Field of Study and Research Methods for an Effect of Cognitive and Information Load on PC's Users

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Abstract—**In this article authors show one of the possible approaches to the experimental research of the cognitive and information load on PC's users – the mental load or amount of efforts, spent because of the necessity of recognition of a screen form's elements and the necessity to process the data presented. The article contains the short description of the problem to be researched, the analogous research projects, the hypotheses to be verified and the approach, selected for the experimental part of the project. The teachers and master student of the "Design of the human-to-computer systems" master's program, ITMO University, are carrying out this project.**

I. INTRODUCTION

This article represents the results of preparation to an experimental research, devoted to the problem of cognitive and information load on PC's users — load caused by the necessity to recognize the active elements of screen forms (e.g. buttons) versus form's graphic decoration or data presented.

In the finished part of the project was devoted to discovering the field of study, origins of the problem and analogous experimental research projects conducted by other research groups. Information about approaches to the experimental measurement of cognitive and information load, designed by other research teams, was collected. Proposals regarding further steps of our own experimental research and test materials to be used were made.

II. THE PROBLEM ORIGINS

The problem to be examined is closely connected with modern trends in graphics and user interfaces (UI) design. Designers tend to decline the realistic ("skeuomorphic" or "traditional") decoration of the screen forms elements and move to the so-called "Flat design" style. This shift is made despite that the realistic decoration makes those elements clearly visible and determinable. This trend mostly affects such elements as buttons and input fields. For example, buttons are decorated without any embossment (Fig. 1, 2, 3, 4).

Such changes in the design paradigm lead to loosing visual hints or clues to the element's purposes and functions, therefore, making users to spend additional time and efforts on detecting elements, their functions and ways of interaction.

Worldwide spreading of this design trend is in dispute with opinion of several industry experts [1], [2]. For example, Jakob Nielsen (Nielsen Norman group) writes about reducing of users work efficiency in connection with visual design changes described [2].

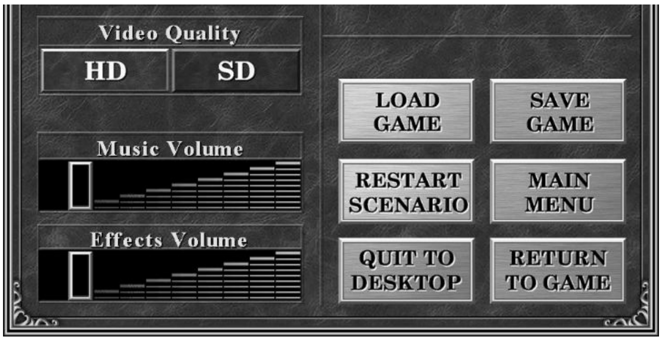

Fig. 1. UI fragment, decorated in the "traditional" graphic style ("Heroes of Might and Magic III – HD Edition", the videogame, UbiSoft)

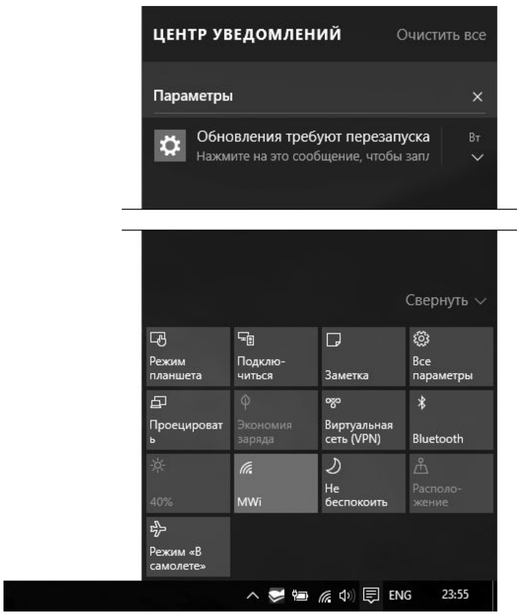

Fig. 2. UI fragment, decorated in the "Flat design" graphic style (Notifications panel, Windows 10, Microsoft corp.)

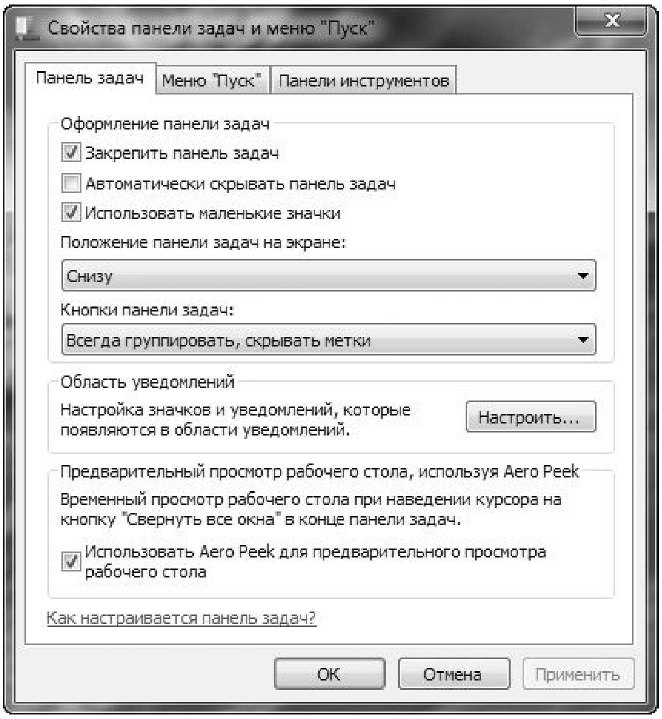

Fig. 3. UI fragment, decorated in the “traditional” graphic style (Taskbar settings window, Windows 7, Microsoft corp.)

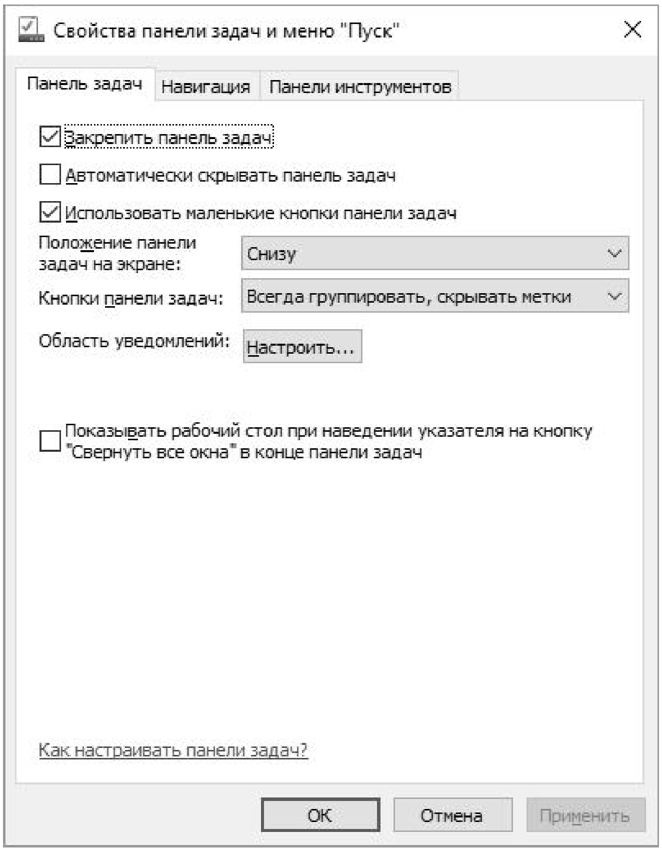

Fig. 4. UI fragment, decorated in the “Flat design” graphic style (Taskbar settings window, Windows 10, Microsoft corp.)

This contravention rises the practical importance of experimental research of the UI visual design impact on the effectiveness of user-to-machine interaction. Especially, in the fields of industry, implying high risks for technological, ecological or financial safety (e.g. technological processes control or bank transactions management).

III. COGNITIVE AND INFORMATION LOAD

The phenomenon, causing progressive growth of mental efforts spent by user to operate the UI, is referenced in various sources as “cognitive load” [2], [3], [4].

NASA human-to-computer interaction (HCI) research group (NASA Johnson Space Center) consider the increasing cognitive load as one of the serious threats for the adequate human-to-machine interaction and, thus, for the mission success [4].

In parallel with the phenomenon of cognitive load, the phenomenon of information load is considered. The term “information overload” is defined as exceeding of the consumed information volume over the information volume, sufficient for the decision-making process [5].

The combined effect of cognitive and information load or overload leads to decreasing of interaction effectiveness, decreasing of user satisfaction [1],[2], [3], [4], [5], moreover, it leads to the increased risk of incidents of various kind. Especially in spheres like industrial manufacturing or transportation [6], [7].

Therefore, thorough research of these phenomena will help to reduce the risk of incidents while maintaining the user’s satisfaction on a high level.

IV. ANALOGOUS RESEARCH PROJECTS

Search and analysis of analogous research projects was conducted. Detailed descriptions of research methods and experimental results are presented in publications [8] and [9]. The publication [10] is devoted not to research, but practical recommendations on decreasing of the cognitive load.

As the advantages of publications [8] and [9] we could mention the detailed review of the research method and results achieved. But, we should also notice the artificial nature of test tasks, introduced in the research [8]. The project, described in [9], is based on well-thought methodology, but it’s results are mostly fundamental and could not be directly applied in the UI design job tasks. Both of this projects were performed very limited amount of test respondents (about 20 persons, all university students).

While measuring the amount of mental effort of “cognitive load”, authors of [8] and [9] recourse to indirect characteristics of the HCI effectiveness:

- Amount of “dummy object is considered to be an active element” (type I errors, α errors);
- Amount of “active element not found” errors (type II errors, β errors);
- Task completion time.

V. HYPOTHESES AND APPROACH TO AN EXPERIMENT

While gathering the data available, the following hypotheses were made:

- Declining the realistic or "traditional" UI elements decoration and moving to the "Flat design" style lead to increasing of the cognitive load and, therefore, to decreasing of the HCI effectiveness;
- Increasing of the amount of data displayed, aggravates the effect, caused by declining the "traditional" UI decoration.

To confirm or to dispose these hypotheses the experimental research is planned. The aim of this research is to measure the effectiveness of HCI under the impact of varying cognitive load, information load and both of these factors.

To avoid the weaknesses of the prior analogues projects mentioned above, the experiment will be hold with test materials, imitating actual screen forms elements. This will allow us to get results, directly applicable in UI design tasks (in contrast to work [9]).

Specially made test screen forms will be used during tests. The screen forms are to contain active elements, decorated in various graphic styles. This will allow us to get the total control over the forms appearance and increase the precision of data measured (in contrast to the method, described in [8]).

Respondents (users) will be asked to complete series of tasks, belonging to one of the following types:

- "Use the UI element" — user is offered to use a specific element of the screen form (e.g. "button, named Next"). The test screen form contains several elements, labeled with the same text (e.g. "Next") and decorated in various styles. This tasks will allow us to trace the associations between the graphic decoration and the element's functions;
- "Locate the active elements" — one or several elements are placed between "distracting stimuli" (see [9]). The element's decoration (i.e. cognitive load) and amount of distracting stimuli (i.e. information load) are changing from task to task. Time of the task completion and amount of errors made are measured;
- "Find the given fragments of data" — respondent is asked to find the set of given fragments (e.g. numbers or graphic symbols) between the distracting stimuli. The amount of target and distracting symbols (i.e. information load) is changing from task to task. Time of the task completion and amount of errors made are measured.

In addition, the survey can be applied to reveal the individual respondent's opinion and satisfaction level. For example, the NASA Task Load Index (NASA TLX) can be used for this purpose [11].

VI. TEST MATERIALS EXAMPLES

Several examples of test materials, designed for the further experimental work, are shown at the Fig. 5, 6 and 7.

Three examples of screen forms for the "Use the UI element" task are presented at the Fig. 5. From the top to the bottom:

- 3 buttons with the same label, decorated in various styles;
- 3 buttons of the same graphic style with different labels (one label is to be target for the respondent);
- 3 buttons of another graphic style with different labels.

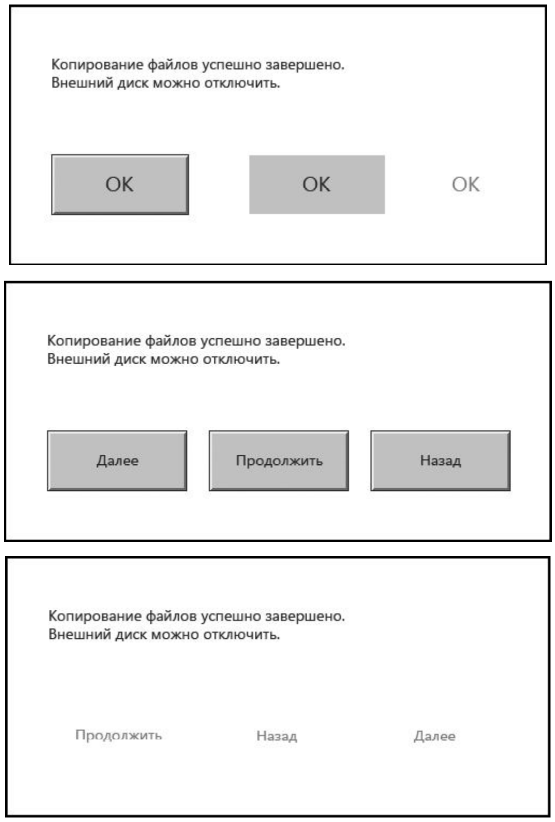

Fig. 5. Test materials examples for the "Use the UI element" task

Two test forms for the "Locate the active elements" task can be found at the Fig. 6. The form, located at the top, contain 1 active element, located within the 3x3 matrix of distracting stimuli. At the from at the bottom contains 3 active elements in the 5x5 distracting matrix. In the second case, the only distinction between the active elements and distracting symbols is the "active" or "accent" colour (a kind of common situation for the "Flat design" graphic style). At the Fig. 6 these active elements are highlighted for the better visualization at this presentation only.

Two examples of the screen forms for the "Find the given fragments of data" task are presented at the Fig. 7. These forms contains 3x3 and 5x5 matrices, while the respondent is to be asked to find all inclusions of a given number (e.g. 5).

VII. TEST MATERIALS, APPROBATION OF

The trial experiment, which purpose was to check the test materials aptitude for the main research, was run at the Usability laboratory of the Design and multimedia center

(ITMO University). The eye tracking technology was applied to observe the process of interaction between the screen forms and trial respondents. The observation results are presented at the Fig 8, 9 and 10.

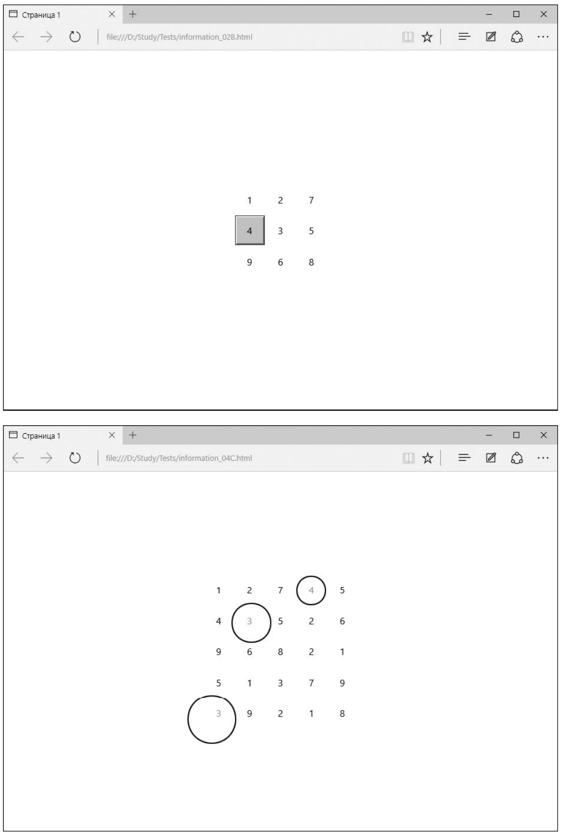

Fig. 6. Test materials examples for the "Locate the active elements" task

These results have no statistic quality, therefore, they do not contain enough data to make any decisions about the effect of cognitive and information load on the HCI effectiveness. However, they show clearly that the screen forms represented allow us to get similar results for different respondents. Therefore, these materials work in the predictable way and can be applied for an experiment involving large group of the respondents.

VIII. Conclusion

As we can say in the conclusion, on the basis of the analogues research projects we have developed the experimental approach to the measuring of the HCI efficiency and, therefore, experimental research of the cognitive and information load.

A. Preliminary results:

Here some of the preliminary results of our project are presented:

- The analogous research projects were discovered and investigated;
- The hypotheses were made and approaches to their experimental verification were formulated;
- The characteristics of the future experiment were described and the trial experiment was conducted.

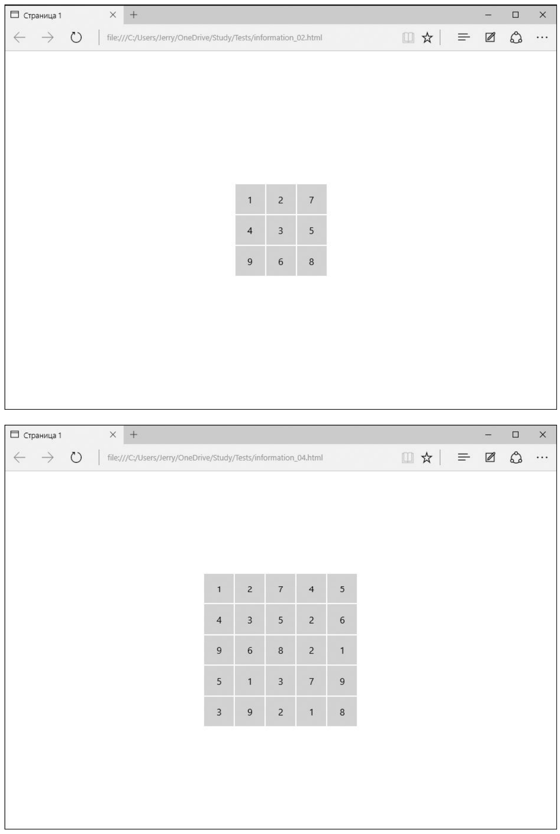

Fig. 7. Test materials examples for the "Find the given fragments of data" task

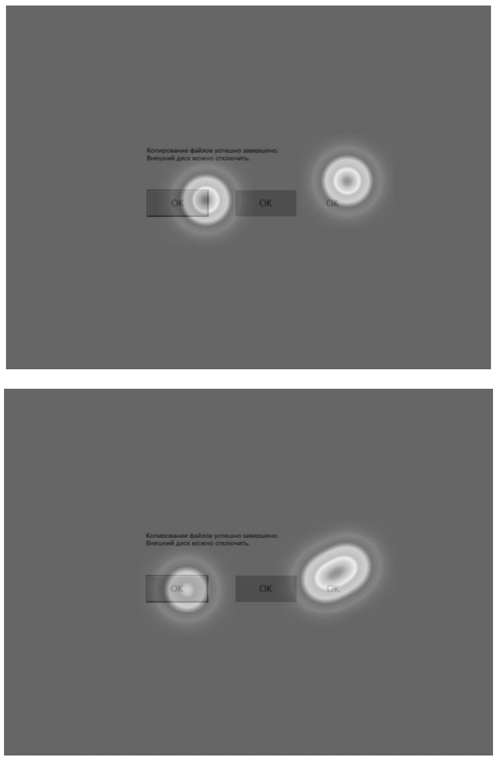

Fig. 8. Trial experiment. At the top – respondent 1, at the bottom – respondent 2

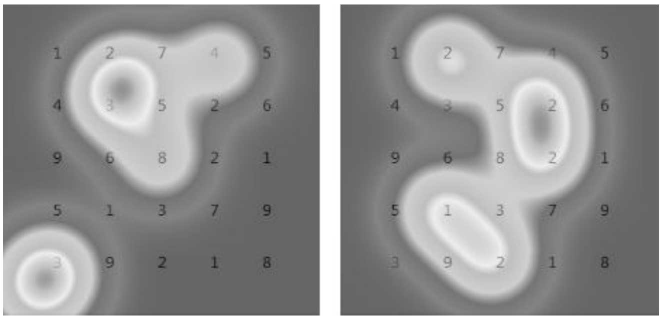

Fig. 9. Trial experiment. On the left — respondent 1, on the right — respondent 2

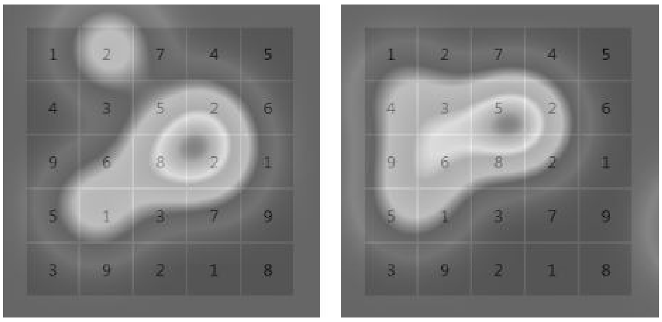

Fig. 9. Trial experiment. On the left — respondent 1, on the right — respondent 2

B. Further research steps:

Our future work on this project will include:

- Full-scale experiment planning;
- Preparation of the test materials set, including the tasks shuffling for leveling of the respondents' individual characteristics;
- Full-scale experiment based on the Internet and web technologies to involve as huge as possible respondents' mass (in the meaning of the respondents amount, ethnographical and geographical distribution);
- Limited auxiliary in-lab research for the better understanding of the interaction process between the respondents and the test materials.

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