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ORIGINAL ARTICLE

Evidence for instructions-based updating of task-set representations: the informed fadeout effect

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Abstract The cognitive system can be updated rapidly and efficiently to maximize performance in cognitive tasks. This paper used a task-switching task to explore updating at the level of the plausible task-sets held for future performance. Previous research suggested a "fadeout effect", performance improvement when moving from task-switching context to single-task context, yet this effect could reflect passive learning rather than intentional control. In a novel "informed fadeout paradigm", one of two tasks was canceled for a certain number of trials and participants were informed or uninformed regarding task cancelation. The "informed fadeout effect" indicates better performance in the informed than uninformed fadeout after one informed trial had been executed. However, the results regarding the first trial were inconclusive. Possible underlying mechanisms are discussed.

Keywords Cognitive control · Task switching · Fadeout

Introduction

Imagine driving on a highway, when suddenly encountering roadworks. You lower your speed, and after a few kilometers you encounter a sign indicating that the roadworks is over. Would you need to experience that the road is clear before increasing your speed? And what if there was no road sign? The goal of the current research is to examine how the cognitive system responds to announced contextual changes (e.g., end of roadworks sign) relative to unannounced (experienced) ones (e.g., no sign); in search for an indication for the removal of irrelevant goals from working memory (WM) (e.g., watch for hazards in the road).

The issue of expectation-based vs. experience-based adjustments of cognitive control has been extensively investigated, for example, in the literature on the proportion of incongruent Stroop trials. In that literature, the debate surrounds mostly whether the reduced Stroop effect is due to trial-to-trial influences (experience-based) vs. proportion (instruction; e.g., Bugg, Diede, Cohen-Shikora, & Selmeczy, 2015; Goldfarb & Henik, 2013; Schmidt, 2013). Importantly, the current study emphasizes *instructions-based performance*. In this sense, this work joins the growing literature regarding the unique human ability to execute tasks following instructions, without actually experiencing them beforehand (e.g., Cole, Laurent, & Stocco, 2013; Gaschler, Frensch, Cohen, & Wenke, 2012; Hartstra, Waszak, & Brass, 2012; Liefooghe, Wenke, & De Houwer, 2012; Meiran, Pereg, Kessler, Cole, & Braver, 2015).

In the current research, we explored a situation in which contextual information changed during performance and should have been updated online to benefit performance. We use the term 'contextual information' to indicate goal-relevant information that is represented in a way that could influence processing (Braver et al., 2001). For example, Botvinick, Braver, Barch, Carter, and Cohen (2001) mention that online maintenance of contextual information is a control mechanism that enables the cognitive system to arrange itself towards task performance. We further refer to 'global context' to describe the event properties that remain

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relevant for some time, and contrast it with local context. In typical experimental settings, local context refers to the current trial, whereas global context refers to several trials, the entire block or even the entire experiment. In the present work, we employed a task-switching task in which both the local context and the global context were manipulated. For that reason, we provide some essential background on task switching in the following section.

Relevant task switching effects

In task switching (see Meiran, 2010; Monsell, 2003; Vandierendonck, Liefooghe, & Verbruggen, 2010, for review), two or more tasks are performed alternately or in a randomly occurring order. In a particular version of the paradigm, the cuing paradigm (Shaffer, 1965; Meiran, 2014, for review), the tasks switch randomly and participants are instructed regarding the relevant task at the beginning of each trial. Performance in these mixed-task blocks is compared with single-task blocks in which the task does not switch during the entire block. Task switching often incurs a performance cost that has two main components: switching cost is the difference between switch and repeat trials (from mixed-task blocks), reflecting the impact of local context change; mixing cost, the difference between repeat trials (from mixed-task blocks) and single trials (from single-task blocks), reflecting the impact of the global (switching) context.

The fadeout cost

Perhaps the most relevant finding for us is the "fadeout cost", originally found by Mayr and Liebscher (2001). In that study, participants performed cued task switching that also included fadeout blocks in which after 40 mixed trials, the fadeout phase began as one of the tasks was canceled (instructed by a cue), leaving only one relevant task to perform until the end of the block. The authors compared participants' performance in the fadeout trials to single-task performance (Trials 42–120). Specifically, they divided the 79 fadeout trials into mini-blocks of 10 trials and found that young adults showed poorer performance in the fadeout trials relative to the single-task trials, but only in the first mini-block that contained nine trials (excluding the trial immediately following the first fadeout cue). Interestingly, elderly participants showed fadeout cost throughout the entire fadeout section.

Aside from providing a vital tool to address our questions, the fadeout cost is interesting to study in its own sake. The fact that this effect is enhanced in old age (Mayr & Liebscher, 2001; Meiran, Gotler, & Perlman, 2001) as well as in some forms of psychopathology (Meiran, Diamond, Toder, & Nemets, 2011) makes it a good candidate for investigation, since better defining the underlying mechanisms at the basis of this phenomenon can improve our understanding of the cognitive deficits that characterize these populations.

As would be explained shortly, the fadeout cost may represent global context updating. Specifically, Spieler, Mayr, and LaGrone (2006) and Mayr, Spieler, and Hutcheon (2015) showed that when older participants are not given task cues during the fadeout phase, their fadeout cost is drastically decreased or even completely diminished. In other words, paying attention to a task cue during the fadeout phase impairs performance, suggesting that the elderly rely heavily on external information for task control. Accordingly, Mayr et al. (2015) suggested that younger adults construct a more complete task space model that includes a higher order control mode differentiating between task switching and task fadeout, according to which they decide whether to rely on external or internal task information. Supposedly, older adults need an external trigger to transfer to an internally guided task control, whereas young adults self-initiate this transition.

Related task control issues have been discussed by other authors. We refer specifically to task decision (choosing which task to perform) and goal maintenance (keeping this task) (Meiran, 2010; Meiran, Kessler, & Adi-Japha, 2008). In detail, since task fadeout is characterized by task certainty, task decision processes could be relaxed as long as the currently relevant task is correctly maintained in working memory (WM). Importantly, this perspective suggests that the one trial in which task decision is still relevant is the first trial after receiving task-cancelation announcement. A relevant finding was observed with the alternating-runs paradigm by Rogers and Monsell (1995, Experiment 6) in which the tasks are arranged in short runs which alternate on a regular basis. This setup creates predictable "runs", such that participants could apply internally guided task control. The results indicate poorer performance in the first (switch) trial of the run than in subsequent trials, which are roughly equivalent. This illustrates the importance of examining the very first trial(s) of a new sequence when trying to understand the underlying mechanism.

Importantly, throughout their works with the fadeout paradigm, Mayr and colleagues did not present the results of trials immediately following task cancelation announcement (i.e., following the first fadeout cue, or 3 trials following a verbal announcement), and term this segment a "transition phase" (Mayr & Liebscher, 2001; Mayr et al., 2015). Therefore, the dynamics of transition from a mixing context to a single-task context, which are in the present focus, remain yet not fully explored.

What underlies the fadeout cost?

Fadeout involves a shift from mixed-task to a single-task context, during performance. As we see it, the fadeout cost reflects a shift from a processing mode characterizing mixed-task performance to a mode characterizing single-task performance. Since this transition is explicitly notified, a possible interpretation is that the quickly diminishing fadeout cost in young adults reflects an instructions-based shift to single-task performance (which Mayr et al., 2015 suggest to be a self-initiated shift within a hierarchical task model). However, we argue that there might be a different interpretation to this effect.

In detail, once the fadeout begins, only one task is involved and a passive shift (involving minimal cognitive control) can be sufficient to perform the needed adjustment after experiencing just one task. Specifically, the design of the fadeout paradigm confounds instructions with the task sequence, since the task sequence before the fadeout phase involves mixed tasks, and only a single task after the announcement. Given this confound, it remains possible that participants have ignored the task-cancelation instructions and used a passive "wait and see" strategy, instead. Since the nature of the task sequence has changed, this change was sufficient to change processing mode based on experience alone.

In line with this possibility, Meiran, Chorev and Sapir (2000), Monsell, Sumner and Waters (2003), and Tornay and Milàn (2001) found a gradual (and rather slow) reduction in response-times (RT) as a function of a task-repetition sequence progress taking place in experimental blocks involving random task switching. This finding suggests that processing mode can change as a function of experience. In fact, the latter finding suggests that the change in processing mode may even take place in spite of the instructions, indicating that task switching is still in effect. This gradual change in processing mode contrasts with the step-function seen under predictable settings (Monsell et al., 2003; Rogers & Monsell, 1995). Therefore, the very first trials following a shift seem to be critical for determining whether the adjustment is instruction-based or experience-based. In both methods, performance reached an asymptote level after three trials and hence, only looking at the more advanced trials does not permit differentiating between the two mechanisms. Hence, we introduce a different control condition to de-confound instructions and task switching, and thus assess the potential contribution of instruction vs. passive, experience-based adaptation to the fadeout effect.

The present study—the informed fadeout paradigm

In the current study, we modified Mayr and Liebscher's (2001) paradigm to examine whether participants update their task-related representation following a notification that one task is not required in the next trials. A cued task switching task was used with two tasks—color (red vs. blue) and shape (square vs. rhombus) performed on (bivalent) colored shapes using the same set of response keys. Participants had to switch between the tasks according to a cue given prior to the target stimulus. Following Mayr and Liebscher (2001), the cue was composed of the two task names (i.e., SHAPE and COLOR), and the relevant task name was underlined. During the fadeout phase, the relevant task was still underlined, but the other, irrelevant task name, was crossed (see Fig. 1). Importantly, the first trial of the fadeout phase was always a task-repetition trial to de-confound fadeout cost from switching cost. Since Mayr and Liebscher reported that young adults showed the fadeout cost only in the first ten trials of the run, the length of the fadeout phase was relatively short and included only ten trials. This can be conceived of as zooming on the trials that are expected to show a fadeout cost.

This fadeout condition was named the "informed fadeout" since the participants were informed that one task has been canceled, and it is roughly equivalent to Mayr & Liebscher's (2001) original fadeout condition. Performance in this condition was compared with a condition termed "uninformed fadeout" in which participants performed a similar sequence of task-repetition trials that took place within a block (or a block segment) declared to involve task switching. This design allows the differentiation between instructions-based and experience-based mode adjustment. Specifically, in the informed condition, fadeout is influenced by both instructions and experience-based adaptation. In contrast, in the uninformed condition, only experience-based adaptation exists. Thus, if instructions contribute to the fadeout effect (as can be seen in Mayr et al., 2015, Experiment 2), this effect should be more pronounced in the informed condition than in the uninformed condition.

We also included Task-Rule Congruency ("Congruency"; Meiran & Kessler, 2008, for review) as an independent variable in the respective analyses to control for its influence on the results. This variable reflects the partial activation of the currently irrelevant task rule, and is operationalized as the performance difference between congruent trials (in which the relevant and irrelevant rules indicate the same response) and incongruent trials (in which the rules indicate conflicting responses). Recently, Bugg and Braver (2016) showed an attenuation of this congruency effect under conditions that are predicted to change the degree to

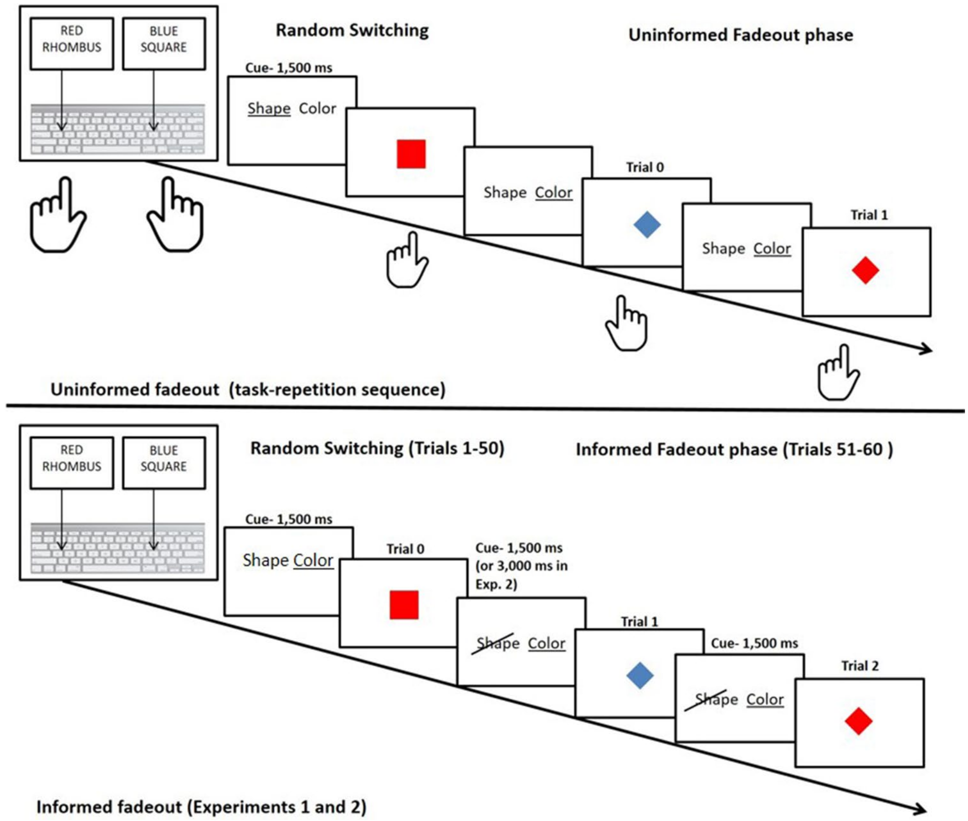

Fig. 1 The informed fadeout paradigm. *Upper panel* uninformed fadeout—a sequence of repeat trials in a mixing context. *Lower panel* informed fadeout—the cue excludes the irrelevant task (the first fadeout cue in Exp. 2 was either 1500 or 3000 ms in each informed fadeout block). In these blocks, the first 50 trials of the block were random switching trials, and the final ten trials are informed fadeout trials

Table 1 Experiments overview

Experiment	Main research question	Outcome
Experiment 1	Is there a fadeout cost (Mayr & Liebscher, 2001) immediately following task cancelation?	An instructions-based advantage is seen from the second trial of the run. The informed fadeout condition reflects an intermediate performance level between single and repeat trials. Replication to Mayr and Liebscher (2001)
Experiment 2	Will providing more preparation time prior to the first informed trial show an instructions-based advantage from the first trial?	Providing more time to prepare for the informed fadeout resulted in a delayed instructions-based advantage
Experiment 3	Will equating the cueing presentation show an instructions-based advantage from the first trial?	Presenting a task-cancelation announcement at the beginning of the fadeout phase and equating the trial-by-trial cues showed an instructions-based advantage from the first trial

which task-irrelevant information is being processed (that is, when task irrelevant information is known to cause conflict, it causes less interference—lower congruency effect). Since none of the results involving Congruency reached significance, the fuller background regarding this effect as well as results are reported in the Appendix.

To sum up, there are a few differences between Mayr and Liebscher's (2001) study and the present study. First, the control condition was not single-task performance as in the fadeout paradigm, but an uninformed fadeout instead, which should involve a passive dissipation of the irrelevant task (Monsell et al., 2003). In addition, we focused on the process of shifting into the fadeout phase using shorter fadeout runs, and zoomed-in on the trial-by-trial changes over this course to better understand the underlying cognitive process.

Experiments and analyses overview

Three experiments are reported in this paper (see Table 1 for an overview, two additional preliminary experiments are reported in Supplementary Materials S1 and S2). The first experiment was meant to test how many trials following a

Table 2 Planned contrasts overview

Contrast number	Contrast	What does the contrast test for?	Contrast weights
1	Difference at baseline	Initial difference between the fadeout conditions prior to fadeout onset	Uninformed<-->informed at baseline
2	Improvement from baseline to first fadeout trial	Immediate reaction to the first fadeout cue (which would be manifested in a difference from baseline)	Baseline<-->Trial 1 (for each fadeout condition separately, and for the interaction)
3	Difference in Trial 1	Difference between the fadeout conditions immediately following the first fadeout cue	Uninformed<-->informed in Trial 1
4	Improvement from Trial 1 to Trials 2–4/5	Difference between the first and the more advanced trials following fadeout onset (tests step-function)	Trial 1<-->Trials 2–4/5 (for each fadeout condition separately, and for the interaction)
5	Improvement within the fadeout phase	Gradual improvement in performance within each fadeout condition	Linear contrast within each condition (Trial 2 <-to-> Trial 4/5)
6	Difference in Trials 2–4/5	Difference between the fadeout conditions in the more advanced trials from fadeout onset	Uninformed<-->informed in Trials 2–4/5

task-cancelation instruction are needed for an instructions-based advantage to emerge. In addition, single-task blocks were introduced to serve as a baseline measure, which also allows a replication for Mayr and colleagues' results. The first experiment showed an instructions-based advantage from the second trial onward. Following this result, two additional experiments were performed to clarify if other circumstences would allow an instructions-based advantage in the first trial immediately following instructions as well. Experiment 2 tested whether supplying more time would benefit performance, and Experiment 3 tested whether such advantage was masked by another process.

To explore the results on a trial-to-trial basis, the results in all of the experiments are shown as a function of trial progression from the informed-fadeout announcement (in the informed condition) or from the beginning of an uninformed task-repetition sequence (in the uninformed condition). In addition, we thought to include the trial prior to the fadeout phase (Trial 0) in the analyses to serve as baseline. However, since we could only use switch trials to equate the two conditions, this baseline created substantial missing data. Thus, we report the results with a different baseline, which was calculated as the mean performance in repeat trials extracted from five trials prior to the fadeout phase[1]. The original baseline is reported in Supplementary Materials S3. Finally, since we had precise questions, our core analyses are not exploratory Analyses of Variance (ANOVAs) but involve a series of 6 planned contrasts (see Table 2 for an overview).

In each experiment, the core analyses tested (1) the initial difference between the fadeout conditions at baseline, (2) improvement in performance once the fadeout began in each condition (first trial relative to baseline), and whether this improvement changed between the fadeout conditions. Additionally, we tested for (3) the difference between the fadeout conditions in the first trial immediately following the fadeout instruction, (4) the difference between the first trial and the more advanced trials of the fadeout phase (for each condition separately, and between the conditions) [2], (5) improvement during the fadeout phase (linear contrast to test for a gradual performance improvement), and (6) differences between the fadeout conditions in the more advanced trials (pooled). Finally, we also looked at the entire informed fadeout sequence to test whether the first 4–5 trials reflect what takes place in the full sequence (up to Trial 10), and whether our informed fadeout resulted in a roughly similar way to Mayr and Liebscher's fadeout condition.

We used G-Power (Faul, Erdfelder, Buchner, & Lang, 2009) to determine the sample size. The following experiments are based on Experiment S2 (see Supplementary Materials). An instructions-related advantage immediately following the instructions (in Trial 1) reached $\eta^2_p = 0.13$ with 14 participants. Thus, according to G-Power, $N=20$ is sufficient for achieving this effect size with Power >0.80 ($\eta^2_p = 0.13$ is equivalent to $D_z=0.64$, with this sample

[1] We wish to thank Michael Ziessler, for reviewing this paper and suggesting this baseline.

[2] The differentiation between the first and the more advanced trials was based on preliminary results that are reported in the Supplementary Materials S1 and S2, and also uses to test for a specific expected pattern.

size). The experiments included 21 participants, other than Experiment 3, in which we ran $N=40$ for reasons specified below.

We hypothesized that if context updating is instructions based, it occurs immediately in response to the first task-cancelation instruction (cue). This would lead to an advantage for the informed fadeout from this trial onward, which would show as a step-function that will indicate an intended, instructions-based process (similar to Rogers & Monsell, 1995). In contrast, if fadeout is experience based, there should not be any advantage for the informed condition and the results should show a gradual improvement in performance in both conditions. The step-function prediction was predicted to reflect in a significant Contrast 4, and a non-significant Contrast 5. Experience-based improvement was predicted to reflect in a significant Contrast 5.

Experiment 1

Preliminary results from experiments involving just an informed fadeout and an uninformed fadeout condition (see Supplementary Materials[3]) indicate an informed-fadeout advantage. Moreover, the pattern indicates a step-function of improvement, as predicted under the instructions-based hypothesis. Yet, it was unclear how efficient performance can become when such explicit notification is provided. Mayr and Liebscher (2001) and Mayr et al. (2015) used single-task performance as baseline and showed that fadeout performance reached the single-task level after one miniblock of 10 trials. To examine whether an informed fadeout can achieve a level of performance that approaches single-task levels, it is necessary to also compare it to single-task performance, as was done in the current experiment.

Method

Participants

Twenty-one Ben-Gurion University of the Negev students (15 females, mean age = 22.33, SD = 1.75) participated in the experiment in return for course credit. All of the participants reported having normal or corrected-to-normal vision including intact color vision and not having diagnosed attention deficits.

[3] Two preliminary experiments are reported in the Supplementary materials, both showing an informed fadeout effect—improved RT from the second informed trial relative to the uninformed condition. According to their results we decided to (a) use a constant fadeout length (Experiment S1) and (b) place the informed condition at the end of trial-blocks (Experiment S2).

Materials and procedure

The experiment was run individually. Participants were presented with the stimuli on a 17″ monitor controlled by a desktop computer, with a software written in E-Prime 2.0 (Psychology Software Tools, 2010). The stimuli were red and blue squares and rhombuses sized 3 × 3 cm. The response keys were the letter keys "L" and "A" (on a QWERTY keyboard) which were covered with stickers, and presented to the participants as right and left responses, accordingly. The association of stimuli to response keys was counter-balanced between participants (see Fig. 1 for an example).

The experimental phase consisted 36 blocks with 60 trials each (65% repeat trials, to enhance the chances for long repetition sequences). One-half of the blocks contained an informed fadeout phase, which took place at the final 10 trials of the block (Trials 51–60). The reason for not including informed fadeout phases at the end of all blocks was to make sure participants remain somewhat uncertain regarding the task cancelation. Thus, the uninformed block was introduced as a "standard" task switching block (i.e., participants were told that only sometimes the computer cancels a task). The uninformed task-repetition sequences were randomly determined by the computer, as was their position within the block, and the task that was discarded. Thus, uninformed trials could either come from the "uninformed blocks" (that do not involve an informed fadeout at their end) or from the "informed blocks" (somewhat prior to the informed trials, since until the fadeout announcement there was no difference between the blocks). This means that the occurrence of long sequences of repeat trials was determined by chance. Nonetheless, we only analyzed uninformed sequences that occurred in the second half of the block (Trials 31–60), to roughly match them to the informed condition (in terms of block progress).

Trial 1 in the informed condition was defined as the trial following the first task cancelation cue. In the uninformed condition, Trial 1 was defined as the first repeat trial in a repetition sequence. Only randomly occurring repetition sequences of at least 5 trials were included in the analyses.

In addition, two single-task blocks (one for each task) were performed for 40 trials at the beginning of the second experimental session. The single-task performance that served a reference in the analyses was the mean in Trials 15–30 (a range thought to capture the performance at its best).

Since the experiment was long, participants completed it in two separate sessions (each lasted one hour). Participants were instructed to register for the second session on the next day, which resulted in a range of 18–29 h between the two sessions. The first session began with a task switching 20 trials practice phase (accompanied by an experimenter) followed by an additional practice block of 100 trials. Afterwards, the informed fadeout paradigm was introduced and participants practiced two blocks—one informed and one uninformed. Following this practice, 18 experimental blocks were performed (half informed and half uninformed). During Session 2, participants first performed a short practice—one informed and one uninformed block, followed by the two single task blocks and the remaining 18 experimental blocks.

We chose to place the single-task condition at the beginning of Session 2 (which is around mid-experiment) to roughly equate it with the other conditions in terms of average time on task. Specifically, if we had recorded the sequential trial number, the average number would have been the same for the mixed condition and the single-trial condition, meaning that in terms of general practice effects if such exist, they would have an equal influence on the two conditions, on average.

Each trial began with a 200 ms fixation, followed by the cue for 1500 ms and the target stimulus, which was presented until the participant responded. The breaks between the trial-blocks included instructions reminder for both task sets.

Data analysis

Trials with an error, or following an error, as well as trials with RT < 150 ms or RT > 3000 ms were not included in the RT analyses. For error analysis, we only excluded trials outside the 150–3000 ms RT window. This resulted in an average of 10% excluded trials (range between 0 and 30%).

Results and discussion

The contrasts (see Table 2) were performed on marginal means from a factorial design involving the within-subjects independent variables Fadeout Type (informed–uninformed-single), Trial (0–5), and Congruency (congruent–incongruent).

Generally, Fig. 2 shows a step function in the RT of the informed condition. Below we report the results of the contrast tests. Table 3 specifies the weights used in each contrast, and the reference to Table 3 in brackets on each contrast refers to it specific line in the Table. Notice that contrasts numbering follow the Contrasts defined in Table 2, whereas the letters (e.g., 2a vs. 2b) refer to sub-contrasts within them.

Difference at baseline (Table 3, Contrast 1)

As predicted, no significant differences were found between the conditions at baseline (trend: −2 ms, and −0.13% PE advantage for the informed condition) [$F(1,20) = 0.22$, $p = .88$, MSE = 2708.75.07, $\eta^2_p < 0.01$ (RT); $F(1,20) = 0.02$, $p = .88$, MSE = 0.002, $\eta^2_p < 0.01$ (PE)]. This can be seen in Fig. 2, comparing the light and dark gray lines at baseline.

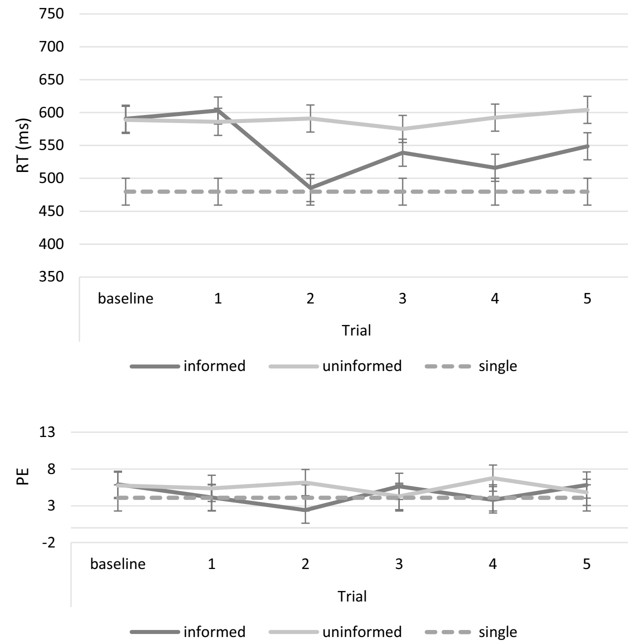

Fig. 2 RT (in ms) and percentage of errors (PE) as a function of Trial and Fadeout Type—Experiment 1. The single-task reference is shown as a constant value, reflecting the mean RT and PE for Trials 15–30. *Error bars* represent within-subject confidence intervals (Hollands & Jarmasz, 2010; Jarmasz, & Hollands, 2009)

Improvement from baseline to first fadeout trial

An indication for an instructions-based effect would be evident in an increased improved performance in the informed (vs. uninformed) condition in Trial 1 relative to baseline. However, the trend in the informed condition suggested slowing (by 12 ms) and PE improvement (by 1.78%; Fig. 2, dark gray line; Table 3, Contrast 2a); whereas the uninformed condition showed an improvement in both RT and PE (by 3 ms and 0.4% errors, respectively; Fig. 2, light gray line; Table 3, Contrast 2b). Descriptively, this suggests speed–accuracy tradeoff, though none of these trends reached significance [$F(1,20) = 0.15$, $p = .70$, MSE = 21,322.61, $\eta^2_p < 0.01$ (informed RT); $F(1,20) = 3.13$, $p = .09$, MSE = 0.002, $\eta^2_p = 0.13$ (informed PE); $F(1,20) = 0.04$, $p = .84$, MSE = 4,795.95, $\eta^2_p < 0.01$ (uninformed RT); $F(1,20) = 0.11$, $p = .74$, MSE = 0.003, $\eta^2_p < 0.01$ (uninformed PE)]. Accordingly, the informed–uninformed difference between these trends did not reach significance [$F(1,20) = 0.21$, $p = .65$, MSE = 12,045.46, $\eta^2_p = 0.01$ (RT); $F(1,20) = 0.92$, $p = .35$, MSE = 0.002, $\eta^2_p = 0.04$ (PE)] (Fig. 2, comparing the

Table 3 Contrasts weights in Experiment 1

Contrast number[a]	Contrast	Fadeout type			Trial					
		Informed	Uninformed	Single	*B*[b]	1	2	3	4	5
1	Difference at baseline	1	−1	0	1	0	0	0	0	0
2a	Improvement from baseline to first fadeout trial—informed condition	1	0	0	1	−1	0	0	0	0
2b	Improvement from baseline to first fadeout trial—uninformed condition	0	1	0	1	−1	0	0	0	0
2c	Improvement from baseline to first fadeout trial—interaction between fadeout types	−1	1	0	1	−1	0	0	0	0
3	Difference in Trial 1	−1	1	0	0	1	0	0	0	0
4a	Improvement from Trial 1 to Trials 2–5—informed condition	1	0	0	0	4	−1	−1	−1	−1
4b	Improvement from Trial 1 to Trials 2–5—uninformed condition	0	1	0	0	4	−1	−1	−1	−1
4c	Improvement from Trial 1 to Trials 2–5—interaction between fadeout types	−1	1	0	0	4	−1	−1	−1	−1
5a	Improvement within the informed fadeout phase	1	0	0	0	0	−2	−1	1	2
5b	Improvement within the uninformed fadeout phase	0	1	0	0	0	−2	−1	1	2
6a	Difference in Trials 2–5	−1	1	0	0	0	1	1	1	1
6b	Difference in Trials 2–5	1	0	−1	0	0	1	1	1	1

[a]Contrasts numbers correspond to the contrast numbers described in Table 2. Letters refer to sub-contrasts within the specific contrast (e.g., 2a, 2b)

[b]*B* baseline

transition from baseline to Trial 1 between the light and dark gray lines; Table 3, Contrast 2c).

Difference in Trial 1 (Table 3, Contrast 3)

Better (e.g., informed RT < uninformed- T) Trial 1 performance would indicate an instructions-based effect. However, no significant effect was found. The informed condition was slower by 17 ms but more accurate by 1.24% than the uninformed condition. [$F(1,20)=0.32$, $p=.58$, MSE = 19,351.83, $\eta^2_p = 0.01$ (RT); $F(1,20)=0.73$, $p=.40$, MSE = 0.004, $\eta^2_p = 0.03$ (PE)] (Fig. 2, comparing the dark and light gray lines in Trial 1).

Improvement from Trial 1 to Trials 2–5

Improvement in performance between the first and the more advanced trials would indicate that the instructions-related advantage occurs only after one trial has been executed, but this pattern is also the indication for a step-function (as expected under the instructions-based hypothesis). The fact that we compared between Trial 1 and Trials 2–5 (and not between baseline and Trials 1–5) is based on preliminary results. As before, we test this effect for each condition separately, and then compare between the informed and the uninformed conditions. The results showed a RT improvement in the informed condition (by 81 ms), but not in PE (−0.3% difference) (Fig. 2, dark gray line; Table 3, Contrast 4a) [$F(1,20)=9.98$, $p>.01$, MSE = 21,950.11, $\eta^2_p = 0.33$ (informed RT); $F(1,20)=0.03$, $p=.86$, MSE = 0.01, $\eta^2_p < 0.01$ (informed PE)]. In contrast, no improvement was found in the uninformed condition (Fig. 2, light gray line; Table 3, Contrast 4b), and the results were in the reversed direction, though non-significantly so (RT was slower by 5 ms and error rate increased by 0.1% in Trials 2–5) [$F(1,20)=0.21$, $p=.65$, MSE = 3,698.90, $\eta^2_p = 0.01$ (uninformed RT); $F(1,20)=0.01$, $p=.91$, MSE = 0.004, $\eta^2_p < 0.01$ (uninformed PE)]. This trend significantly differed between the Fadeout conditions. In fact, the RT trends in the two conditions were in opposite directions [$F(1,20)=9.47$, $p<.01$, MSE = 12,978.88, $\eta^2_p = 0.32$] (Fig. 2, testing the difference between the light and dark gray lines in the transition from Trial 1 to the mean of Trials 2–5; Table 3, Contrast 4c).

Improvement within the fadeout phase

To test whether there was a gradual improvement in performance throughout the fadeout phase (supporting the experience-based assumption), a linear contrast testing the entire fadeout sequence from Trial 2 to Trial 5 was tested in both conditions. The descriptive results actually demonstrate performance worsening with trial

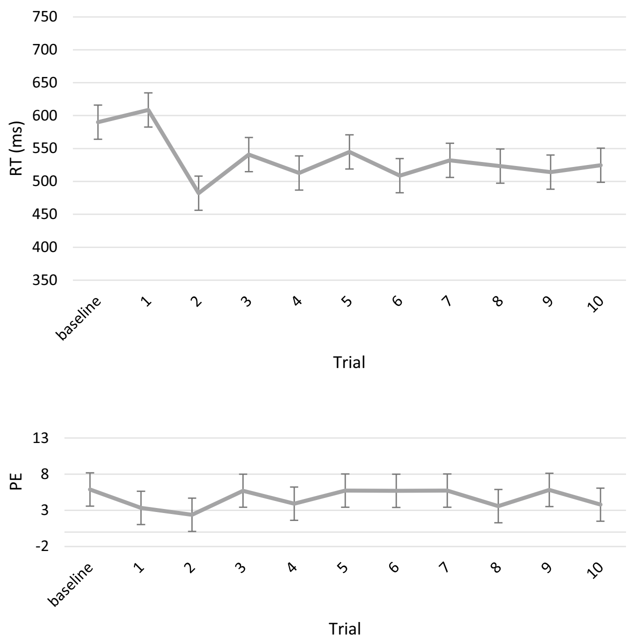

Fig. 3 RT (in ms) and Percentage of Errors (PE) as a function of Trial in the informed fadeout condition—Experiment 1. *Error bars* represent within-subject confidence intervals (Hollands & Jarmasz, 2010; Jarmasz, & Hollands, 2009)

progression in the informed condition, which is opposite to what experience-based adaptation would predict. This (opposite-to-predicted) linear trend reached significance [$F(1,20) = 11.81$, $p < .01$, MSE = 4,979.91, η^2_p = 37 (informed RT); $F(1,20) = 2.35$, $p = .14$, MSE = 0.006, $\eta^2_p = 0.10$ (informed PE)] (Fig. 2, dark gray line; Table 3, Contrast 5a). The equivalent linear trend did not reach significance in the uninformed condition [$F(1,20) = 1.06$, $p = .31$, MSE = 6,275.29, $\eta^2_p = 0.05$ (uninformed RT); $F(1,20) = 0.10$, $p = .75$, MSE = 0.005, $\eta^2_p < 0.01$ (uninformed PE)] (Fig. 2, light gray line; Table 3, Contrast 5b).

Taken together with the previous contrast (showing an improvement from Trial 1 to Trials 2–5) these results rule out the experience-based hypothesis and show that it is not even feasible. Importantly, RT seems to stabilize afterwards (see Fig. 3 and relevant analyses).

Difference in Trials 2–5 (pooled)

Performance was better in the informed than the uninformed condition (a 68 ms and 1.1% errors advantage for the informed condition). This advantage was significant only in RT [$F(1,20) = 20.18$, $p < .01$, MSE = 19,409.02, $\eta^2_p = 0.50$ (RT); $F(1,20) = 2.04$, $p = .17$, MSE = 0.005, $\eta^2_p = 0.09$ (PE)]. Nonetheless, performance in Trial 2-informed was relatively quick and this might have biased the aforementioned comparison (indeed, it was significantly faster than Trials 3–5 [$F(1,20) = 14.68$, $p < .01$, MSE = 5,204.43, $\eta^2_p = 0.42$]) (Table 3, Contrast 6a). Therefore, we tested the difference between the informed and the uninformed condition in Trials 3–5, and it still showed an informed advantage (of 50 ms) [$F(1,20) = 14.33$, $p < .01$, MSE = 13,704.38, $\eta^2_p = 0.42$]. This can be seen in Fig. 2, comparing the difference between the dark and light gray lines in the mean of Trials 2–5.

Last, the advantage of the single-task condition over the informed condition (44 ms in RT and 0.7% in errors) also reached significance [$F(1,20) = 7.89$, $p = .01$, MSE = 19,291.62, $\eta^2_p = 0.28$ (RT); $F(1,20) = 0.23$, $p = .63$, MSE = 0.004, $\eta^2_p = 0.01$ (PE)] (Fig. 2, comparing the dark gray and the dashed lines in the mean of Trials 2–5) (Table 3, Contrast 6b).

Examining the full informed fadeout sequence (Fig. 3)

Finally, we wanted to make sure that performance in Trials 2–5 of the informed condition correctly reflects the final level of performance achieved by the end of the block. In both RT and PE, there was no significant difference between Trials 2–5 and Trials 7–10 [$F(1,20) = 0.18$, $p = 49$, MSE = 2,537.06, $\eta^2_p < 0.1$ (RT); $F(1,20) = 0.09$, $p = .76$, MSE = 0.004, $\eta^2_p < 0.1$ (PE)].

In summary, the informed condition showed a performance advantage in RT, but only from the second trial of the run (after one trial was executed following the fadeout announcement). We term the informed-over-uninformed advantage "the informed fadeout effect". Yet, this improvement was insufficient to reach single-task performance level (indicating fadeout cost, replicating Mayr and Liebscher 2001).

The pattern of results in the informed fadeout condition closely resembles Rogers and Monsell's (1995) step function, only that the first informed trial involved task repetition and not a task switch. Thus, the reason for the lack of advantage in the first fadeout trial is not clear. The following experiment is focused on maximizing the informed condition's opportunity to benefit performance immediately following the first fadeout trial.

Experiment 2

One reason for the lack of informed-over-uninformed advantage in Trial 1 may be the sudden, unexpected change in the task cue. This situation thus resembles a "restart cost" (or a "first-trial cost"), a worsening in performance seen in the first trial after resuming the task under unexpected conditions (Allport & Wylie, 2000; Gopher, Armony, & Greenshpan, 2000). This effect was suggested to involve a process specific for the first trial of a run regardless of task switching and it may also be relevant to the aforementioned Rogers and Monsell's (1995) results (see Altmann, 2007).

We thus thought that an informed-over-uninformed advantage can be seen already in the first informed trial if this trial is less surprising. We also reasoned that surprise would be reduced with increasing pre-warning time (CTI). In Experiment 1, CTI was 1500 ms, which is considered relatively long and sufficient for task preparation (Meiran et al., 2000). Nonetheless, it is possible that when the cue conveys a new and unexpected information this CTI-period is insufficient. For example, Ecker, Lewandowsky, and Oberauer (2014) showed that presenting a cue indicating that information should be removed from WM for a period of 1500 ms was sufficient to decrease but not diminish WM updating effects, suggesting that information removal was still incomplete. Importantly, cue presentation time in that study had an effect (1500 ms showed better results than 200 ms), suggesting that an even longer cue presentation time might help taking into account task cancelation immediately following this announcement. Therefore, in this experiment, the CTI in the first trial of the informed condition was doubled (3000 ms) in one-half of the relevant trial-blocks. We predicted that if the reason for the lack of informed-fadeout effect in Trial 1 was due to insufficient pre-warning, this effect would be observed when CTI is doubled.

Method

Participants

Twenty-one Ben-Gurion University of the Negev students, similar to those in the previous experiment (16 females, mean age = 24.09, SD = 2.07), participated in the experiment in return for course credit or monetary compensation (70 NIS, ~$18 U.S).

Materials and procedure

The procedure was the same as in Experiment 1, apart from manipulating informed-fadeout cue duration and the change in the number of blocks as specified below. This manipulation was only applied to the first cue in the informed fadeout sequence (just prior to Trial 1), but it was kept 1500 ms in all the subsequent fadeout trials (as in Experiment 1). There were 24 blocks with an informed fadeout at their end, 12 of which had a first long cue (3000 ms; i.e., the long-informed condition henceforth) and 12 had a short/standard first cue (1500 ms; i.e., the short-informed condition henceforth). In addition, there were 8 uninformed blocks (without an informed fadeout). These blocks were introduced to keep some ambiguity regarding the chances of task cancelation at the end of the block, and were used to extract uninformed trials (in addition to the informed blocks). As in Experiment 1—since the informed trials were at the final 10 trials of the block, random repeat sequences preceding the informed phase (but during the second half of the block) were also considered uninformed trials.

Results and discussion

The following analyses are divided into independent contrasts: informed (pooled across cue-length conditions) vs. uninformed, and short- vs. long-informed conditions. Trial exclusion in this experiment resulted in an average of 8% excluded trials (range between 0 and 30%). As in Experiment 1, the accompanying Table 4 describes the contrast weights used in each comparison.

Difference at baseline

A significant difference was found at baseline RT, in favor of the (pooled) informed conditions relative to the uninformed condition (whereas the PE showed a 0.9% error rate advantage for the *uninformed* condition) [$F(1,20) = 6.65$, $p = .02$, MSE = 2,356.14, $\eta^2_p = 0.25$ (RT); $F(1,20) = 1.59$, $p = .22$, MSE = 0.001, $\eta^2_p = 0.07$ (PE)] (Fig. 4, comparing the mean of the dark gray and dashed lines with the light gray line; Table 4, Contrast 1a). No significant differences were found between the short- and long-informed conditions (with a 3 ms advantage for the *long*-informed condition, and a 1.2% error rate advantage for the *short*-informed condition) [$F(1,20) = 0.05$, $p = .82$, MSE = 3,875.44, $\eta^2_p < 0.01$ (RT); $F(1,20) <= 0.95$, $p = .34$, MSE = 0.002, $\eta^2_p = 0.04$ (PE)] (Fig. 4, comparing the dark gray and dashed lines; Table 4, Contrast 1b). Since there was an initial advantage for the informed conditions, we will also examine the later advantage relative to baseline.

Improvement from baseline to first fadeout trial

As in Experiment 1, a trend for speed–accuracy tradeoff following the first informed cue was observed (RT slowing was by 50 and 42 ms; accuracy improvement by 1.05 and 4.64%, in the short- and long-informed conditions (see Fig. 4, dark gray and dashed lines; Table 4, Contrasts 2a and 2b), respectively). Nevertheless, none of these trends reached significance [$F(1,20) = 3.17$, $p = .09$, MSE = 16,590.51, $\eta^2_p = 0.14$ (short-informed RT); $F(1,20) = 0.23$, $p = .64$, MSE = 0.003, $\eta^2_p = 0.01$ (short-informed PE); $F(1,20) = 2.97$, $p = .10$, MSE = 12,518.92, $\eta^2_p = 0.13$ (long-informed RT); $F(1,20) = 2.30$, $p = .14$, MSE = 0.003, $\eta^2_p = 0.10$ (long-informed PE)].

However, in the uninformed condition (Fig. 4, light gray line; Table 4, Contrast 2c), a non-significant improvement

Table 4 Contrast weights in Experiment 2

Contrast number[a]	Contrast	Fadeout type			Trial					
		Short-informed	Long-informed	Uninformed	B[b]	1	2	3	4	5
1a	Difference at baseline—pooled informed vs. uninformed	1	1	−2	1	0	0	0	0	0
1b	Difference at baseline—short- vs. long-informed	1	−1	0	1	0	0	0	0	0
2a	Improvement from baseline to first fadeout trial—short-informed condition	1	0	0	1	−1	0	0	0	0
2b	Improvement from baseline to first fadeout trial—long-informed condition	0	1	0	1	−1	0	0	0	0
2c	Improvement from baseline to first fadeout trial—uninformed condition	0	0	1	1	−1	0	0	0	0
2d	Improvement from baseline to first fadeout trial—interaction between pooled informed and uninformed conditions	1	1	−2	1	−1	0	0	0	0
2e	Improvement from baseline to first fadeout trial—interaction between short- and long-informed conditions	1	−1	0	1	−1	0	0	0	0
3a	Difference in Trial 1—pooled informed vs. uninformed conditions	1	1	−1	0	1	0	0	0	0
3b	Difference in Trial 1—short- vs. long-informed conditions	1	−1	0	0	1	0	0	0	0
4a	Improvement from Trial 1 to Trials 2–5—uninformed condition	0	0	1	0	4	−1	−1	−1	−1
4b	Improvement from Trial 1 to Trials 2–5—uninformed vs. pooled informed conditions	1	1	−2	0	4	−1	−1	−1	−1
4c	Improvement from Trial 1 to Trials 2–5—short informed condition	1	0	0	0	4	−1	−1	−1	−1
4d	Improvement from Trial 1 to Trials 2–5—long-informed condition	0	1	0	0	4	−1	−1	−1	−1
4e	Improvement from Trial 1 to Trials 2–5—interaction between short- and long-informed conditions	−1	1	0	0	4	−1	−1	−1	−1
5a	Improvement within the short-informed fadeout phase	1	0	0	0	0	−2	−1	1	2
5b	Improvement within the long-informed fadeout phase	0	1	0	0	0	−2	−1	1	2
5c	Improvement within the uninformed fadeout phase	0	0	1	0	0	−2	−1	1	2
6a	Difference in Trials 2–5—uninformed vs. pooled informed conditions	1	1	−2	0	0	1	1	1	1
6b	Difference in Trials 2–5—short- vs. long-informed conditions	1	−1	0	0	0	1	1	1	1
6c	Difference in Trials 3–5—short- vs. long-informed	1	−1	0	0	0	0	1	1	1

[a]Contrasts numbers correspond to the Contrast numbers described in Table 2. Letters refer to sub-contrasts within the specific contrast (e.g., 2a, 2b)

[b]*B* baseline

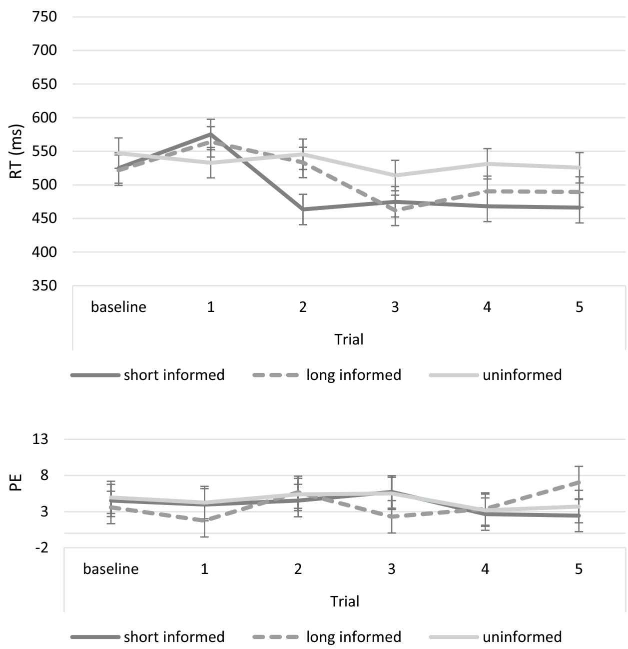

Fig. 4 RT (in ms) and Percentage of Errors (PE) as a function of Trial and Fadeout Type—Experiment 2. "Informed-short" represents the informed condition with 1500 ms duration in the first cue (replicating Experiment 1), and "informed-long" represents the informed condition with 3000 ms duration in the first cue. *Error bars* represent within-subject confidence intervals (Hollands & Jarmasz, 2010; Jarmasz & Hollands, 2009)

in performance was observed in both RT and PE (by 14 ms and 1.3% errors) [$F(1,20) = 1.43$, $p = .24$, MSE = 2,932.76, η^2_p = 0.07 (uninformed RT); $F(1,20) = 0.32$, $p = .57$, MSE = 0.003, $\eta^2_p = 0.02$ (uninformed PE)].

The interaction testing the difference in Contrast 2 between the (pooled) informed conditions and the uninformed condition reached significance in RT, but the similar comparison in PE did not [$F(1,20) = 6.08$, $p = .02$, MSE = 8,351.38, η^2_p = 0.23 (RT); $F(1,20) = 0.08$, $p = .78$, MSE = 0.004, η^2_p < 0.01 (PE)] (comparing the transition from baseline to Trial 1, between the mean of the dark gray and dashed lines and the light gray line in Fig. 4; Table 4, Contrast 2d). However, there were no significant differences in this trend between the short- and long-informed conditions [$F(1,20) = 0.07$, $p = .79$, MSE = 8,853.79, η^2_p < 0.01 (RT); $F(1,20) = 0.53$, $p = .47$, MSE = 0.003, η^2_p = 0.02 (PE)] (comparing the transition from baseline to Trial 1, between the dark gray and the dashed lines in Fig. 4; Table 4, Contrast 2e).

Difference in Trial 1

First, as in Experiment 1, a non-significant RT advantage for the uninformed condition was indicated by the difference between the two informed conditions, pooled, and the uninformed condition in the first repeat trial of the sequence (36 ms) [$F(1,20) = 3.13$, $p = .09$, MSE = 11,947.87, η^2_p = 0.13] (this can be seen by comparing the difference between the mean of the dark gray and dashed lines with the light gray line, in Trial 1 in Fig. 4; Table 4, Contrast 3a). This trend was reversed in PE (1.4% advantage for the informed conditions) [$F(1,20) = 1.16$, $p = .29$, MSE = 0.005, η^2_p = 0.05 (PE)]. Second, and more importantly, the difference between the short- and long-informed conditions (Table 4, Contrast 3b; dark gray and dashed lines in Fig. 4, respectively) did not reach significance (11 ms in RT, and 2.2% in PE in favor of the long-informed condition) [$F(1,20) = 0.19$, $p = .67$, MSE = 13,560.89, η^2_p < 0.01 (RT); $F(1,20) = 2.62$, $p = .12$, MSE = 0.004, η^2_p = 0.11 (PE)]. This result already indicates no significant advantage for a longer first-informed cue, though the descriptive results were in the expected direction.

Improvement from Trial 1 to Trials 2–5

In the uninformed condition (light gray line in Fig. 4; Table 4, Contrast 4a), no significant improvement was found (RT decreased by 4 ms, and increased by 0.2% errors) [$F(1,20) = 0.07$, $p = .79$, MSE = 7,437.25, η^2_p < 0.01 (uninformed RT); $F(1,20) = 0.04$, $p = .84$, MSE = 0.003, η^2_p < 0.01 (uninformed PE)]. The difference in this pattern between the uninformed condition and the (pooled) informed condition (which showed an RT decrease of 88 ms, and PE increase of 1%) reached significance only in RT [$F(1,20) = 14.51$, $p < .01$, MSE = 11,072.29, η^2_p = 0.42 (RT); $F(1,20) = 1.05$, $p = .32$, MSE = 0.003, η^2_p = 0.05 (PE)] (this can be seen in Fig. 4 by comparing the mean of the dark gray and dashed lines with the light gray line, in the transition from Trial 1 to Trials 2–5; Table 4, Contrast 4b).

Similar to Experiment 1, a significant improvement was found in RT (by 107 ms in the short-informed condition, and by 70 ms in the long-informed condition), though a reversed (non-significant) pattern was found in PE in both the short-informed condition (by 0.1% errors) [$F(1,20) = 31.46$, $p < .001$, MSE = 12,231.36, η^2_p = 0.61 (short-informed RT); $F(1,20) = 0.01$, $p = .92$, MSE = 0.004, η^2_p < 0.01 (short-informed PE)], and the long-informed condition (by 2.9% errors) [$F(1,20) = 21.94$, $p < .001$, MSE = 7,561.08, η^2_p = 0.52 (long-informed RT); $F(1,20) = 3.67$, $p = .07$, MSE = 0.007, η^2_p = 0.15 (long-informed PE)] (comparing the dark gray and dashed lines in their transition from Trial 1 to Trials 2–5 in Fig. 4; Table 4, Contrasts 4c and 4d).

The pattern of results shows a sharp reduction in RT after the first short-informed trial (as in Experiment 1), whereas this pattern seems delayed in the long-informed condition and only appears after the second trial has been

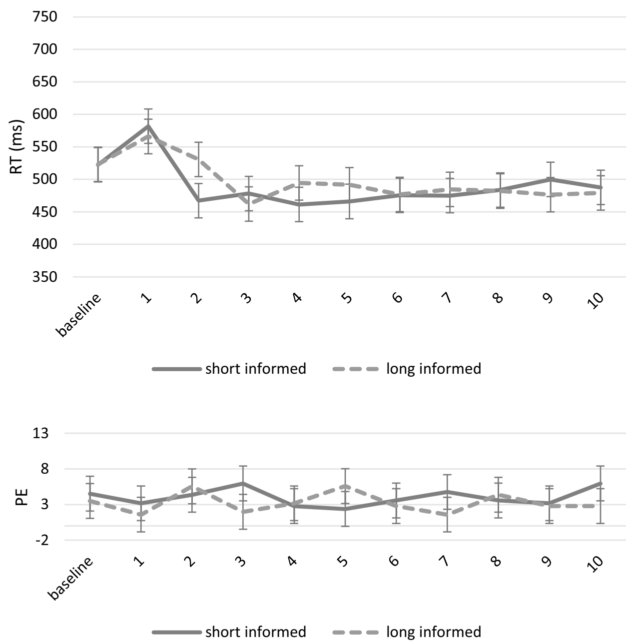

Fig. 5 RT (in ms) and Percentage of Errors (PE) as a function of Trial and fadeout Type in the informed fadeout conditions—Experiment 2. *Error bars* represent within-subject confidence intervals (Hollands & Jarmasz, 2010; Jarmasz & Hollands, 2009)

executed. Therefore, we also tested the difference between these conditions in Trial 2, and found a significant result [$F(1,20)=19.16$, $p<.001$, MSE=5,369.69, η^2_p = 0.49], indicating an earlier advantage for the short-informed condition, contrary to the hypothesis.

Nonetheless, the interaction testing the difference from Trial 1 to Trials 2–5 between the short- and the long-informed conditions did *not* reach significance [$F(1,20)=2.42$, $p=.13$, MSE=9,385.80, η^2_p = 0.10 (RT); $F(1,20)=2.18$, $p=.15$, MSE=0.007, η^2_p = 0.10 (PE)], suggesting that there was no overall advantage for either condition (this can be seen in Fig. 4 by comparing the difference between Trial 1 and the mean of Trials 2–5 between the dark gray and dashed lines; Table 4, Contrast 4e).

Improvement within the fadeout phase

In the short-informed fadeout, no RT improvement was found after the first trial has been executed [$F(1,20)<0.1$, $p=.97$, MSE=2,230.83, η^2_p < 0.01] (seen in the pattern between Trials 2 to 5 in the dark gray line in Fig. 4; Table 4, Contrast 5a). A marginally significant trend was found in PE [$F(1,20)=3.89$, $p=.06$, MSE=0.005, η^2_p = 0.16], supposedly indicating improvement in error rate within the fadeout phase. However, the results of the full sequence (see Fig. 5 and the related analysis) show that the error pattern was quite noisy and that the low error rate in Trials 4 and 5 was restricted to these trials. In the long-informed fadeout (the dashed line in Fig. 4; Table 4, Contrast 5b), a trend for RT improvement between Trials 2–5 was observed [$F(1,20)=2.67$, $p=.12$, MSE=8,418.63, η^2_p = 0.12], though this probably reflects the delayed instructions-based advantage. Additionally, RT in Trials 4 and 5 were longer than in Trial 3. No such trend was observed for PE, in which the pattern was revered with an increase in PE between Trials 2 and 5 [$F(1,20)=0.76$, $p=.39$, MSE=0.007, η^2_p = 04]. Finally, a non-significant trend towards a gradual improvement was only found in PE in the uninformed condition (light gray line in Fig. 4; Table 4, Contrast 5c) [$F(1,20)=1.33$, $p=.26$, MSE=2,862.26, η^2_p = 0.06 (RT); $F(1,20)=3.03$, $p=.10$, MSE=0.004, η^2_p = 0.13 (PE)].

Difference in Trials 2–5

First, replicating Experiment 1, an informed-related RT advantage was found for the pooled informed conditions relative to the uninformed condition (by 48 ms and 0.6% errors) [$F(1,20)=17.79$, $p<.001$, MSE=14,583.53, η^2_p = 0.47 (RT); $F(1,20)=0.08$, $p=.78$, MSE=0.007, η^2_p < 0.01 (PE)]. This can be seen in Fig. 4 by comparing the mean of the dark gray and dashed lines to the light gray line (Table 4, Contrast 6a).

Second, we wanted to test whether supplying more time to prepare for the beginning of the informed fadeout phase led to improved performance. To this end, performance in Trials 2–5 was compared between the short- and long-informed conditions. The results showed a RT advantage for the short-informed condition over the long-informed condition (by 26 ms, and 0.8% errors), contrary to the prediction [$F(1,20)=6.32$, $p=.02$, MSE=8,770.68, η^2_p = 0.24 (RT); $F(1,20)=0.54$, $p=.47$, MSE=0.009, η^2_p = 0.03 (PE)]. This can be seen in Fig. 4 as the difference between the dark gray and dashed lines (Table 4, Contrast 6b).

Nonetheless, this pattern of results stems from Trial 2 which was an outlier. Indeed, removing this trial (i.e., examining Trials 3–5; Table 4, Contrast 6c) resulted in a non-significant difference between the two informed conditions [$F(1,20)=0.91$, $p=.35$, MSE=8,266.81, η^2_p = 0.04 (RT), $F(1,20)=0.38$, $p=.54$ MSE=0.006, η^2_p = 0.02 (PE)].

Examining the full informed fadeout sequence (Fig. 5)

In the short-informed condition (dark gray line in Fig. 5), there was a slight *increase* in RT from Trials 2–5 to Trials 7–10 [$F(1,20)=8.82$, $p<.01$, MSE=1,599.77, η^2_p = 0.31 (RT); $F(1,20)=0.21$, $p=.65$, MSE=0.005, η^2_p = 0.10 (PE)], indicating that performance was best at the beginning of the run. In the long-informed condition (dashed line in Fig. 5), a marginally significant *decrease* in RT was found between Trials 2–5 and 7–10 [$F(1,20) = 3.85$, $p = .06$, MSE = 2,193.42, $\eta^2_p = 0.16$ (RT); $F(1,20) = 1.53$, $p = .23$, MSE = 0.004, $\eta^2_p = 0.07$ (PE)], possibly due to the delayed advantage which is seen in a slow Trial 2. Indeed, removing Trial 2 resulted in a non-significant effect indicating no further improvement throughout the long-informed fadeout phase [$F(1,20) = 0.19$, $p = .66$, MSE = 2,131.20, $\eta^2_p < 0.01$].

Since performance throughout the informed fadeout conditions did not seem as stable as it was in Experiment 1, we also tested whether the improvement from baseline was seen in the final trials of the run. To do that, we tested the trials (Trial 6–Trial 10) that were not analyzed before and compared them to baseline. Importantly, in the short-fadeout condition Trials 6–10 were faster than baseline, suggesting that the task-cancelation benefit lasted until the end of the sequence and was not limited to the beginning of the run [$F(1,20) = 7.12$, $p = .01$, MSE = 3,565.88, $\eta^2_p = 0.26$ (RT); $F(1,20) = 0.19$, $p = .66$, MSE < 0.001, $\eta^2_p < 0.01$ (PE)].

The long-informed condition also showed advantageous RT relative to baseline in Trials 6–10 [$F(1,20) = 5.88$, $p = .02$, MSE = 5,607.34, $\eta^2_p = 0.22$ (RT); $F(1,20) = 0.74$, $p = .40$, MSE < 0.001, $\eta^2_p = 0.03$ (PE)]. However, this advantage was delayed by one trial in the long-informed condition and only appeared from Trial 3.

To conclude, the results do not support the hypothesis concerning insufficient warning time in the informed fadeout condition, as performance was similar in the two informed conditions, other than the delayed advantage.

The result showing a delayed performance advantage in the long- informed condition was surprising to us. We attribute this unexpected result post hoc, to the violation of temporal expectancy. Specifically, given the constant CTI (1500 ms), it is conceivable that participants have formed temporal expectancy. When the target appeared after 3000 ms and not after 1500 ms, this had violated the expectancy and impaired performance. In addition, it is possible that this effect reflects participants' difficulty to maintain readiness for a relatively long period, due to its effortful character (e.g., Jenning & van der Molen, 2005).

Experiment 3

The informed fadeout effect in the previous experiments could be attributed to the different task cues in the informed and the uninformed conditions. Perhaps, the informed cue facilitates the informed fadeout effect on the one hand (which shows in Trials 2–5), but the unexpected and sudden appearance of this different cue impairs performance in Trial 1 on the other hand.

This account predicts that the informed fadeout effect may be observed already in Trial 1 if we equate the informed and the uninformed conditions in terms of the task cue. We acknowledge the fact that when the visual displays are identical, we drop the constant reminder from the informed condition and this could possibly enforce higher WM load in the informed condition, by requiring to hold the task-cancelation instruction in mind. Thus, we hypothesized that the informed fadeout effect would be smaller in the advanced trials than it was in the previous experiments, but importantly, we predicted that the effect would already show in Trial 1.

In this experiment, participants were given the standard task cues throughout the experiment and we introduced a separate warning at some point during the block (see Fig. 6), regarding whether switching continues or just one task is to be performed (and cues were relevant as before). Thus, the trial-by-trial cues were the same in both conditions, but the content of the separate warning differed between the conditions.

Method

Participants

Forty Ben-Gurion University of the Negev undergraduate students, similar to those in the previous experiments (27 females, mean age = 23.7, SD = 1.90). The compensation was either monetary (45 NIS, ~$12 US) or by course credit. We decided to double *N*, given the prediction regarding a smaller informed fadeout effect. The current *N* provides Power > 0.80 for effect sizes of $D_z = 0.45$ (equivalent to $\eta^2_p = 0.07$ with this sample size) in planned two-sided contrasts.

Material and procedure

The procedure was similar to that in the previous experiments except as noted. The main differences involved shortening the blocks to 37 trials (which resulted in one experimental session that lasted 80 min), and including an announcement screen after Trial 27 that was presented for 2500 ms. Half of the blocks (16, randomly selected) involved informed fadeout and half (16) did not involve informed fadeout. In the fadeout blocks, the announcement could be "Only the Color task", for example, and in the control blocks it was "Color and Shape" (i.e., continue switching). Of the 16 blocks without informed fadeout, nine involved uninformed fadeout (four consecutive task repetition trials following the announcement) and seven involved random task switching (and were not further analyzed. These served to create the feeling that indeed switching continues as usual after the announcement in this condition). This means that unlike the previous experiments, uninformed trials were extracted from pre-programmed blocks.

Fig. 6 Example trial sequence in Experiment 3. *Upper panel* Informed fadeout—the task cancelation announcement before Trial 28 informs the participants which task to perform until the end of the block. Task cues are the same as before the announcement. *Lower panel* Uninformed fadeout—instead of the task cancelation announcement, before Trial 28 a screen announcing that both tasks are still relevant appears. Afterwards, there are four repeat trials, and only then the task switches and randomly mixed

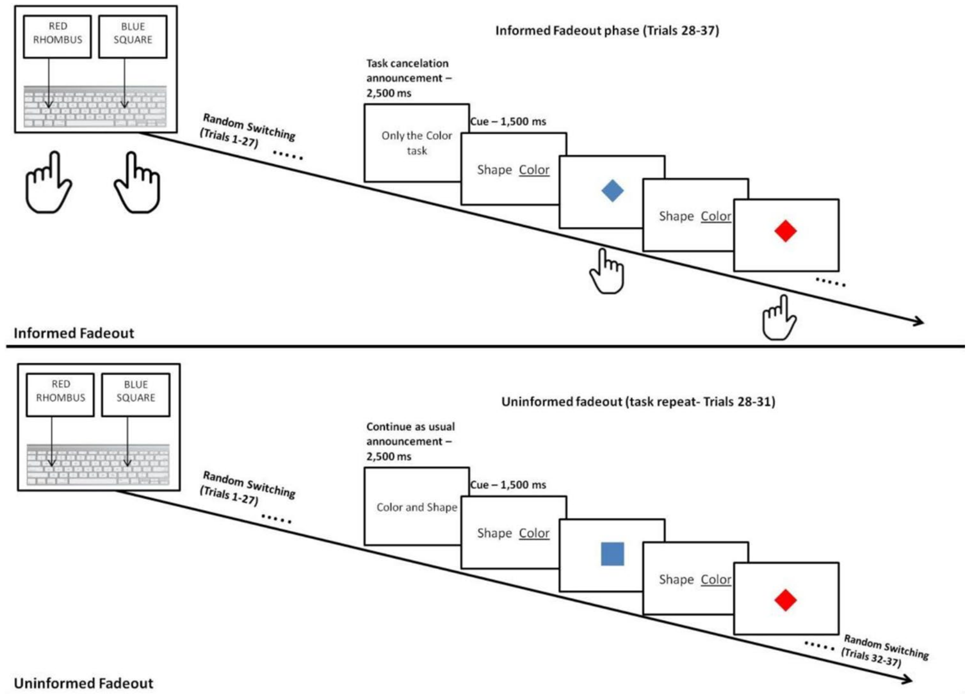

Table 5 Contrasts weights in Experiment 3

Contrast number[a]	Contrast	Fadeout type		Trial				
		Informed	Uninformed	*B*[b]	1	2	3	4
1	Difference at baseline	1	−1	1	0	0	0	0
2a	Improvement from baseline to first fadeout trial—informed condition	1	0	1	−1	0	0	0
2b	Improvement from baseline to first fadeout trial—uninformed condition	0	1	1	−1	0	0	0
2c	Improvement from baseline to first fadeout trial—interaction between fadeout types	−1	1	1	−1	0	0	0
3	Difference in Trial 1	−1	1	0	1	0	0	0
4a	Improvement from Trial 1 to Trials 2–4—informed condition	1	0	0	3	−1	−1	−1
4b	Improvement from Trial 1 to Trials 2–4—uninformed condition	0	1	0	3	−1	−1	−1
4c	Improvement from Trial 1 to Trials 2–4—interaction between fadeout types	−1	1	0	3	−1	−1	−1
4d	Improvement from baseline to Trials 2–4—uninformed condition	−1	1	3	0	−1	−1	−1
4e	Improvement from baseline to Trials 2–4—informed condition	−1	1	3	0	−1	−1	−1
5a	Improvement within the informed fadeout phase	1	0	0	0	1	0	−1
5b	Improvement within the uninformed fadeout phase	0	1	0	0	1	0	−1
6	Difference in Trials 2–4	1	−1	0	0	1	1	1

[a]Contrasts numbers correspond to the contrast numbers described in Table 2. Letters refer to sub-contrasts within the specific contrast (e.g., 2a, 2b)

[b]*B* baseline

Results and discussion

Trial exclusion in this experiment resulted in an average 8% (ranging between 0 and 36%). Table 5 specifies the contrast weights used in each comparison.

Difference at baseline (Table 5, Contrast 1)

No initial differences between the informed and the uninformed (−9 ms, 0.63% errors) conditions were observed [$F(1,38)=0.69$, $p=.42$, MSE = 5,69156, $\eta^2_p = 0.02$ (RT);

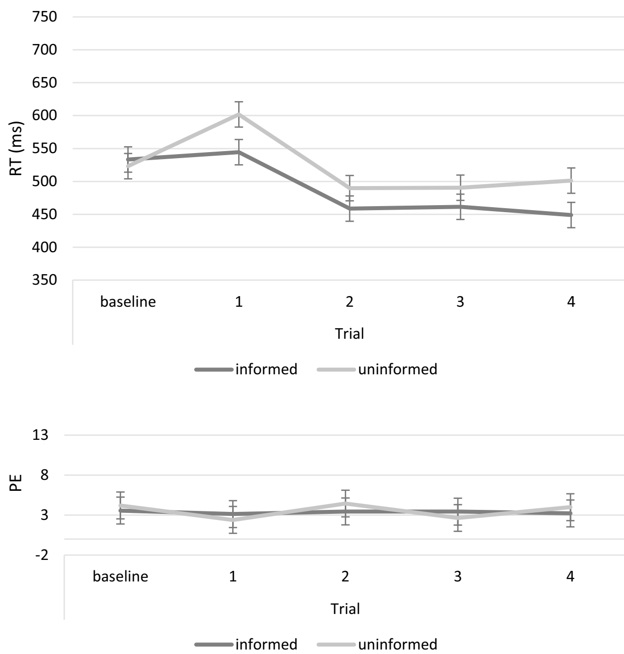

Fig. 7 RT (in ms) and percentage of errors (PE) as a function of Trial and Fadeout Type—Experiment 3. *Error bars* represent within-subject confidence intervals (Hollands & Jarmasz, 2010; Jarmasz & Hollands, 2009)

$F(1,39) = 0.65$, $p = .42$, MSE = 0.002, $\eta^2_p = 0.02$ (PE)] (the difference between the dark and light gray lines at baseline in Fig. 7).

Improvement from baseline to first fadeout trial

In the informed condition (Table 5, Contrast 2a), there was a non-significant RT increase and a non-significant PE decrease from baseline to Trial 1 (−11 ms, 0.43%) [$F(1,38) = 0.51$, $p = .48$, MSE = 9,758.97, $\eta^2_p = 0.01$ (RT); $F(1,39) = 0.26$, $p = .62$, MSE = 0.003, $\eta^2_p < 0.01$ (PE)]. In the uninformed condition (Table 5, Contrast 2b), the same pattern appeared, though to a greater extent (−78 ms, 1.8% PE) [$F(1,38) = 23.49$, $p < .001$, MSE = 10,237.22, $\eta^2_p = 0.38$ (RT); $F(1,39) = 2.79$, $p = .10$, MSE = 0.005, $\eta^2_p = 0.07$ (PE)]. This pattern implies a strategic change following the announcement, though since PE results did not reach significance, speed–accuracy tradeoff could not be inferred. The interaction testing the difference between the fadeout conditions in these trends reached significance in RT but not in PE [$F(1,38) = 9.10$, $p < .01$, MSE = 9,682.18, $\eta^2_p = 0.19$ (RT); $F(1,39) = 0.73$, $p = .40$, MSE = 0.005, $\eta^2_p = 0.02$ (PE)]. This can be seen in Fig. 7 by comparing the transition from baseline to Trial 1 between the dark and light gray lines (Table 5, Contrast 2c).

Difference in Trial 1 (Table 5, Contrast 3)

Contrary to previous experiments, a significant RT advantage for the informed condition (57 ms) was found in Trial 1 [$F(1,38) = 6.83$, $p = .01$, MSE = 18,767.29, $\eta^2_p = 0.15$ (RT)]. This effect was accompanied by a non-significant PE disadvantage (of 0.7% in favor of the uninformed condition) [$F(1,39) = 0.44$, $p = .51$, MSE = 0.005, $\eta^2_p = 0.01$ (PE)]. That is, an informed fadeout effect emerged after the task cancelation announcement, supposedly due to the slight increase in RT in the uninformed condition (and not due to improvement in the informed condition, see Fig. 7 for the transition from baseline to Trial 1 in the light gray line).

Since the results in the uninformed condition suggest speed–accuracy tradeoff, the interpretation of the results remains unclear. To try and shed light on these unclear results, we combined speed and accuracy using the linear integrated speed–accuracy score (LISAS; Vandierendonck, 2016) which incorporates both RT and PE in each condition, and the overall RT and PE standard deviations of each participant. We tested the effect in Trial 1 (the difference between informed and uninformed conditions), and got a marginally significant result [$F(1,38) = 3.76$, $p = .06$, MSE = 22,228.65, $\eta^2_p = 0.09$].

Therefore, we performed a Bayesian one-sided t test (which allows accepting the null hypothesis, Rouder, Morey, Speckman & Province, 2012) using JASP 0.7.0 (Love et al., 2015) and received $BF_{10} = 1.41$ (a posterior relative odd that H1 is more probable than H0), which is considered anecdotal evidence for H1. These supplementary analyses suggest that there is no substantial informed fadeout effect in Trial 1.

Improvement from Trial 1 to Trials 2–4

As before, RT in the informed condition improved (by 88 ms) but PE did not (−0.2% in errors) after one informed trial has been executed [$F(1,38) = 38.59$, $p < .001$, MSE = 11,783.28, $\eta^2_p = 0.50$ (RT); $F(1,39) = 0.08$, $p = .78$, MSE = 0.004, $\eta^2_p < 0.01$ (PE)] (see the transition from Trial 1 to the mean of Trials 2–4 in the dark gray line in Fig. 7; Table 5, Contrast 4a). However, unlike previous experiments, the same trend was observed in the *uninformed* condition (a difference of 108 ms and −1.3% in errors) [$F(1,38) = 47.40$, $p < .001$, MSE = 14,404.09, $\eta^2_p = 0.55$ (RT); $F(1,39) = 2.57$, $p = .12$, MSE = 0.004, $\eta^2_p = 0.06$ (PE[4])] (see the transition from Trial 1 to the mean of Trials 2–4 in the light gray line in Fig. 7; Table 5, Contrast 4b). Moreover, this

[4] The trend in PE was very noisy, and if anything showed an average increase in PE.

pattern did not significantly differ between the fadeout conditions [$F(1,38)=1.29$, $p=.26$, $MSE=8{,}953.40$, $\eta^2_p = 0.03$ (RT); $F(1,39)=1.04$, $p=.31$, $MSE=0.003$, $\eta^2_p = 0.03$ (PE)] (Table 5, Contrast 4c). Given this result, we decided post hoc to test whether there was a RT improvement relative to *baseline* (testing baseline compared to Trials 2–4). This test turned significant in both the uninformed [$F(1,38)=8.62$, $p<.01$, $MSE=30{,}515.62$, $\eta^2_p = 0.18$] and the informed condition [$F(1,38)=35.26$, $p<.001$, $MSE=15{,}060.87$, $\eta^2_p = 0.48$] (see Fig. 7; Table 5, Contrasts 4d and 4e, respectively).

Improvement within the fadeout phase

No improvement between Trials 2–4 was found within either condition [$F(1,39)=2.10$, $p=.15$, $MSE=4{,}151.02$, $\eta^2_p = 0.05$ (informed RT); $F(1,39)=0.05$, $p=.82$, $MSE=0.004$, $\eta^2_p < 0.01$ (informed PE); $F(1,39)=0.74$, $p=.39$, $MSE=10{,}345.70$, $\eta^2_p = 0.02$ (uninformed RT); $F(1,39)=0.10$, $p=.75$, $MSE=0.008$, $\eta^2_p < 0.01$ (uninformed PE)] (Table 5, Contrasts 5a and 5b, respectively). As in the previous experiments, this result supports the instructions-based hypothesis.

Difference in Trials 2–4 (Table 5, Contrast 6)

Although a similar pattern of results emerged in both fadeout conditions, it seems that the reduction in RT was steeper in the informed condition, as can be evidenced by a significant instruction-based advantage in Trials 2–4, replicating the previous results (38 ms in RT, 0.4% in errors) [$F(1,38)=11.62$, $p<.01$, $MSE=14{,}122.42$, $\eta^2_p = 0.23$ (RT); $F(1,39)=0.12$, $p=.73$, $MSE=0.010$, $\eta^2_p < 0.01$ (PE)]. This can be seen in Fig. 7 by comparing the difference between the dark and light gray lines in the mean of Trials 2–4.

Examining the full informed fadeout sequence (Fig. 8)

Testing the difference between Trials 2–5 and Trials 7–10 yielded no significant difference in both RT and PE [$F(1,39)=1.65$, $p=.21$, $MSE=4{,}706.45$, $\eta^2_p = 0.04$ (RT); $F(1,39)=2.15$, $p=.15$, $MSE=0.003$, $\eta^2_p = 0.05$ (PE)]. This result is especially interesting since there was no reminder regarding task cancelation and yet, the task-cancelation benefit was kept throughout the run.

The results of the current experiment differed from the preceding experiments mostly in the sharp RT reduction relative to baseline that was also observed in the uninformed condition. Although the RT results suggest an

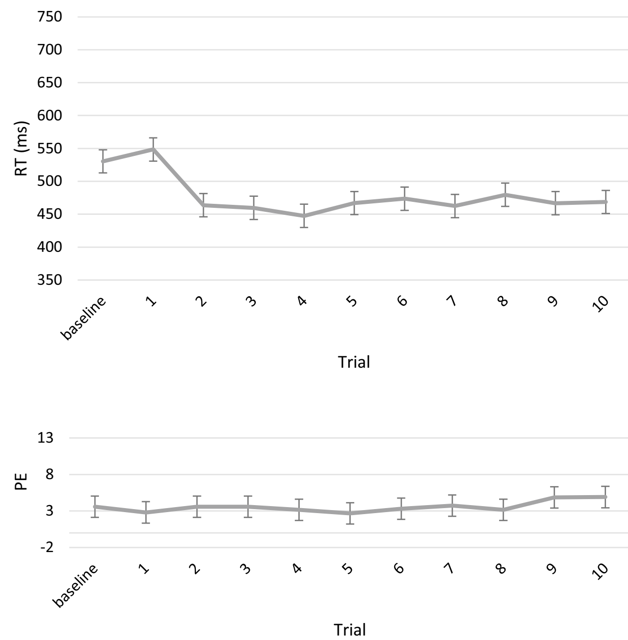

Fig. 8 RT (in ms) and percentage of errors (PE) as a function of Trial in the informed fadeout condition—Experiment 3. *Error bars* represent within-subject confidence intervals (Hollands & Jarmasz, 2010; Jarmasz & Hollands, 2009)

informed-fadeout effect already in the first trial, such an interpretation is unwarranted. Only from Trials 2 onward, a stable informed-fadeout effect was obtained. As predicted, the informed fadeout effect in Trials 2–4 was significant, but smaller in size than in the previous experiments, supposedly since task cancelation was only instructed at the beginning of the fadeout phase. However, contrary to the prediction, it seems that this effect is caused by a larger than usual RT reduction seen in the uninformed condition and not a smaller than usual reduction in the informed condition.

General discussion

The current work examined whether the fadeout cost, originally found by Mayr and Liebscher (2001) is instructions based or experience based. We addressed this question using a different control condition that dealt with an alternative account (i.e., uninformed fadeout). Three experiments showed the informed fadeout effect: a reduction in RT (but not error rate) following an announcement that one of the currently activated tasks is canceled, compared with a randomly occurring sequence of task repetitions. Another secondary finding is that in all three experiments, this drop in RT was reliably found only after one trial has been executed in the informed condition. The results of Experiments 2 and 3 do not support the interpretation that the lack of informed fadeout effect in Trial 1 was due to insufficient warning or a change in the physical attributes of the task cue.

Recent works regarding the power of instructions already showed, for example, that constructing new rules can lead to their reflexive activation (e.g., Liefooghe et al., 2012; Meiran et al., 2015) and guide implicit sequence learning (Gaschler et al., 2012). A finding more closely related to the current study showed that instructions can guide removal of declarative information from WM (Ecker et al., 2014); although this information was only held for future recollection, and could have been completely removed. However, in the current study, the irrelevant information is needed for task control and is only irrelevant for a few trials. Thus, this study shows for the first time to our knowledge that instructions can guide temporary disregard of procedural information. This ability means that one can adjust a certain contextual behavior based on mere instructions in an online manner (that is, adjustment while performing this behavior). Another novelty of the present work is that while most of the previous work on the immediate influence of instruction focused on simple aspects of the task rules (e.g., the stimulus–response rules), the present work extends this conclusion to quite abstract task-control representations, those involved in determining which task-set is currently relevant. We next discuss potential mechanisms for explaining these results.

As has been noted, the pattern of results within the informed condition resembles the results found by Rogers and Monsell (1995, Experiment 6). One of the mechanisms suggested to explain Rogers and Monsell's results was *retroactive adjustment* (RA, e.g., Meiran, 1996). The RA hypothesis proposes that task-set reconfiguration completes only after actual task execution (i.e., the first trial of a run). It seems to provide a plausible account in our case as well, explaining (a) why improvement was seen only after one trial has been executed, and (b) the lack of preparation time effect (meaning that if reconfiguration depends on *execution* it does not matter if a very long preparation is available). Under this explanation, we hypothesize that the first informed trial serves to define the type of learning in the following task context. This means that instructions serve an important role in determining what does one gain from experience.

Another way of putting things is that the instructions regarding task-irrelevancy allow participants to relax their constant monitoring of the environment. A related paradigm is prospective memory. In this paradigm, participants hold in mind instructions for future performance, which should be executed once a specific target is presented. Smith (2003) showed that holding in mind prospective instructions takes a toll over the ongoing task performance, and causes slowing. In a sense, mixing-blocks always include monitoring two stimulus-dimensions (especially with bivalent stimuli, Rubin & Meiran, 2005), which is similar to holding in mind prospective instructions (i.e., holding the task rule for execution once its cue appears). However, single-task blocks allow the monitoring of only one dimension, and thus the shift from mixing to single-task context might include acceleration due to less environmental monitoring.

Another potential account could be in terms of task shielding effects. Task shielding is a term meant to denote the advantage task sets have relative to a list of S–R rules (Dreisbach, 2012, for review). In their work, Dreisbach and Haider (2008) directly showed that holding a task set helped inhibiting irrelevant environmental information, supposedly an advantageous property that is not usually observed in task-switching studies since it is masked by switch-cost (that is, grouping into task sets is a prerequisite for switch-cost to emerge in the first place). Their work also shows that while task sets are useful in some respects (e.g., help shielding), they are costly in other respects, as seen in switch costs and in generally poorer performance (Dreisbach, Goschke, & Haider, 2006). Allegedly, the informed fadeout condition involves dismantling the two task set representation and re-building a (simpler) single task set representation, thus improving performance. Nonetheless, the results concerning Congruency (see Appendix) suggest that the irrelevant task was not completely removed from WM during the observed time frame.

Although we have clear-cut findings regarding the presence of an informed fadeout effect, the main limitation of the present work, as we see it, is the lack of clear findings regarding the first fadeout trial. Potentially, the informed fadeout effect in the first fadeout trial was masked by another effect, such as surprise or cue processing (which could be considered task switching). However, the conditions under which we get a slowing from baseline to Trial 1 in the informed condition are not yet clear, and thus we do not like to further speculate regarding this effect until further research clarifies the empirical picture. Another limitation is that the uninformed condition did not show the expected gradual improvement in RT, possibly because the (randomly created) uninformed sequences were not sufficiently long (Monsell et al., 2003), causing participants not to commit to the task repetition sequence.

In conclusion, the present study showed that instructions can guide a rapid reaction to a contextual cue, though the advantage in performance was not immediate upon the arrival of the cue, but only seen after one response in the new context was completed.

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Compliance with ethical standards

This research was supported by a research grant from the USA–Israel Bi-national Science Foundation to the second author. The first author declares she has no conflict of interest. The second author declares he has no conflict of interest.
All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee. Informed consent was obtained from all individual participants included in the study.

Appendix: Task-rule congruency effect (TRCE)

The Task-Rule Congruency Effect (TRCE) might help understanding the mechanism at the basis of the informed-fadeout effect. In short, if the informed fadeout includes the removal of the irrelevant task set from WM, it should not interfere with the relevant task, and thus not cause TRCE. Nonetheless, TRCE is considered to be based on two structures—both activated long-term memory (A-LTM), consisting of all the task-relevant representations, that would not be eliminated during a short-fadeout; and residual bindings in the bridge, which only holds the currently relevant task rules (Oberauer et al., 2013; see also; Kiesel, Wendt, & Peters, 2007). Below, we present results involving Congruency in the three experiments presented in this study. Since there were generally no consistent results regarding TRCE, we pooled the three experiments to increase statistical power (Experiment was entered as a between-subjects independent variable, and we used the lowest common denominator and included four trials within the fadeout sequence, and the short-informed condition from Experiment 2 (which was more comparable to the other experiments)). The results do not show an informed fadeout effect in TRCE.

Results and discussion

Importantly, none of the interactions with Congruency reached significance, including the interactions between Congruency and Experiment (suggesting that the TRCE patterns were not different between the experiments). We took the same set of planned comparisons as in the Results sections and added Congruency. In RT, none of the comparisons approached significance (all Fs < 0.86, ps > 0.35) (see Fig. 9).

However, some of the comparisons in PE reached significance. In the informed condition, a significant reduction in

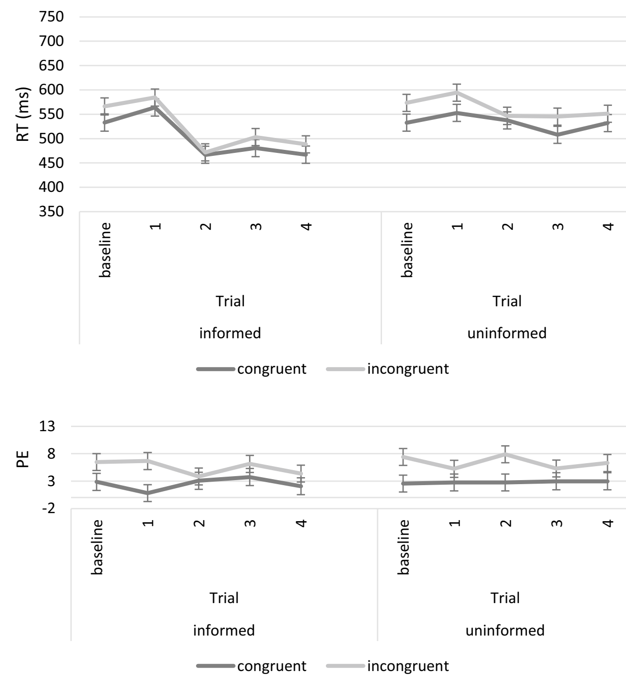

Fig. 9 RT (in ms) and percentage of errors (PE) as a function of Trial, fadeout Type and congruency, pooled across experiments. The results are shown above and beyond Experiment. *Error bars* represent within-subject confidence intervals (Hollands & Jarmasz, 2010; Jarmasz & Hollands, 2009)

PE-TRCE was found between baseline and Trial 1 (by 4% erros) [$F(1,79) = 6.40$, $p = .01$, MSE = 0.007, η^2_p = 0.07], and this trend was significantly different than the uninformed condition [$F(1,79) = 5.49$, $p = .02$, MSE = 0.007, η^2_p = 0.06]. However, this result seems to stem from an *increase* in PE in congruent trials [$F(1,79) = 15.88$, $p < .001$, MSE = 0.002, η^2_p = 0.17] and not from a decrease in PE in incongruent trials [$F(1,79) = 1.71$, $p = .19$, MSE = 0.011, η^2_p = 0.02]. Other effects nearly approaching significance were the difference in PE-TRCE in Trial 1 between the fadeout conditions (which was higher in the informed condition by 3.36% errors) [$F(1,79) = 3.39$, $p = .07$, MSE = 0.006, η^2_p = 0.04]; the difference in PE-TRCE in Trials 2–4 between the fadeout conditions [$F(1,79) = 3.08$, $p = .08$, MSE = 0.005, η^2_p = 0.04]. Other than these trends, none of the other comparisons approached significance [all Fs < 2.07, ps > 0.15].

Importantly, a significant TRCE was found in Trials 2–4 in both RT [$F(1,78) = 4.45$, $p = .04$, MSE = 6,678.08, η^2_p = 0.05] and PE [$F(1,79) = 7.66$, $p < .01$, MSE = 0.005, η^2_p = 0.09].

The consistent TRCE in both RT and PE seen in the informed fadeout condition indicates that the irrelevant task was not removed from WM. Nonetheless, it is still possible that there was removal of information from the limited-capacity bridge part, holding procedural information, though not from A-LTM. Such a scenario predicts that TRCE would still emerge.

References

Tornay, F. J., & Milán, E. G. (2001). A more complete task-set reconfiguration in random than in predictable task switch. *The Quarterly Journal of Experimental Psychology: Section A ,54*, 785–803.

Allport, A., & Wylie, G. (2000). Task-switching, stimulus-response bindings and negative priming. In S. Monsell & J. Driver (Eds.), *Control of cognitive processes: Attention and performance XVIII* (pp. 35–70). Cambridge, MA: MIT.

Altmann, E. M. (2007). Comparing switch costs: alternating runs and explicit cuing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, 475–483.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review ,108*, 624–652.

Braver, T. S., Barch, D. M., Keys, B. A., Carter, C. S., Cohen, J. D., Kaye, J. A., Janowsky, J. S., Taylor, S. F., Yesavage, J. A., & Mumenthaler, M. S. (2001). Context processing in older adults: Evidence for a theory relating cognitive control to neurobiology in healthy aging. J. *ournal of Experimental Psychology: General, 130*, 746–763.

Bugg, J. M., & Braver, T. S. (2016). Proactive control of irrelevant task rules during cued task switching. *Psychological Research, 80*, 1–17.

Bugg, J. M., Diede, N. T., Cohen-Shikora, E. R., & Selmeczy, D. (2015). Expectations and experience: Dissociable bases for cognitive control? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41*, 1349–1373.

Cole, M. W., Laurent, P., & Stocco, A. (2013). Rapid instructed task learning: A new window into the human brain's unique capacity for flexible cognitive control. *Cognitive, Affective, & Behavioral Neuroscience,13*, 1–22.

Dreisbach, G. (2012). Mechanisms of cognitive control the functional role of task rules. *Current Directions in Psychological Science, 21*, 227–231

Dreisbach, G., Goschke, T., & Haider, H. (2006). Implicit task sets in task switching? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 1221–1233.

Dreisbach, G., & Haider, H. (2008). That's what task sets are for: shielding against irrelevant information. *Psychological Research, 72*, 355–361.

Ecker, U. K., Lewandowsky, S., & Oberauer, K. (2014). Removal of information from working memory: A specific updating process. *Journal of Memory and Language, 74*, 77–90.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149–1160.

Gaschler, R., Frensch, P. A., Cohen, A., & Wenke, D. (2012). Implicit sequence learning based on instructed task set. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*, 1389–1407.

Goldfarb, L., & Henik, A. (2013). The effect of a preceding cue on the conflict solving mechanism. *Experimental Psychology, 60*, 347–353.

Gopher, D., Armony, L., & Greenshpan, Y. (2000). Switching tasks and attention policies. *Journal of Experimental Psychology: General, 129*, 308–339.

Hartstra, E., Waszak, F., & Brass, M. (2012). The implementation of verbal instructions: dissociating motor preparation from the formation of stimulus–response associations. *Neuroimage, 63*, 1143–1153.

Hollands, J. G., & Jarmasz, J. (2010). Revisiting confidence intervals for repeated measures designs. *Psychonomic Bulletin & Review, 17*, 135–138.

Jarmasz, J., & Hollands, J. G. (2009). Confidence intervals in repeated measures designs: The number of observations principle. *Canadian Journal of Experimental Psychology, 63*, 124–138.

Jennings, J. R., & van der Molen, M. W. (2005). Preparation for speeded action as a psychophysiological concept. *Psychological Bulletin, 131*, 434–459.

Kiesel, A., Wendt, M., & Peters, A. (2007). Task switching: On the origin of response congruency effects. *Psychological Research Psychologische Forschung, 71*, 117–125.

Liefooghe, B., Wenke, D., & De Houwer, J. (2012). Instruction-based task-rule congruency effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*, 1325–1335.

Love, J., Selker, R., Marsman, M., Jamil, T., Dropmann, D., Verhagen, A. J., & Wagenmakers, E. J. (2015). JASP (Version 0.7) [Computer software].

Mayr, U., & Liebscher, T. (2001). Is there an age deficit in the selection of mental sets? *European Journal of Cognitive Psychology, 13*, 47–69.

Mayr, U., Spieler, D. H., & Hutcheon, T. G. (2015). When and why do old adults outsource control to the environment?. *Psychology and Aging, 30*, 624–633.

Meiran, N. (1996). Reconfiguration of Processing Mode Prior to Task Performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 1423–1442.

Meiran, N. (2010). Task switching: Mechanisms underlying rigid vs. flexible self-control. In R. Hassin, K. Ochsner & Y. Trope (Eds.), *Self-control in society, mind and brain* (pp. 202–220). NY: Oxford University Press.

Meiran, N. (2014). The task cuing paradigm: A user's guide. In J. A. Grange & G. Houghton (Eds.), *Task switching and cognitive control* (pp. 45–73). Oxford University Press.

Meiran, N., Chorev, Z., & Sapir, A. (2000). Component processes in task switching. *Cognitive Psychology, 41*, 211–253.

Meiran, N., Diamond, G. M., Toder, D., & Nemets, B. (2011). Cognitive rigidity in unipolar depression and obsessive compulsive disorder: Examination of task switching, Stroop, working memory updating and post-conflict adaptation. *Psychiatry Research, 185*, 149–156.

Meiran, N., Gotler, A., & Perlman, A. (2001). Old age is associated with a pattern of relatively intact and relatively impaired task-set switching abilities. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 56*, 88–102.

Meiran, N., & Kessler, Y. (2008). The task rule congruency effect in task switching reflects activated long-term memory. *Journal of Experimental Psychology: Human Perception and Performance 34*, 137–157.

Meiran, N., Kessler, Y., & Adi-Japha, E. (2008). Control by action representation and input selection (CARIS): A theoretical framework for task switching. *Psychological Research, 72*, 473–500.

Meiran, N., Pereg, M., Kessler, Y., Cole, M. W., & Braver, T. S. (2015). The power of instructions: Proactive configuration of stimulus–response translation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41*, 768–786.

Monsell, S. (2003). Task Switching. *Trends in Cognitive Sciences, 7*, 134–140.

Monsell, S., Sumner, P., & Waters, H. (2003). Task-set reconfiguration with predictable and unpredictable task switches. *Memory & Cognition, 31*, 327–342.

Oberauer, K., Souza, A. S., Druey, M. D., & Gade, M. (2013). Analogous mechanisms of selection and updating in declarative and procedural working memory: Experiments and a computational model. *Cognitive Psychology, 66*, 157–211.

Psychology Software Tools (2010). *E-Prime 2.0*. Sharpsburg, PA: Psychology Software Tools, Inc.

Rogers, R. D., & Monsell, S. (1995). The cost of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General, 124*, 207–231.

Rouder, J. N., Morey, R. D., Speckman, P. L., & Province, J. M. (2012). Default Bayes factors for ANOVA designs. *Journal of Mathematical Psychology, 56*, 356–374.

Rubin, O., & Meiran, N. (2005). On the origins of the task mixing cost in the cuing task-switching paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 1477–1491.

Schmidt, J. R. (2013). Temporal learning and list-level proportion congruency: conflict adaptation or learning when to respond? *PloS ONE, 8*, e82320.

Shaffer, L. H. (1965). Choice reaction with variable S–R mapping. *Journal of Experimental Psychology, 70*, 284–288.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 347–361.

Spieler, D. H., Mayr, U., & LaGrone, S. (2006). Outsourcing cognitive control to the environment: Adult age differences in the use of task cues. *Psychonomic Bulletin & Review, 13*, 787–793.

Vandierendonck, A. (2016). A comparison of methods to combine speed and accuracy measures of performance: A rejoinder on the binning procedure. *Behavior Research Methods*. Advance online publication. doi:10.3758/s13428-016-0721-5.

Vandierendonck, A., Liefooghe, B., & Verbruggen, F. (2010). Task switching: Interplay of reconfiguration and interference. *Psychological Bulletin, 136*, 601–626.