Current Task Activation Predicts General Effects of Advance Preparation in Task Switching

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Abstract. Two experiments investigated the way that beforehand preparation influences general task execution in reaction-time matching tasks. Response times (RTs) and error rates were measured for switching and nonswitching conditions in a color- and shape-matching task. The task blocks could repeat (task repetition) or alternate (task switch), and the preparation interval (PI) was manipulated within-subjects (Experiment 1) and between-subjects (Experiment 2). The study illustrated a comparable general task performance after a *long* PI for both experiments, within and between PI manipulations. After a *short* PI, however, the general task performance increased significantly for the between-subjects manipulation of the PI. Furthermore, both experiments demonstrated an analogous preparation effect for both task switching and task repetitions. Next, a consistent switch cost throughout the whole run of trials and a within-run slowing effect were observed in both experiments. Altogether, the present study implies that the effects of the advance preparation go beyond the first trials and confirms different points of the activation approach (Altmann, 2002) to task switching.

Keywords: preparation effects, task switching, task repetition, general task performance

Preparing mentally for an action in advance may, to some extent, be beneficial for the execution of this action. The literature on task switching has provided extensive evidence for the preparation benefit with regard to task-switching performance. The aim of the present study was to explore whether advance preparation, besides its helpfulness in handling the switch, might also affect the general task performance in a task-switching paradigm.

A typical task-switching paradigm involves switching between different stimulus-response assignments (e.g., Monsell, 2003, for a review on task switching). The central finding of this research field is a performance cost, which is mostly reported in terms of slower response times (RT) or higher error rates on trials immediately after a task switch (e.g., Allport, Styles, & Hsieh, 1994; Meiran, 1996; Rogers & Monsell, 1995; Rubinstein, Meyer, & Evans, 2001). The most remarkable property of this switch cost is that it can be partly reduced if an appropriate preparation interval (PI) is provided (e.g., Mayr & Kliegl, 2003; Meiran, 2000; Rogers & Monsell, 1995). The common explanation for this switch-preparation effect is given in terms of the ability of the cognitive system to prepare endogenously for the upcoming task switch during the PI. Accordingly, the endogenous preparation could benefit from a longer PI and, thus, reduce the switch costs.

Recently, however, Altmann (2004a, 2004b) proposed an alternative account for the switch-preparation effect. With regard to task switching in general, he suggested viewing it as a memory problem because, according to him, the most active task representation in memory is the one that currently governs behavior. Accordingly, with regard to the preparation effect in particular, he proposed that the preparatory process that takes place during the PI is not task-switch specific, but instead involves the preparation of the *relevant* task (see also Koch, 2005; Ruthruff, Remington, & Johnston, 2001; Sohn & Carlson, 2000). This activation account is supported by at least three different findings. First, several studies reported analogous benefits of task preparation for switch and repetition trials resulting from task-sequence predictability (e.g., Gotler, Meiran, & Tzelgov, 2003; Heuer, Schmidtke, & Kleinsorge, 2001; Koch, 2005). For instance, in Koch's study (Experiments 1 and 2), participants performed explicitly instructed task sequences for five blocks of trials. Block 6 included a random task sequence and was followed by the last block of trials, block 7, in which the task sequence was again predictable. Koch found that the benefit of task preparation resulting from task predictability was not switch-specific.

Second, Altmann (2004b) showed that switch costs are not unconditionally associated with the benefit of advance preparation. Specifically, the preparation effect for task switching was observed if the PI was manipulated within-subjects but not if the PI was manipulated between-subjects. On the basis of his data, Altmann suggested that if there is something like a switching process, it does not automatically take advantage of the available preparation time.

Third, some studies on task switching reported an additional performance cost that occurred after task interruptions that involved no change in stimulus–response assignment (Allport & Wylie, 2000; Altmann, 2002; Altmann, 2004a; Altmann & Gray, 2002; Gopher, Armony, &

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Greenshpan, 2000; Kramer, Hahn, & Gopher, 1999; Waszak, Hommel, & Allport, 2003). Altmann (2004a) showed that, just like a regular switch cost, this restart cost also could profit from an appropriate preparation interval.

These findings seem to imply that the processes involved in advance preparation are more strongly associated with the general preparation of tasks than with the specific preparation of a task switch (see also Brass & von Cramon, 2002, 2004, for recent evidence from functional imaging). However, since Allport and Wylie (2000) suggested the special status of first trials in a run of speeded RT trials, the studies on preparatory processes in task switching and restarting have solely focused on first-trial effects. Yet, from the activation perspective (Altmann, 2004a, 2004b; see also Koch, 2005; Logan & Bundesen, 2003; Ruthruff et al., 2001; Sohn & Carlson, 2000), it seems plausible to assume that preparatory processes in task switching might also affect the general task performance. In the paradigm used in this study, task cues were only perceptually present during the PI. Therefore, the correct task performance on the trials that were not directly preceded by a task cue required access to the relevant episodic task representation in memory. We assumed here that the strength of the relevant task representation is crucial in defining the performance in trials that follow the first trial in a run. Furthermore, we assumed that the longer the perceptual availability of the task cue (that is, the PI here), the stronger the episodic task representation. In the present study, we investigated the level of generality the preparation effect might have on task execution during the full series of trials in a run. We expected that the possible effects of the advance preparation on the strength of the episodic task representation should not be restricted to the first trials only, but should also be present on the trials that follow in a run.

Overview of Experiments

The aim of this study was to explore the extent to which beforehand preparation influences the general task execution. We assumed that longer PI durations result in stronger episodic task representations, which effect we specifically expected to find in trials that followed the first trial in a run. Furthermore, we tested the robustness of the assumed general influence of the preparation effect in the same way the robustness of the preparation effect for switch costs was investigated by Altmann (2004a, Experiments 3 and 4).

For this purpose, we conducted two experiments, in which short (300 ms) and long (900 ms) PIs were provided in a within-subjects design (Experiment 1) and a between-subjects design (Experiment 2). In both experiments, a multiple-trials paradigm was applied, which required participants to retain the cue in memory and to activate properly the relevant task representation in order to execute the task correctly for the whole run of trials (Altmann, 2004a). The cues were explicitly presented at the outset of a run in both experiments and were followed by a trial stimulus after one of the two levels of the PI.

Method

This method section is valid for both experiments. However, because two different groups of participants took part in Experiments 1 and 2, participants will be described for each experiment separately.

Stimuli and Tasks

Stimuli consisted of a reference figure and four match figures. The reference figure was displayed in the upper half of the screen, while the four match figures were displayed simultaneously in the lower half of the screen. The task was to find the match in either the color (task 1) or the shape (task 2) of the reference figure among the four match figures.

The stimuli were selected from a collection of four different geometric figures (a square, a triangle, a circle, and a hexagon) and were displayed in one of four different colors (red, blue, yellow, or green). The color–shape combination of the stimuli was randomly chosen for both tasks with two restrictions. First, no repetition of shape or color was allowed for the four match figures within a trial. Second, the exact match (in both shape *and* color) was not allowed between the reference and the match figures. In this way, the possibility was avoided that one and the same match figure would be the correct response for both tasks. This was done to control for the possible congruency effects, which are considered to play an important role in contributing to switch costs (e.g., Meiran, 2000; Rogers & Monsell, 1995).

Procedure

The participant was seated in front of a screen of a Pentium 166 MHz (15-inch effective screen) at a distance of approximately 60 cm. Written instructions were displayed on the screen, and the experiment was also verbally explained. The participant was asked to respond as quickly as possible by pressing one of four buttons on a button box with either the index or the middle finger of either the right or left hand. The four buttons corresponded to the location of the four match figures that were presented on the screen. Both the reference and the match figures remained on the screen until the participant gave a response, or until the maximum response time of 3 seconds had elapsed (no response). In the latter case, the participant received feedback to respond more quickly.

After reading the instructions, the participant started practicing the tasks. The actual tasks were organized in blocks of seven trials on average, with a minimum of five and a maximum of nine trials. The actual length of task blocks was randomly determined and therefore unpredictable for the participants. The difference between the two matching tasks lay in the relevant stimulus information, which means that either the color or the shape of the reference figure needed to be matched. The nature of the upcoming task was specified by a written cue, which was printed in uppercase 32-point Times New Roman font. Either the word "KLEUR" or the word "VORM," being the Dutch equivalents for "color" and "shape," appeared at the center of the computer screen at the beginning of a task block and disappeared as soon as the preparation interval (300 or 900 ms) was over. Immediately after the cue disappeared, the first stimuli appeared on the screen until a response (or feedback if too slow) was given. The response–stimulus interval (RSI) was fixed at 100 ms within the block, after which period a new stimulus figure appeared, followed by a response. This was repeated until the response on the last stimulus was given. The interval between the last response of a block and the first stimulus of a new block was fixed at 1,500 ms, which was done to control for the possible passive dissipation effects (Meiran, 1996, 2000). If the PI lasted 300 ms, then the preceding response-cue-interval (RCI) lasted for 1,200 ms, whereas if the PI lasted 900 ms, the RCI was 600 ms long. The RCI consisted of a blank screen presentation. No switching between the two tasks occurred within blocks.

The practice session contained 20 task blocks and was followed by an experimental session, which was divided in six consecutive parts of 31 task blocks each. These parts were separated by a break, and the participants were encouraged to use the breaks if needed to recover.

Design

The first task block of each experimental part was considered a warming-up block. Half of the remaining blocks were the so-called switch blocks, in which the task differed from the task in the previous block. The other half were the repetition blocks, in which the task to perform was identical to the task in the preceding block. In Experiment 1, the switch and the repetition blocks were equally spread over the two levels of the PI. Experiment 2 had the same total number of task blocks as Experiment 1. However, as the PI was manipulated between participants in Experiment 2, the number of switch and repetition blocks for each level of the PI was doubled here.

The two tasks were equally represented in both types of task blocks. This constraint of equal task (and PI, for Experiment 1) occurrence together with the constraint of the fixed number of block types as explained previously made the task sequence pseudo-random. Response times were measured for each button press, and incorrect responses as well as no-responses were recorded.

Analysis

Apart from the 20 practice blocks that were not analyzed, error trials and no-response trials were also excluded from the analysis as well as the trials that immediately followed. Furthermore, if within a certain task block all trials were error trials, then the whole task block that immediately followed was also not included in the analysis.

Because both experiments showed only a main effect of task variation (color and shape, with the color task being consistently faster than the shape task) and never any interaction, we decided to collapse the data across the task variable. Next, two analyses of variance (ANOVAs) were conducted on median RTs. First, for testing the influence of the PI on the general task performance, that is, on the strength of the resulting task representation, a three-way repeated-measures ANOVA was applied on trials 2 to 6, with the factors of block type (switch and repetition), preparation interval (300 and 900 ms), and trial (2, 3, 4, 5, and 6). Second, to replicate the switch and restart preparation effects, a two-way repeated-measures ANOVA was applied on first trials, with the factors of block type (switch and repetition) and preparation interval (300 and 900 ms). Error rates were first transformed using the arcsine transformation (Bishop, Fienberg, & Holland, 1975) to achieve approximate variance equality and then subjected to ANOVAs of the same format as for RT.

An alpha level of .05 was used for all statistical tests in this study.

Experiment 1 (PI Within-Subjects)

In this experiment, we investigated the influence of the preparatory processes on the general task execution, where the two levels (300 and 900 ms) of the PI were manipulated within participants. We also tried to test the reliability of the basic assumption of the activation approach (Altmann 2004a, 2004b), which assumes an analogy in advance preparation between task switching and task repetitions.

Participants

Twenty participants, 17 women and 3 men, were paid for taking part in this experiment. Their ages ranged between 18 and 27 years, with a mean age of 21.8 years. Three participants were left-handed, and the remaining 17 were right-handed. All participants had normal or corrected-to-normal vision. Six additional participants were excluded because their performance accuracy was below 90%.

Results

The task blocks that were included in the analyses contained on average a low error rate of 4.1%. The error rates were positively correlated with the median RT ($r = .45$, $p = .026$), suggesting that systematic RT differences did not stem from any speed–accuracy trade-off.

General Task Performance

A $2 \times 2 \times 5$ (Block Type $\times$ Preparation Interval $\times$ Trial) repeated-measures ANOVA, which was applied on trials 2 to 6, yielded two significant main effects for RT data: block type, $F(1, 19) = 15.79$, $p < .005$; and trial, $F(4, 16) = 3.55$, $p < .05$. On average, the responses on trials 2 to 6 after a task switch were significantly slower (699 ms) than the responses on the same trials after a task repetition (687 ms). Furthermore, a significant linear trend, $F(1, 19) = 14.42$, $p < .005$, accounted for 92% of the variance because of trial. Figure 1 shows a gradual increase of RTs for trials 2 to 6. Importantly, the main effect of the preparation interval was not significant ($F < 1$), implying no differential preparation effect for general task execution in this experiment. No other main effects or interactions were observed here.

First Trial Performance

A 2 × 2 (Block Type × Preparation Interval) repeated-measures ANOVA, which was applied on the first trials, yielded two significant main effects for RT data: block type, $F(1, 19) = 22.05$, $p < .001$; and preparation interval, $F(1, 19) = 8.66$, $p < .01$. On average, the responses immediately after a task switch were significantly slower (837 ms) than the responses immediately after a task repetition (747 ms). Furthermore, the shorter preparation interval was followed by longer responses (815 ms) on first trials as compared to the longer preparation interval (770 ms). Importantly, Figure 1 shows no interaction between block type and preparation interval ($F < 1$), indicating that the first trial preparation effect did not differ for the two types of block.

Error Data

The two repeated-measures ANOVAs, a 2 × 2 (Block Type × Preparation Interval) ANOVA that was applied on the first trials and a 2 × 2 × 5 (Block Type × Preparation Interval × Trial) ANOVA that was applied on trials 2 to 6, yielded both only one significant main effect, block type: $F(1, 19) = 23.20$, $p < .001$ and $F(1, 19) = 29.88$, $p < .001$, respectively. On average, participants made significantly more errors after a task switch than after a task repetition, on both first trials (6.58% and 2.17%, respectively) and the subsequent trials (5.19% and 2.34%) in a run. No other main effects of interactions were observed here (see Table 1).

Discussion

Importantly, the RT and error data of Experiment 1 demonstrated no difference in general task execution for the two levels of the PI. This suggests that if a variable PI is offered to the cognitive system, then the episodic task representation is produced with an analogous strength for both PI durations.

Furthermore, it is interesting to note that the general performance after a task switch was slower than the general performance after a task repetition. This suggests that repetition benefits (or switch costs) are not restricted to the first trials only and that the general task performance can also profit from the repetition of a task (or can suffer from a task switch).

Finally, the RT data on first trials show a similar benefit

Table 1. Experiment 1: Error rates (in %) as a function of trial, block type, and preparation interval (PI)

		Trial					
Block type	PI	1	2	3	4	5	6
Switch							
	300	6.56	5.33	4.78	5.56	5.22	4.44
	900	6.61	5.56	4.78	5.55	5.89	4.78
Repetition							
	300	2.22	2.33	1.67	2.33	3.00	2.22
	900	2.11	2.44	2.11	2.55	2.89	1.89

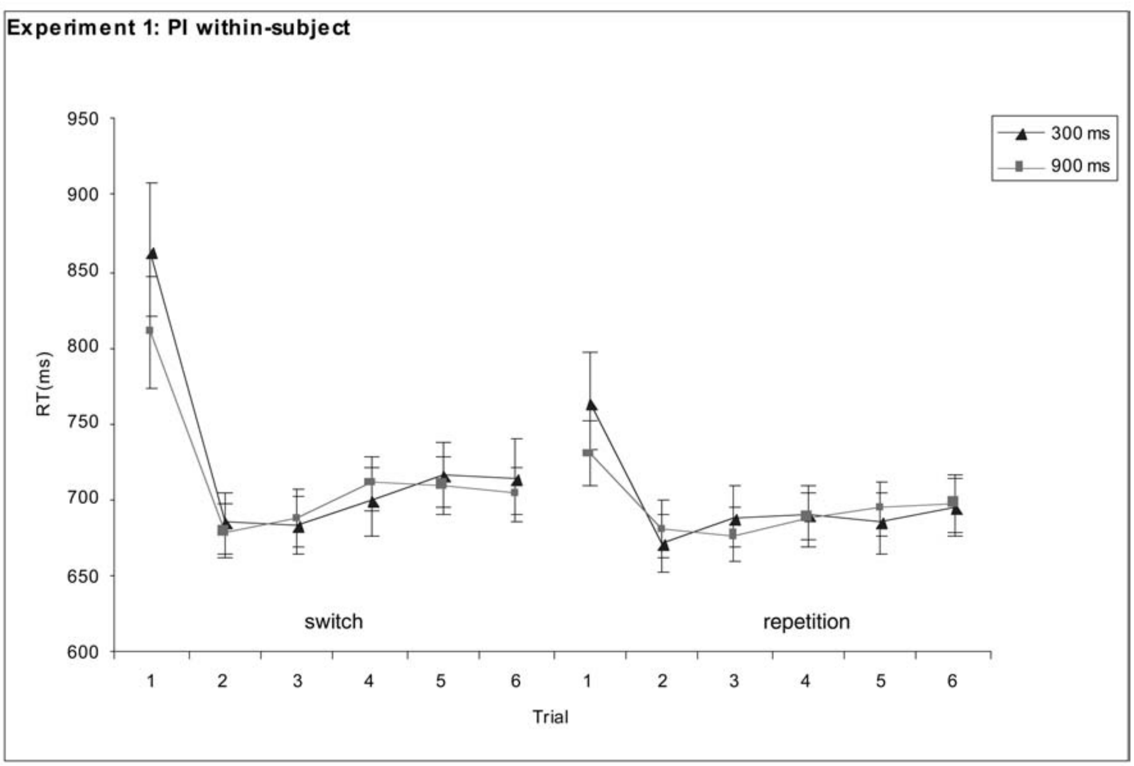

Figure 1. Means of median response time (ms) and standard error in Experiment 1 as a function of trial position (1, 2, 3, 4, 5, and 6) for two preparation-interval durations (300 and 900 ms) over two task block types (switch and repetition).

of longer PI after both a task switch and a task repetition. It seems that our cognitive system can partly prepare to (re)start the appropriate task in advance, at least if the preparation interval is sufficiently long and variable within a session, as it was in this experiment. This finding confirms the basic assumption of the activation approach (Altmann 2004a; 2004b; also Koch, 2005; Ruthruff et al., 2001; Sohn & Carlson, 2000), which assumes an analogy in advance preparation between task switching and task repetitions. An additional support for the activation approach was the replication of the within-run slowing introduced by Altmann (2002) and Altmann and Gray (2002). They attribute this gradual but regular increase in latencies across successive trials starting with the second trial to decay of memory for the most recent task representation.

Experiment 2 (PI Between-Subjects)

Also in this experiment, we investigated the influence of the preparatory processes on the general task execution and the reliability of the assumption of analogy in advance preparation between task switching and task repetitions. Here, however, the two levels (300 and 900 ms) of the PI were manipulated between participants.

Participants

This experiment involved 68 participants,[1] who were randomly assigned to one of the two PI conditions. This group consisted of 57 women and 11 men. Their ages varied between 17 and 34 years, with a mean age of 22.4 years. Six participants were left-handed and the remaining 62 were right-handed. All participants had normal or corrected-to-normal vision. Five additional participants were excluded because their performance accuracy was below 90%.

Results

The task blocks that were included in the analyses contained on average a low error rate of 3.9%. Also in this experiment, the error rates were positively correlated with the median RT ($r = .47$, $p = .022$), suggesting that systematic RT differences did not stem from any speed–accuracy trade-off.

General Task Performance

A 2 × 2 × 5 (Block Type × Preparation Interval × Trial) repeated-measures ANOVA, which was applied on trials 2 to 6, yielded three significant main effects for RT data: block type, $F(1, 66) = 43.50$, $p < .001$; preparation interval, $F(1, 66) = 5.22$, $p < .05$; and trial, $F(4, 63) = 7.94$, $p < .001$. Also in this experiment, the responses on trials 2 to 6 after a task switch were on average significantly slower (726 ms) than the responses on the same trials after a task repetition (711 ms). Importantly, different from Experiment 1, the shorter preparation interval was followed by, on average, longer responses (741 ms) on trials 2 to 6 as compared with the longer preparation interval (696 ms). Finally, as in Experiment 1, a significant linear trend, $F(1, 66) = 28.00$, $p < .001$, accounted for 99% of the variance resulting from trial. Figure 2 shows a gradual increase of RTs for trials 2 to 6. No other main effects or interactions were observed here.

First Trial Performance

A 2 × 2 (Block Type × Preparation Interval) repeated-measures ANOVA, which was applied on the first trials, yielded two significant main effects for RT data: block type, $F(1, 66) = 22.05$, $p < .001$; and preparation interval, $F(1, 66) = 8.66$, $p < .01$. Also in this experiment, the responses immediately after a task switch were significantly slower (867 ms) than the responses immediately after a task repetition (782 ms). Furthermore, the shorter preparation interval was again followed by longer responses (858 ms) on first trials as compared with the longer preparation interval (791 ms). Importantly, Figure 2 shows no interaction between block type and preparation interval ($F < 1$). This indicated that, also in this experiment, the first trial preparation effect did not differ for the two types of block.

Error Data

Also in Experiment 2, the two repeated-measures ANOVAs, a 2 × 2 (Block Type × Preparation Interval) ANOVA that was applied on the first trials and a 2 × 2 × 5 (Block Type × Preparation Interval × Trial) ANOVA that was applied on trials 2 to 6, yielded both only one significant main effect, block type: $F(1, 66) = 80.01$, $p < .001$ and $F(1, 66) = 55.97$, $p < .001$, respectively. On average, participants made significantly more errors after a task switch than after a task repetition, on both first trials (5.95% and 2.65%, respectively) and the subsequent trials (4.54% and 2.48%) in a run. No other main effects of interactions were observed here (see Table 2).

Discussion

In contrast to Experiment 1, the data of Experiment 2 showed a consistent cost of a short advance preparation for general task execution. This implies that a difference in strength of the episodic task representation is manifested by a cost throughout the whole run of trials if the cognitive system is exposed to a short and constant preparation interval. Accordingly, the cost of the shorter interval is not specifically associated with first trials.

As in Experiment 1, the general performance after a task switch was slower than the general performance after a task repetition. This confirms our suggestion based on the data

[1] An a priori power analysis (done by the G-Power program by Erdfelder, Faul, & Buchner, 1996) indicated that, given an alpha of .05, we needed 34 participants per condition to detect a preparation effect of $\omega^2 = .09$ (which is somewhat smaller than found in Experiment 1) with the probability of (1-beta) = .80.

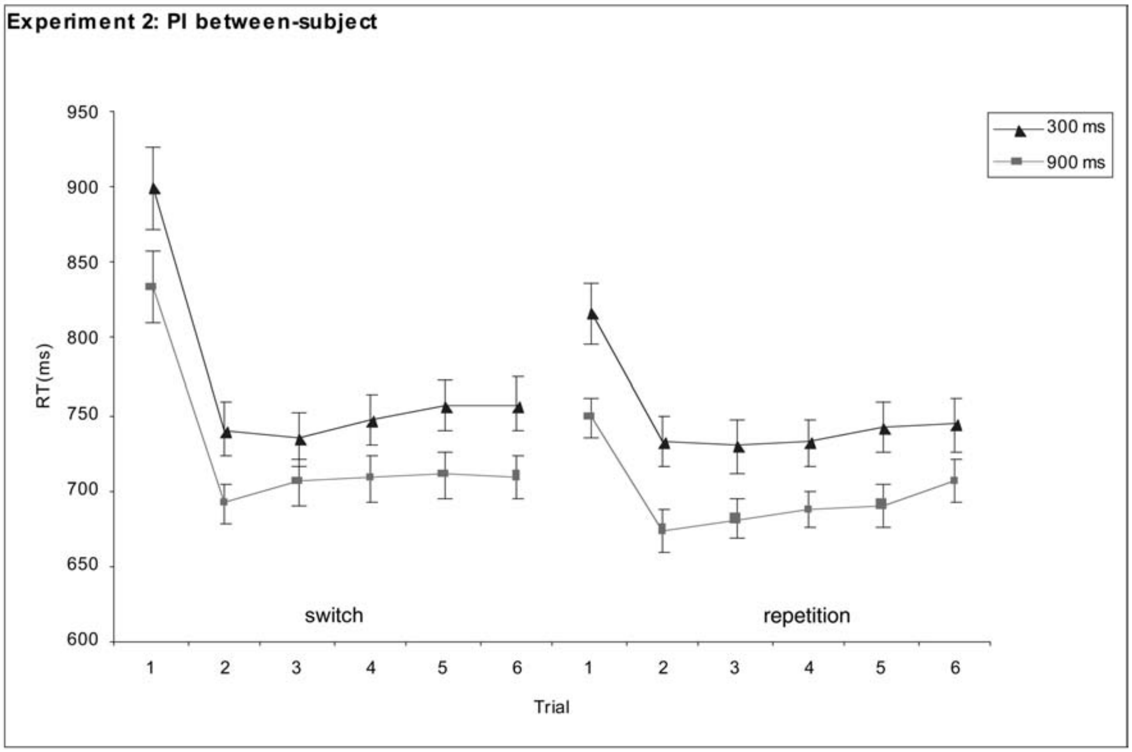

Figure 2. Means of median response time (ms) and standard error in Experiment 2 as a function of trial position (1, 2, 3, 4, 5, and 6) for two preparation-interval durations (300 and 900 ms) over two task block types (switch and repetition).

Table 2. Experiment 2: Error rates (in %) as a function of trial, block type, and preparation interval (PI)

		Trial					
Block type	PI	1	2	3	4	5	6
Switch							
	300	5.88	4.77	4.08	4.25	4.87	4.38
	900	6.01	4.77	4.41	4.61	4.93	4.28
Pure interruption							
	300	2.68	2.78	2.61	2.42	2.74	2.02
	900	2.61	2.58	2.19	2.71	2.58	2.16

of Experiment 1 that, next to first trials, the general task performance also could profit from the repetition of a task. Consequently, this emphasizes even more the importance of a broader view of performance. Focusing solely on first trials could lead to an incomplete (or maybe even incorrect) understanding of task-switching performance. This issue has, for instance, already been brought up in studies (e.g., Wylie & Allport, 2000) discussing the idea of full task preparation for the repetition trials as assumed in some task-switching paradigms (e.g., alternating-runs paradigm and random-cuing paradigm). We address this issue in more detail in the "General Discussion" section.

Finally, analogous to the data of Experiment 1, first trials showed similar benefits of longer PI for both task switching and task repetitions. It seems that our cognitive system can partly prepare to (re)start the appropriate task in advance, independently of the way the different preparation-interval durations are being offered to the system. This finding confirms again the basic assumption of the activation approach (Altmann 2004a, 2004b; also Koch, 2005; Ruthruff et al., 2001; Sohn & Carlson, 2000), which assumes an analogy in advance preparation between task switching and task repetitions. The additional support for the activation approach in terms of the within-run slowing was again observed in this experiment.

General Discussion

The aim of the present study was to explore the extent to which advance preparation influences the general task execution. Importantly, this study establishes that the influence of advance preparation is not restricted to first trials: our data showed that the general task performance suffers from insufficiently long task preparation if the cognitive system is exposed to a constant preparation interval. A possible explanation for design dependency of the preparation effect for general task execution could be given as follows. Sufficiently long PIs may produce relatively strong episodic task representations, independently of the way the PI is being manipulated. For shorter PIs, the episodic task representation is weaker, and therefore, the general task execution worsens as compared with longer PIs. However, the variability of the PI in the within-subjects design could help the system to recognize the functionality of the advance preparation.[2] Consequently, both short and long PI durations could produce episodic task representations of an analogous strength. Accordingly, the strength of an episodic task representation produced during short intervals would be higher in a within-subjects design than in a between-subjects design. This could be seen as a gain in strength of the episodic task representations for short PIs because of mixing PI durations. Following this idea, one would expect the general task performance to profit from advance preparation for short PIs only in a within-subjects design, which is precisely what we observed in this study.

An alternative explanation for this design dependency of the preparation effect for general task execution could be that in a within-subjects design, the participants might simply adopt a response criterion common to both long and short PIs. It is plausible to assume that the participants do not change the response criterion from part to part, but adapt a criterion according to the requirements of the whole session. In a between-subjects design, the participants might also calculate a session-wise criterion. Here, however, the participants presented with short PIs implement a higher criterion than the participants presented with long PIs. In this way, this alternative idea also would predict the observed finding of a relatively slower general task execution for short PIs in a between-subjects design. However, following this reasoning, one would also expect a speed-accuracy trade-off between the two PI levels in the between-subjects design. The data of this study do not provide any evidence for this trade-off effect. This could, however, be because the tasks used in this study resulted in an insufficient error rate to permit discovery of this possible speed-accuracy trade-off. Running more subjects or a study with, on average, higher error rates could provide a clearer picture on this issue. The data of the present study seem to favor the explanation in terms of differences in episodic task representations. Whether the explanation for the observed design dependency of the preparation effect for general task execution is to be found at the level of episodic task representations or at the level of response criterions is an interesting issue that can be addressed in future research.

As to the influence of the advance preparation on the first-trial performance, this study shows similar preparation benefits for both task switching and task repetitions. Our cognitive system seems to able to partly prepare the (re)start of the relevant task in advance, independently of the way the different preparation interval durations are being offered to the system. This finding confirms again the basic assumption of the activation approach (Altmann 2004a, 2004b), which assumes an analogy in advance preparation between task switching and task repetitions.

This finding, however, differs from the usual preparation effects reported in the literature on task switching. Typically, the benefit of a longer PI is reported to be larger after a task switch than after a pure task interruption. Altmann (2004a, 2004b) has already shown that this switch-preparation effect is not a stable finding by showing its design dependency. Here, we show that, even with a within-subjects manipulation of the PI, the switch-preparation effect is sometimes absent. We think that the standard switch-preparation effect observed in the experiments with the within-subjects manipulation of PIs might simply be a result of a greater chance of improvement in performance on first trial after a task switch as compared with the performance after a task repetition.

Finally, two interesting findings were observed in this study independently of the design used concerning the PI. First, the general performance after a task switch was slower than the general performance after a task repetition. Second, the within-run slowing seemed also to be present independently of the way the PI was offered to the cognitive system.

As to the difference in general task performance between two transition types (task switch and task repetition), this finding implies that, next to first trials, also the general task performance could profit from the repetition of a task. This is again in accordance with the activation approach, if one considers the option of difference in initial task-activation levels between tasks that switch and tasks that repeat. In addition, it is important to mention that this finding offers further support against the idea of full task preparation on repetition trials, which are often used as the baseline (e.g., Meiran, 1996; Rogers & Monsell, 1995). The assumption of fully prepared tasks on trials that follow the first trial in a run would predict no difference in general task performance between two transitions, which is the opposite of what is observed in this study. First evidence against this idea was provided by studies that reported a cost on repetition trials in an alternating-task condition as compared with a pure-task condition (e.g., Jersild, 1927). This mixing cost (see Los, 1996, for review) has been attributed to the difference in memory requirements between the two conditions: in the alternating-task condition, participants need to hold two tasks in mind, whereas only one task at a time needs to be active in memory in the pure-task condition. Second evidence against the idea of full preparation on repetition trials was provided by Allport and Wylie (2000), who reported a cost in general task performance also within a pure-task condition. In their "before and after" paradigm, the participants were first asked to execute a task A for a certain number of blocks of trials (phase 1). Next, the participants were instructed to execute a second task, task B, for a further number of trials (phase 2) before returning to the task A (phase 3). A cost in general task performance was observed when participants returned to task A after performing the competing task B (Experiment 3). The control group of subjects, who completed the same phase 1 and 3, but simply rested during the phase 2, showed no cost in general task performance in the last phase. Therefore, Allport and Wylie attributed the observed cost to persisting interference from a competing task that was previously executed. Altogether, the mixing cost (alternating-task versus pure-task condition), the persisting interference cost (pure-task conditions before and after the execution of the competing task), and the cost observed in the present study (alternating condition, task switch versus task repetition)

[2] Poulton (1982) showed already that the system sometimes fails to notice two levels of a factor in isolation but still responds to the same two in combination.

offer ample support against the idea of full preparation on repetition trials.

As to the within-run slowing, this finding suggests that the decay of memory for the most recent task representation, which is being offered as the main source for (re)starting costs (Altmann & Gray, 2002), is a more reliable phenomenon than the switch-preparation effect. This, again, speaks in favor of the activation account.

Altogether, the present study demonstrates a consistent cost in general task performance after a relatively short and steady advance preparation. In addition, it supports the activation approach (Altmann 2004a, 2004b) by showing (a) an analogous preparation effect for both task switching and task repetitions, (b) a consistent switch cost throughout the whole run of trials, and (c) a stable within-run slowing effect.

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