem will be more successful. In his experiment, Ponomarev used a class of connecting dots problems (four-dots, nine-dots, sixteen-dots, etc.). These problems are similar to a point where the participant can rely on a formula to calculate the required number of lines to connect the dots. This experiment confirmed that the solution of a more complex problem can be facilitated through solving a simpler one (Ponomarev, 1999).

Rubinstein wrote that the solving experience is successfully transferred if the solver can abstract from the current situation and generalize the solution principle (Rubinstein, 2000). Duncker demonstrated that the consistent solution of problems based on the same principle but different in form allowed the participants to pinpoint commonalities in the solution and promoted skill transfer, even if the participants could not immediately explain the problem similarity (Duncker, 1945). Gick and Holyoak used a similar set of problems, where the first problem was presented as a story with the disclosure of conflict, and showed that such facilitating influence has a relatively weak effect (Gick & Holyoak, 1980). This may be due to the fact that the problems were very different in form and that their descriptions had a relative nature.

### *Internal Facilitation Conditions*

**Problem difficulty reduction.** Some of the most informative experiments in this area reduce one of the complexities of a problem to a hint. The researcher determines the key difficulty of a problem, reveals it as a hint and, if the hint improves the solution performance, concludes that this source of difficulty is indeed present in the problem. In their notable study, Цllinger and colleagues (Öllinger et al., 2017) identified three key difficulties of the ten-penny problem. Three experimental groups were given one, two or three hints, while the control group received none. The results confirmed that the problem contained the assumed difficulties. Another noteworthy aspect of this study is the assumption that the participants exposed to all the difficulties of a problem should not have encountered any difficulties at all, for the problem was devoid of obstacles which create the problem proper and provoke thinking. However, this group did not follow the instruction to find the answer. Instead, it attempted to solve the problem and encountered obstacles on the way to the answer. This could mean that the researchers did not expose all the problem difficulties, but it seems more likely that the solution process was overcomplicated by an excessively long task description. Another complicating factor is the ambiguity of hint application. Often, participants understood the hint, but did not know how to translate this knowledge into a solution. Thus, hints can create "secondary difficulties" that are associated with the lengthening of the problem description and the complexity of hint application. An example of a secondary difficulty is the increased complexity of answer verification, for the answer has to be checked for compliance with the hint (Newell & Simon, 1972).

**Part of the answer as a hint.** Often a part of the answer is presented as a hint. It might be effective because of its double nature — it reflects both the key difficulty of the problem and an actual part of the solution. For example, Maier's experiment with the two-string problem showed that swinging one of the strings leads to a quick answer (Maier, 1931). However, there are some stunning examples. MacGregor and colleagues gave the participants a "shadow of the answer" as a hint in the nine-dot problem, and it still did not lead to an instant solution (MacGregor et al., 2001).

**Hint presentation time.** In experiments with hints, researchers must decide when exactly to present the hint. A hint given right at the start is perceived as part of the problem description, occasionally as something extra. While working on a solution, participants process the problem and single out the main obstacles. Brushlinsky points out that hints are not useful prior to analysis (Brushlinsky, 1970). At what solution stage should a hint be shown so that it does not cease to be useful? Moss and colleagues demonstrated that a hint is most effective immediately after a solver reaches an impasse (Moss et al., 2011). It should be noted that this effect was not replicated in a similar experiment (Markina et al., 2018).

Another way of looking at hint presentation time is this: if the solver is able to use the hint, then they have analyzed the problem sufficiently and the researcher can deduce which stage of the solution they have reached.

### *Facilitation Section Summary*

This section reviewed the main ways to simplify problem solution. A hint is most effective when it is applied in the areas of key difficulties, and the most effective time to present it is immediately after an impasse. Problems are fundamentally different from instructions, since no evidence was found to demonstrate that a hint immediately grants an understanding of the entire solution. The fact that a problem consistently causes difficulties is corroborated by the studies which showed that presenting the answer or revealing all the difficulties still does not destroy the problem.

## Inhibition

Inhibition, or complication of problems is not as well understood as facilitation. What new information about thinking could this research tool reveal? Typically, complication is simplification in reverse, and hints can have the opposite effect. For example, some skill transfer studies presented difficult problems first and simple problems last. Certain methodological tools also fall in the category of problem complication. This section will provide examples of problem complication, focusing on its benefits for the theories of thinking. Just like facilitating conditions, inhibiting conditions fall into two categories:

1. External inhibition – experience and social environment.
2. Internal inhibition – "reverse hints", additional information leading the solver away from the correct answer.

### *External Inhibition*

**The role of experience.** To solve a problem (any problem), one needs a certain experience. Experts normally solve domain-specific problems better than beginners (Bilali et al., 2019). For the purposes of this article, it is useful to review how experience and functional fixedness complicate problem solving. One striking example comes from the study of Bilali et al. (2008), in which expert knowledge prevented

chess players from applying an effective solution strategy. This interfering experience can be acquired in the course of the experiment proper. In the classic case study of water jar problems, participants worked out an algorithm which later hindered their solution of a simple problem (Luchins & Luchins, 1950).

**Social pressure.** When social pressure is high, problem solving performance deteriorates, because some of the participants' resources, which could have been allocated to solution finding, are used up to experience and assess the situation (Beilock & Carr, 2005). Another study discovered a decrease in the ability to solve problems only in participants with a high WM. It is associated with a forced change in strategy (Beilock & DeCaro, 2007).

**Distractors.** The method of distraction was first used by Baddeley and Hitch (1974) in their studies of WM. A dual task is one example of distraction. Participants are asked to simultaneously perform two tasks: the main problem (completion takes a long time) and the additional task (usually, it is simple and monotonous). Based on the dynamics of the additional task completion, researchers can estimate how much resource is allocated to the main problem (e.g., Korovkin et al., 2018). Thus, complication of the process with an additional task makes it possible to track the problem solving dynamics for the main problem. By suppressing various components of WM, Robbins and colleagues assessed the role these components play in the solution of chess problems (Robbins et al., 1996).

### *Internal Inhibition*

**Increasing the number of operations.** Ash and Wiley presented their participants with two variants of the same problem: many moves (available and fruitless moves in the initial problem space) and few moves (limited moves after which solvers faced an impasse). It turned out that the many moves problem was harder to solve. The authors stipulated that only this variant can be considered as an insight problem. To put it another way, adding simple actions to a problem can make it creative; here, quantity turns into quality (Ash & Wiley, 2006).

The same problem manipulation logic was applied to the eight-coins problem: participants performed worse if they had more space for wrong moves (Öllinger et al., 2013; Ormerod et al., 2002). The comparison of two problem versions made it possible to test the consequences of two problem solving theories (the representation change theory and the progress monitoring theory). An increase in the number of moves shows the importance of both the limitation of problem space and the representational change for the solver.

**Reverse hint.** Smith and Blankenship used inappropriate priming as a reverse hint. They asked participants to solve RAT (Remote Associates Test) problems, misleading them with additional words. This reverse hint directed the solution in the wrong direction, whereupon problem solving efficiency decreased by about half (Smith & Blankenship, 1991). Setting the solvers on the wrong solution path made it possible to test the effectiveness of the incubation effect. A similar complication was used by Spiridonov and colleagues. They complicated a problem via priming, which set an irrelevant representation of the homonym from the main problem. It

increased the probability of getting into an impasse (Spiridonov et al., 2021). This experimental design helped to clarify the role of the impasse for insight problem solving.

### *Summary of the Inhibition Section*

Problem solving complication can be distinguished from simplification only conditionally, with the one method acting as a "mirror" of the other. The main areas of inhibition application are the problem description, the problem space before the impasse, the loading of WM and the external social environment. A complication enables the clarification of many aspects of problem solving processes, e.g., their dynamics, the role of WM and favorable conditions for solving.

## Conclusion

This paper provides an overview of the fundamental works on problems and the most relevant case studies of problem complexity manipulation. The significance of problems is so great that the 20th century saw a call for a separate science — problemology (Fridman, 2009). It hasn't been created just yet, but the scientific community accumulated a lot of data concerning problems as a tool and an object of scientific research. Classical works on problems were written in the 20th century; possibly, they exhausted the subject, hence the scarceness of contemporary papers. Today, the use of problems in psychological experiments is a consensus that has developed through their ease of use, their theoretical validity, and the variety of manipulation techniques. The main technique entails altering problem difficulty: simplification and complication of both the problem and conditions for working with it.

The main conclusion of this study is the stability of the problem. It is corroborated by the fact that even the reduction of all difficulties does not destroy the essence of the problem, i.e., the problem does not become an instruction and its description does not turn into a set of rules. In addition, the complication of a simple problem occasionally makes it creative rather than unsolvable (Lazareva & Vladimirov, 2019). The stability of the problem makes it an excellent material for psychological studies with different variables.

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