Task performance under influence of interruptions

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Abstract. An execution of computerized task was analyzed in simulated office environment[1]. Work of subjects in half of the cases was interrupted. Interrupting tasks varied in complexity. The main task was interrupted at different points. It was shown that (1) interruptions decreased accuracy of performance and increased the number of task related actions, but the time spent for the execution of the main task did not change; (2) more complicated interrupting tasks intensify subjects' activity, consume more time for the resumption of the main task, but lead to a significant decrease in the number of errors; (3) the more difficult was a subtask in the moment of interruption, the more elaborated behavioral strategies were used in the condition of interference. Results were interpreted in the framework of Leontiev's Activity Theory.

Interruption can be determined as a certain event, which interferes with work process and results in the cessation and suspension of human activity. Brief external interference is often considered as an everyday stressor with negative impact on the effectiveness of performance. Under condition of interruption people look for ways of overcoming its negative influence. Their choice depends, first, on external conditions (for example, type of interruption) and secondly on internal conditions (for example, personality traits and current functional state).

In the framework of a multifactoral investigation of the impact of interruptions on computerized task performance, carried on in the Laboratory of Work Psychology of Moscow State University, various effects were demonstrated [1]. In this study performance of a routine computerized task was interrupted by additional tasks of different complexity. Impacts of two independent external factors were analyzed: presence/absence of interruption, and the complexity of interrupting task. Among dependent variables there were parameters of task performance, behavioral patterns, current emotional and psychological states, personality traits, cognitive processes. In this article we present the results concerning quality of performance and behavioral strategies.

Experimental paradigm was based on Leontiev's Activity Theory [2] which presumes, human activity has a complicated structure which includes external (behavioral) and internal (mental) planes and various levels of their actualization. This structure depends on different factors. Any changes of conditions result in changes in macro- and/or microstructure of activity. We suppose that interruptions cause structural changes in the activity flow (Hypothesis 1) and that this effect depends on the complexity of an additional task (Hypothesis 2), and at the moment of interference in the performance of the main task (Hypothesis 3).

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1. Method

31 staff members of Moscow State University participated in the experimental study. The experimental task resembled their everyday work duties. Subjects had to do text editing according to hand-written corrections. In half of sessions their work activity was interrupted by two phone calls. During a phone call subjects were told to execute an additional, or interrupting task (factor "presence of interruption"). It could be a simple task - to find a telephone number in the telephone book, or a more complicated task – to correct all typing faults in a short article (factor "complexity of interruption"). Subjects were interrupted twice: first time while they were typing a text, second time while they were moving a block of a text, right after they press "cut" and before "paste" (factor "point of interruption").

The experiment took place in a simulated office environment. One room was equipped as an office workplace (with furniture, a personal computer and an intercom telephone), while the other was used as a control room. In the office location a movable tripod video camera was placed to monitor the subject. The video signals from the camera and from the computer screen were routed to a video mixer in the adjacent control room. From this room the experimenter controlled the experiment and watched the mixed video signal (a view of the subject plus the contents of the subject's computer screen) via the video monitor. The mixed video signal was also recorded on a VCR. An intercom phone was used for communication between the control room and the office location.

At the beginning and at the end of each experimental session psychological and physiological indicators of functional states of subjects were tested. It included cognitive resources (operative memory and attention span), self-estimation of current emotional state, current psychological state and mental effort; level of activation. These data are discussed in detail in A.Leonova's paper [1].

Both qualitative and quantitative aspects of task performance were measured. We analyzed different types of actions used by subjects (task related actions – all actions connected with the execution of the main task, interruption handling actions, supportive actions, non-relevant actions), number of errors, various chronometrical parameters. We registered Total Work Time, Time-on-Task (how long did it take a subject to perform the main task), Change-over Time (actually it took subjects some time to come back to the execution of the main task after he/she completed the additional task).

2. Results and discussion

Statistical analysis revealed the significant effects of interruptions and the interruption complexity on both the qualitative and quantitative parameters of performance.

2.1. The main effects of interruptions

Interruptions caused significant increase of the total work time, although time spent on the execution of the main task did not change. A slight increase in the total number of errors was observed (Table 1). Despite the fact, that subjects spent the same time on the main task the number of task related actions increased. It means that subjects try to keep time parameters of task performance at the expense of quality of performance and intensification of external activity.

Table 1. Duration and quality of task performance
(descriptive statistics and results of the one-way ANOVA model)

Variables	Interruption NO			Interruption YES			ANOVA		
	mean	*SD*	*n*	*Mean*	*Sd*	*n*	*F*	*df*	*p*
Work time (sec)	2177	722	57	2490	820	57	4.7	1	**0.03****
Main task (sec)	2177	722	57	2113	786	57	0.1	1	0.8
Number of errors	5.3	3.4	57	6.6	3.9	57	2.9	1	**0.09***
Task related actions	2177.5	722.1	57	2489.9	820.3	57	4.8	1	**0.03****

Main task related actions turned to be a very informative indicator. They are sensitive both to presence/absence of interruption and to complexity of the interrupting task. In Table 2 two experimental factors are analyzed according to the number of different types of actions. Though we had expected the increase of the number of all types of actions (task related actions, supportive actions and non-relevant actions), only the number of main task related actions grew significantly when work flow was interrupted and the interrupting task became more complicated. Probably the number of non-relevant actions would grow when external interfering event is crucial, but our experimental design did not pretend to be extreme for a subject. The number of supportive actions would probably grow when a subject was more experienced in similar situations and could consciously use premeditated coping strategies. But our subjects were not ready for any extraordinary step.

Table 2. Effect of presence and complexity of interruption task on type of actions in the main task

Variables	Presence of interruption			Complexity of interruption		
	F	*df*	*P*	*F*	*df*	*p*
Task related actions	4.83	1	**0.03****	2.20	1	**0.14***
Supportive actions	0.12	1	0.72	0.43	1	0.51
Non-relevant actions	0.40	1	0.53	0.12	1	0.73

2.2. Changes in activity flow in different interruption conditions

Interruption handling activity was subdivided into four steps beginning with picking up the telephone receiver, listening to additional instructions, execution of the alternative task and change-over to the main task after he/she completed the additional task.

The most important results are shown in Table 3. It is not surprising that more complicated additional tasks took more time. The most interesting result is that the change-over time in these cases was significantly longer. We may suggest that interruptions influences not only an external, but also an internal planes of human activity. Simple interrupting tasks do not destroy the consecutive chain of external and internal actions and operations, where each behavioral act is based upon a mental preparatory plane. In this case an additional task blocks or distorts external behavior, but internal readiness to continue interrupted actions does not suffer. Complex interrupting tasks intervene both in external and internal activity. When an additional task is completed it takes subject some time to change-over to the main task. That time is necessary for the restoration of the internal plane of actions and activation of external performance.

Paradoxical by enough the number of errors in the process of the execution of the main task was lower when the additional task was more complicated. Thus a complex interrupting task considerably distorts the process of the performance of the main task but decreases the number of errors comparative to simple interrupting task. Presumably it can be explained by implementation of different performance strategies in these two cases. When an interrupting task is complicated, the main and the additional tasks are performed consequently: main task – additional task – main task. When an interrupting task is simple, the main and the additional tasks are performed simultaneously. That is why in the first case change-over time is longer, but the number of errors is significantly less, because there is no direct interference of two executive processes.

Table 3. Effect of the complexity of interrupting task on interruption handling activity and quality of performance of the main task

Parameters	Simple interruption			Complex interruption			ANOVA		
	mean	*SD*	*n*	*mean*	*SD*	*n*	*F*	*df*	*p*
Reception of interrupting task	73.2	31.6	51	41.2	14.5	51	30.3	1	**0.001*** **
Change-over to the main task	**2.7**	4.0	51	4.3	**4.9**	51	4.3	1	**0.04** **
Number of errors	**7.3**	3.7	51	**5.9**	2.51	51	2.5	1	**0.1***

2.3. Changes in interruption handling strategies

The analysis of video-tapes demonstrated various subjects' reactions towards interruptions. Five behavioral strategies in handling an interrupting task were defined: whether a subject responded to the interrupting phone call immediately or with some delay, whether the interrupting task and the main task were executed serially or in parallel etc.

Strategy 1. Signal - pick-up - listen - lay down - interrupting task.
Strategy 2. Signal - continue - pick-up - listen - lay down - interrupting task.
Strategy 3. Signal - pick-up - continue and listen - lay down - interrupting task.
Strategy 4. Signal - continue - pick-up - continue and listen - lay down - interrupting task.
Strategy 5. Signal - pick up - listen - lay down - continue main task - interrupting task.

Table 4. Effect of the complexity of additional task on the choice of interruption handling strategy (%)

Type of strategy	First interruption (at the moment of a routine operation)	Second interruption (at the moment of a more complicated operation)
Strategy 1	78.1	48.4
Strategy 2	6.1	12.9
Strategy 3	12.1	22.6
Strategy 4	3.7	6.5
Strategy 5	0	9.6

The percentage of different behavioral strategies are represented in Table 4. When subjects were interrupted first time (at a point while they were typing a text) they preferred to react to the phone call immediately and right after getting instructions from the experimenter they started to implement an additional task (Strategy1). But when they were interrupted at a more difficult stage of the execution of the main task (right after they pressed “cut” and a block of a text disappeared from the display) the distribution of strategies changed: some subjects preferred not to put aside the main task, but first to finish a current operation and only after that to pick up (Strategy 2 and 4) and when it was more convenient for them to do what the experimenter asked (Strategy 5). Some subjects tried to combine two actions: listening to instructions and working on the main task (Strategies 3 and 4). Thus characteristics of task performance depend not only on presence/absence and complexity of an interrupting task, but also on the complexity of the interrupted activity. Difficult subtasks are more resistant to interferences than easy subtasks.

3. Conclusions

All our hypothesis were confirmed. We observed deviations in the regular flow of activity and in the execution of the primary task in various interruption conditions. Interruptions decrease accuracy of performance and increase the number of task related actions. These data agree with some results obtained in laboratory studies on interruptions (see for example [3]). Nevertheless, contrary to studies using laboratory tasks we found that time spent for the execution of the main task did not grow. We also demonstrated effects of the complexity of interrupting tasks on characteristics of main task performance and of the complexity of an interrupted operation on the interruption handling strategies. These data is only partially in accord with experimental results obtained by T. Gillie and D. Broadbent [4]. In their study the effect of the complexity of an interrupting activity was more significant in comparison to the effect of the point at which the main task was interrupted. Actually it can be explained by principal differences between our experiments: first our subjects were involved in work activity, and their subjects played a computer-based game; secondly we tried to analyze changes in the work flow and restructive effects, when T.Gilie and D. Broadbent emphasized destructive effects of interruptions.

Interruption is not merely a matter of executing of an additional task. Interruptions have a pronounced impact on task performance changing the whole structure of human activity. The deeper is the subject’s involvement in the interrupting task, more time it takes him/her to be disengaged from the additional task and to be ready to resume the main task. When additional tasks were more complicated, subjects worked more intensively and more accurately. In these cases subjects start to use more efficient strategies in order to overcome difficulties. When additional tasks are rather simple, subjects use automatic strategies of performance. Speed and number of actions increases, but accuracy of the main task performance decreases. It is so called “reactive coping”. When additional tasks are more complicated, automatic strategies are not enough. Subjects change to consciously planned strategies, or “proactive coping”. These more considered actions result in the decrease of errors, but in the increase of the duration of task performance and time required to switching back to the main interrupted activity.

Not only the type and the complexity of an interrupting task affect the performance of a main task, but between these two tasks there is a strong interaction: the degree of complexity of the main task can affect the performance of an interrupting task. As it was shown in our experiment the point at which the main task was interrupted turned to be crucial for the way a subject reacted towards any interference. The more a subject is involved into a task, the more difficult it is to switch to another task. These results once more prove that it is impossible to consider interrupted and interrupting activities separately. Both of them are integral parts of work activity and can be analyzed only within a general framework of human activity.

References

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