The Nature of Residual Cost in Regular Switch: Response Factors

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ABSTRACT

Two experiments are presented that compare the residual cost found when switching from one task to another in predictable conditions. We wanted to explore the roles played by the stimulus, the response, or both in the process of mental set reconfiguration necessary to switch between two tasks. In these experiments, we tested Rogers and Monsell's (1995) stimulus-cued-completion hypothesis and Schuch and Koch´s (2003) hypothesis of response selection as the key factor in the nature of switch cost. In our first experiment, we created two conditions that varied in terms of a Go-No-Go signal: The "Go trials" were a replication of Tornay and Milán (2001, Experiment 3); The "No-Go trials" were identical to the first condition, except that participants did not execute a response in the trial N-1 (Schuch & Koch, 2003). We also manipulated the percentage of Go and No-Go trials. Only in the high Go signal frequency case (experiment 2), the cost was significant but with abrupt offset in Go trials and with gradual offset in No Go trials. Therefore, we conclude that paying attention to the stimulus or to the preparation of a response is not enough to complete the reconfiguration.

1. INTRODUCTION.

One important psychological issue has to do with how people reorganize their actions when they have to switch between two different cognitive tasks. In order to study this question, psychologists need to design experimental paradigms that isolate the workings of individual processes from the general organization of the processing. A paradigm that has proved useful in this respect involves switching between two or more different tasks with similar cognitive demands. When people have to switch from one activity to another, there is a transient impairment in performance, which can be measured both as a decrease in accuracy and as an increase in reaction time (RT).

1.1. The switching paradigm.

In 1976, Spector and Biederman took up the paradigm of switch of mental set again (after Jersild, 1927). They interpreted their results as evidence that the major determinant of switch cost is the extent to which the appearance of the new stimulus provides an effective cue for the task required in a given trial. Allport, Styles, and Hsieh (1994) also employed this paradigm. Since the publication of these studies, the topic has recovered importance and many new studies have been undertaken. Rogers and Monsell (1995) carried out a series of experiments to explore the preparation for a new task. They made sure that no differences in either stimuli or responses existed between the tasks. A stimulus pair consisting of a number and a letter was presented on every trial, and participants were asked to respond either to the letter or to the number. Both tasks shared the same set of responses. The two tasks alternated every two trials (except in their last experiment, which will be explained later), so that the experiment consisted of repetitions of four-trial sequences: letter-letter-number-number (LLNN). On each trial within a given sequence the stimuli were presented on different screen quadrants. This allowed participants to keep track of the task required on that trial. Rogers and Monsell's results showed a reliable decrease in switch cost as preparation time increased. However, the cost never vanished, even when very long foreperiods were used.

1.2. Two components in switch costs.

Based on these results, Rogers and Monsell (1995) concluded that there are two different components in switch cost. They called one of them the 'non-residual component' and the other the 'residual component'. In their Experiment 6, Rogers and Monsell (1995) explored the nature of the residual component of cost. In this experiment, the tasks alternated every four, rather than every two trials, which produced eight-trial sequences (LLLLNNNN). Stimuli were presented in different sectors of a circle divided into eight parts. The results of this experiment indicated that the residual cost dissipated after the first repetition trial, so that no further improvement occurred on subsequent repetitions. An explanation of the residual cost in terms of task set proactive interference or mental inertia (Allport et al., 1994) would have predicted a gradual decrease of cost as this inertia dissipated. An account based on an improvement in performance by means of trial-by-trial feedback or retroactive adjustment (micropractice hypothesis, Meiran, 1996, explained later) would also imply that the decrease takes place on more than one trial. Rogers and Monsell (1995) explained the abrupt disappearance of cost on the first repetition trial by assuming the existence of two different reconfiguration processes: An endogenous, anticipatory process, which is responsible for the non-residual component and which can only achieve part of the reconfiguration; and an exogenous process triggered by the stimulus associated with the task.

The fact that it is not possible to attain a complete endogenous task set reconfiguration is a surprising finding. It hints at the existence of an absolute cognitive limitation for preparing a change of the task. Subsequent studies have also found evidence of a switch cost component that does not disappear as preparation time increases (i.e., Dreisbach, Haider, Kawski, Kluwe, & Luna, 1998; Sohn & Anderson, 2001). However there are also several studies not replicating the dissipation of switch cost after the first repetition trial. This finding seems to depend on predictable versus random task sequences (Tornay & Milán, 2001; Milán, Sanabria, Tornay & González, 2005). But with regular task switch sequences the cost abrupt offset is a universal finding. Rogers and Monsell's opinion is that this residual cost is related to the appearance of a stimulus related to the new task. The appearance of the target stimulus would trigger a so-called 'exogenous reconfiguration process'. This is what they called the 'stimulus-cued completion hypothesis'. A similar position about the importance of the stimulus is that adopted by Pösse and Hommel (1998). Stablum, Leonardi, Mazzoldi, Umiltá, and Morra (1994) also agreed with a stimulus-based explanation: They argued that mental reconfiguration always waits for a new stimulus before completion. In their opinion, an exogenous component, reflected in the residual cost with long RSI, and triggered by stimulus presentation would consist of a bottom-up completion of task set reconfiguration. However, the stimulus-cued completion hypothesis and its variants are not the only possible explanations of the abrupt cost disappearance reported by Rogers and Monsell. In the present studies, our starting point is the response cued completion hypothesis proposed by Tornay and Milán (2001) and González, Milán, Pereda & Hochel (accepted). We hypothesized that the response, rather than the stimulus, is the key triggering factor for the exogenous reconfiguration process. A plausible explanation of the abrupt cost disappearance pattern would be to suppose that making a less than optimal response (making an error or responding more slowly than usual) activates negative feedback systems, such as the so-called corollary discharge (e.g., Sperry, 1943; Von Holst & Mittelsteadt, 1950), which may inhibit the interfering previous task set and, thus, eliminate the cost. Such a hypothesis assumes that cost dissipates as soon as the response is selected, i.e., after the switch trial, and seems to fit the basic pattern of results better than a stimulus-based interpretation (Milán, González, Pereda & Tornay, 2005).

1.3. Response selection as the key factor to produce switch cost

We also should distinguish between the factors that produce residual cost and the factors that can eliminate it. Schuch and Koch (2003) explored the role of response selection to produce task switching cost using a Go/No-Go methodology. In their first experiment (similar to our experiments), the results showed no residual cost after No-Go trials. Apparently their results agree with a crucial role of response selection in task switching. The stimulus onset and the stop signal (or Go/No-Go signal) both occurred at the same time, thus triggering stimulus information processing including the response selection in Go trials, but excluding response selection in No-Go trials. However, response execution is also included in Go trials but excluded in No-Go trials. It is therefore difficult to distinguish the effects of response selection and response execution on residual cost. If we analyze more deeply their pattern of results, what might have happened is that RT for repetition trials after a No-Go switch trial increased by about 120 ms (with respect to repetition trials after a Go switch trial). This means that instead of no residual cost after No-Go trials, the results could show no repetition benefit or cost in repetition trials after a No-Go trial in N-1. The only way to test if there was a cost in first repetition trials is to compare them with respect to second repetition trials, but they did not analyze position in the trial sequence. At the same time, Schuch and Koch (2003) described a test of their hypothesis about the role of response selection to produce cost in task switching in the discussion of their Experiment 1: "The data from experiment one are not unequivocal with respect to a response selection based explanation of switch cost. For instance, one could assume that the No-Go manipulation led to inhibition of a prepared response. This would be similar to what happens in the stop signal paradigm (Logan, 1994), in which a stop signal occurs some time after the stimulus. In the present experiment, the stop signal delay was zero....then inhibition of the selected response is unlikely…" (Schuch

& Koch, p. 95). In our study the critical difference to the study of Schuch and Koch (2003) was the delayed presentation of the go/no-go signal.

1.4. Hypotheses and overview of the experiments.

The present studies intended to tackle the following issues. We wanted first to verify the disappearance of residual cost after the first repetition trial and second, to determine the real nature of this component. We presented two experiments, each comparing two basic conditions. One of the conditions was a replication of the usual procedure in which the abrupt cost disappearance effect was found: Predictable switch with more than two-trial sequences. We compared this condition with another in which participants were asked not to make any response. The former condition will be referred to as the 'N-1 Go trial' and the latter as the 'N-1 No-Go trial'. We analyzed RT and accuracy in N trials. The stimulus-cued completion hypothesis would predict a normal cost pattern after the N-1 No-Go trials in all experiments, because the relevant stimulus is presented, exactly as in the Go trials, triggering the exogenous component and eliminating the cost on the first repetition trial. However, the hypothesis that cost dissipates abruptly after making the response on switch trials would predict a radically different pattern of results. In the N-1 No-Go switch trials, such a response is not made. Therefore, the cost should not dissipate until after the first repetition trial. In other words, there should be a cost in the switch trials (with respect to the second repetition trials) and in the first repetition trials (with respect to the second repetition trials), similar to the one found in the Go switch trials with respect to Go first repetition trials.

We also evaluated the hypothesis of response selection as the key factor to produce cost. As we said, in our study the critical difference to the study of Schuch and Koch (2003) was the delayed presentation of the go/no-go signal. The percentage of go trials in their experiment 1 was 75%. In our experiment 1 the percentage of Go trials was 50% and 80% in our experiment 2. If there is a role of response selection in task switching, we expected to replicate the results of Schuch and Koch in our first experiment whereas the second should not replicate them. In other words, we expected switch cost in No Go trials in experiment 2. When Go and No-Go trials are of equal probability, participants do most likely not select and prepare for a response during the delay between stimulus target and Go/No-Go signal. In contrast, with a high probability of Go trials, a selection and preparation of a response should occur even in No Go trials.

To summarize, our main goals in the present report were to test the stimulus-cued completion hypothesis and the effects of response selection and execution on residual cost. For these purposes, we introduced the following changes in the switch of mental set paradigm and the Go/No-Go signal manipulation with respect to Schuch and Koch (2003).

1. To explore the nature of residual cost (what factors produces it and what factors complete reconfiguration), the switch of mental set should occur in regular sequences. In the case of random task switch (e.g., in Schuch & Koch, 2003) it is not always possible to obtain residual cost with long RSI (Meiran, 1996; Tornay & Milán, 2001; Milán, Sanabria, Tornay & González., 2005). It is possible that different processes are involved in mental set reconfiguration under regular and random sequences.

2. With Go/No-Go manipulation, there appears the problem of sequential effects (Alegría, 1978): A general slowing of RT after No-Go trials that may have obscured residual switch cost (Milán, González, Pereda & Tornay, 2005). Even in single task situations, Go trials are slower when they follow No-Go trials than when they follow Go trials. Schuch and Koch (2003, Experiment 1) found an interaction between the type of trial (switch trial vs. repetition trial) and Go/No-Go trials. The typical slower RT after a No-Go trial was found for repetition trials, but not for switch trials. This interaction was interpreted in favor of the role of response selection in producing residual cost. To avoid this confound we studied the effect of position of repetition trial in the trial sequence. Sequential effects should produce the same slowing of RT in first and second repetition trials.

3. With regular task switch sequences, after a No-Go trial the status of the type of trial changes only for first repetition trials. In the case of three-trial sequences (with switch trials, first repetition trials, and second repetition trials for each alternating task), a switch trial after a No-Go trial is still a switch trial, a second repetition trial after a No-Go trial is still a repetition trial but a first repetition trial after a No-Go trial could behave like a switch trial (the previous No-Go switch trial is like a blank trial). If we found cost in first repetition trials (even after a very long empty and anticipatory interval because of the N-1 No-Go switch trial, that produces cost passive decay what acts against our response cued completion hypothesis) with respect to second repetition trials, then a significant role of response execution must be considered for mental set reconfiguration (if every step of stimulus processing except response execution occurs in No-Go trials).

4. We manipulated the frequency of Go trials (the proportion of Go to No-Go trials). In Experiment 1, we used a frequency of 50% Go trials, while in Experiment 2 we used 80% Go trials. In

Experiment 1, we expected to replicate the results of Schuch and Koch (2003, Experiment 1): An interaction between type of trial (task switch or task repetition trials) and Go/No-Go trials, and also no residual cost for No-Go trials. In Experiment 2, we expected the same interaction but also residual cost for No-Go switch trials and in first repetition trials according to our response-cued completion hypothesis.

2. EXPERIMENT 1.

With this first experiment our main goal was to replicate the pattern of results of Schuch and Koch (2003): A significant interaction between type of trial and Go/No-Go trials in the reconfiguration process. We accept their interpretation of this interaction in favor of the role of response selection in the cost of task switching. Another problem that we tried to solve with Experiment 1 was the sequential effect of a Go signal. Even in single task situations, Go trials are slower when they follow No-Go trials than when they follow Go trials (Alegría, 1978). Thus, we expected first repetition trials after a No-Go trial to be slower than a first repetition trial after a Go trial due to a sequential effect. In Experiment 1 Go and No-Go trials occurred for any type of trial in the three-trial sequences (switch trials, first repetition trials, and second repetition trials). After solving these methodological problems from our previous research (the percentage of Go trials and sequential effects, –Milán et al., 2005), the expected pattern of results was the following: No residual cost in No-Go trials. Slower RTs in trials after a No-Go N-1 trial can be attributed to sequential effects, but the non-significant residual cost argues against the stimulus-cued completion hypothesis and in favor of response selection account of the cost of task switching. In all No-Go trials, the target stimulus was always present but response selection did not occur before the onset of the stop signal due to its random frequency.

2.1. Method.

2.1.1. Participants.

Twentyfive undergraduates (seventeen women and eight men) took part in this experiment for course credit. Their vision was normal or corrected to normal.

2.1.2. Design.

We used a repeated measures design with three independent variables. All the variables varied on a trial-by-trial basis: Task (number or letter), Repetition ("switch trials", "first repetition trials", and "second repetition trials"). The third variable was "N-1 Go/No Go trial", and it depended on the Go-Signal: If the Go-Signal was "yes" in the trials N-1 and N, it was a "Go trial", and if the Go-Signal was "no" in the trial N-1 and "yes" in the trial N the trial N was considered a "No-Go trial". We analyzed RT and accuracy for N trials. The response-stimulus-interval (RSI) was 1,200 ms throughout the experiment. The predictability was always the same: Switching occurred every three trials: LLLNNN... (L being the letter task and N the number task).

2.1.3. Apparatus and stimuli.

The experiments were designed using the e-prime program (Schneider, Eschman & Zuccolotto, 2002). They were run in dimly illuminated rooms, on Intel Pentium 300 computers with a VGA graphics card. On every trial a fixation point appeared at the center of the screen. It was either a hash ("#") or an at symbol ("@"), depending on which task was to be performed, as explained later. Both symbols subtended 2.86° x 2.86° of visual angle. Later on the trial, a stimulus pair consisting of a number and a letter (e.g., 6K, E9, 3P, S4...) was presented at the center of the screen, replacing the fixation point. Later on the trial, the Go/No-Go signal (or stop signal) consisting of the words "YES" (written in green) or "No" (written in red) was presented 2° of visual angle above the stimulus pair. The stimulus pair and the stop signal subtended 4.76° X 2.86° of visual angle

2.1.4. Procedure.

The participants were asked to perform one of two possible tasks. For every number-letter pair they had either to indicate whether the number was odd or even (number task) or whether the letter was a vowel or a consonant (letter task). In both tasks, participants responded by pressing the "b" and the "n" keys on the keyboard. This way, both tasks shared the same stimuli and responses. Half of the participants were required to press "b" to indicate that the number was even or the letter was a vowel, and "n" to indicate when the number was odd or the letter was a consonant. For the other half, the reverse stimulus-key mapping was used. Each participant was randomly assigned to either mapping. Participants were given a maximum of three seconds after the appearance of the stimulus pair to emit the response before proceeding to the next trial. The new fixation point was presented as soon as the trial finished (the response was emitted or the 3 seconds elapsed). Therefore, the RSI corresponded with the cue (fixation point) stimulus (target) asynchrony (1,200 ms).

Participants knew which task was to be carried out on a given trial by means of the fixation point: A hash symbol (#) signaled the number task; an at symbol (@) indicated that the letter task was required. Tasks alternated regularly every 3 trials: LLLNNN... (L being the letter task and N the number task). Therefore, there could be three kinds of trials of each task: Switch trial; First repetition trial; And second repetition trials. The Go-No-Go methodology (or stop signal), that informed the participants to respond or to withhold a response, was introduced in all types of trials (switch trials, first repetition trials, and second repetition trials). Fifty percent of trials were Go trials, and fifty percent were No-Go trials. All trials were randomized with respect to trial type (switch trials, first repetition trials, and second repetition trials), with the only condition that two No-Go trials could not occur consecutively within a cycle of three trials (switch trial, first repetition trial, and second repetition trial). The stimulus onset asynchrony (SOA) between target onset and stop signal onset was 500 ms. The Go/No-Go signal and the stimulus pair remained on the screen until the response. RT was measured from target stimulus onset

Overall, there were 900 trials in this experiment, divided into two experimental blocks of 450 trials each. Both blocks began with 60 additional practice trials for both tasks.

2.2. Results.

We submitted both RT and accuracy data to a 2 (Go-signal) x 2 (Task) x 3 (Repetition) repeated measures analysis of variance (ANOVA). To reproduce the same logic of analysis of Schuch and Koch (2003, Experiment 1, we studied N trials (switch trials, first repetition trials, and second repetition trials) as a function of N-1, Go or No-Go trials. The alpha level adopted was .05, as in our previous studies.

The analysis of the RT measures (see Figure 1) showed a main effect of Repetition, $F(2,48) = 11.76$, $p < .0007$. Post hoc comparisons (Fisher LSD) revealed reliable differences between switch trials and repetition trials ($p < .003$), but there were no significant differences between first and second repetition trials. We also found a reliable interaction between Go-Signal and Repetition, $F(2,48) = 3.30$, $p < .04$. Post-hoc comparisons showed significant differences between Go switch trials and Go first repetition trials ($p < .0004$) and between Go switch trials and Go second repetition trials ($p < .0001$). We also compared the points from both conditions (Go and No Go trials): There were significant differences between No Go switch trials and Go repetition trials ($p < .001$) and between No Go repetition trials and Go repetition trials ($p < .029$).

Please, insert Figure 1 about here

The analyses for accuracy data (see table 1) showed a main effect of Repetition, F (2, 48) = 12.35, $p < .0005$. We also found a significant interaction involving Go-Signal and Repetition, F (2, 48) =3.19, $p < .04$. Post-Hoc comparisons (Fisher LSD) showed differences between Go switch trials and Go second repetition trials ($p < .009$).

2.3. Discussion.

In Go-trials the pattern of results was consistent with the normal residual cost found under predictable conditions (Rogers & Monsell, 1995; Tornay & Milán, 2001): An abrupt significant cost onset in switch trials and an abrupt cost offset in first repetition trials. But for No-Go trials there was no cost, as reported by Schuch and Koch (2003). The stimulus-cued completion hypothesis predicts residual cost for No-Go trials. In Experiment 1, we tested the role of response selection triggered by the onset of the target stimulus, and we tried to separate sequential effects from task switching effects. We expected and observed a replication of the results of Schuch and Koch (2003, Experiment 1), but with an asynchrony between the stimulus onset and the stop signal onset. In fact, we obtained non-residual cost in the No-Go condition: If response selection does not occur then non-residual cost is expected.

Please, insert Table 1 about here

3. EXPERIMENT 2.

The main difference between Experiment 1 and Experiment 2 is the frequency of the Go signal. In Experiment 2 it appeared in 80 per cent of trials and the No-Go signal appeared in the remaining 20 per cent of trials. Schuch and Koch's (2003) results showed an interaction between sequential effects and the type of trial: RTs were slower after No-Go trials in repetition trials, but were faster after No-Go trials in switch trials. For that reason, no residual cost was found when it was computed as the difference between repetition and switch trials. The normal effect in RTs for No-Go trials (Alegría, 1978) is reversed in switch trials. Something similar happened with response repetition priming in Rogers and Monsell (1995). These interactions are probably telling us something important. However, most relevant to the current experiments is that Schuch and Koch (2003) did not separate first and second repetition trials (their task switching was random), and that is the crucial point to distinguish sequential effects from the cost of task switching, at least under predictable sequences. In Experiment 2, we expected response selection in No-Go trials before stop signal onset and residual cost in switch trials, and overall in the first repetition trials with respect to the second repetition trials if response execution is a significant factor to complete mental set reconfiguration.

3.1. Method.

3.1.1. Participants.

Twentyfive undergraduates (fifteen women and ten men) took part in this experiment for course credit. Their vision was normal or corrected to normal. None of them had participated in Experiment 1.

3.1.2. Design, apparatus and stimuli.

The design, apparatus and stimuli are identical to those of Experiment 1.

3.1.3. Procedure.

The trial sequence was identical to that employed in Experiment 1. The only difference was the percentage of Go trials. In this second experiment 80 percent of trials were Go trials, and 20 percent of trials were No-Go trials. Trials were randomized with respect to trial type (switch trials, first repetition trials, and second repetition trials). The stimulus onset asynchrony between target onset and stop signal onset was 500 ms, identically to Experiment 1.

3.2. Results.

We submitted both RT and accuracy data to a 2 (Go-Signal) x 2 (Task) x 3 (Repetition) repeated measures analysis of variance (ANOVA). The alpha level adopted was .05, as in the previous experiment.

The analysis of the RT data (see Figure 2) revealed a significant main effect of Go-Signal, $F(1,24)$ =

27.97, $p < .0002$, and Repetition, $F(2,48) = 10.07$, $p < .0002$. Additionally, we observed a significant interaction involving Go-Signal and Repetition, $F(2,48) = 3.38$, $p < .046$. Post-Hoc comparisons (Fisher LSD) showed significant differences between Go switch trials and Go first ($p < .0004$) and Go second repetition trials ($p < .0002$). The difference between No Go switch trials and No Go second repetition trials ($p < .018$) was significant. We also compared points from both conditions: There was a linear trend in No Go trials, $F(1,24) = 6.57$, $p < .015$, and a cuadratic trend for Go trials, $F(1,24) = 6.11$, $p < .02$. The differences between Go switch trials and No Go switch trials ($p <.002$) and No Go first repetition trials ($p < .041$) were significant. We found also significant differences between No Go switch trials and Go repetition trials ($p < .0001$), between No Go first repetition trials and Go repetition trials ($p < .0001$) and between No Go second repetition trials and Go repetition trials ($p <.0001$).

Please, insert Figure 2 about here

Analysis of the accuracy data (see table 2) revealed only a significant interaction between Go-Signal and Repetition, $F(2, 48) = 3.78$, $p < .29$. Post-Hoc comparisons (Fisher LSD) showed reliable differences between Go switch trials and Go first ($p < .002$) and Go second repetition trials ($p < .004$).

Please, insert Table 2 about here

3.3. Discussion.

As we can see from the results of Experiment 2, the Go-Signal frequency is important. The pattern of results in Experiment 2 was different from that of Experiment 1. This difference was in line with our predictions, and supports our interpretation of the results of Experiment 1. However, an important result of Experiment 2 was that perhaps residual cost was still apparent in the first repetition trials after No-Go switch trials. At the same time, the difference between first repetition trials after No-Go trials and switch trials after No-Go trials was not significant. This last result does not necessarily mean that there was no residual cost. Reaction times for first repetition trials after No-Go trials increased because of the cost of the switch and sequential effects. Reaction times for second repetition trials after No-Go trials increased because of sequential effects. For these reasons it is almost impossible to obtain significant differences between them and with respect to switch trials. Schuch and Koch (2003) explored the role of response selection in task switching using the Go/No-Go methodology. In their first experiment the results showed no residual cost after No-Go trials. But, as we said, if we re-analyze these results, what happens is that RTs for repetition trials after No-Go trials increased (with respect to repetition trials after Go trials). Unfortunately, to explore the nature of residual cost (the main purpose of our experiments) they ran random task switch sequences without making a distinction between first and second repetition trials. At the same time, they described a test of their hypothesis concerning the role of response selection in task switching. If the stop signal appears after the target onset, response selection (but not response execution) should occur in No-Go trials, and then residual cost would follow. This is the case in our Experiment 2. The stimulus-cued completion hypothesis of Rogers and Monsell (1995) predicts a significant residual cost in switch trials with respect to repetition trials in the No-Go condition in both experiments; however, this was not the case in the experiments reported here.

From Schuch and Koch's (2003) point of view, response selection is the crucial factor required in order to produce cost (proactive interference consists of persisting inhibition of task sets). To implement a new task set, the previous set must be inhibited. This retroactive inhibition is related to response selection. Only response-related processes require inhibition of the competing task set, and then a new task set can be prepared without cost if response selection does not occur. This should be the case in No-Go trials with a zero delay or in our Experiment 1. Our results in Experiment 2 indicated that in the case of a low frequency stop signal, including a delay with respect to the target onset, the pattern of results remained as follows: significant Residual cost in No Go switch trials with respect to second repetition trials after No-Go trials, and a non-significant cost when we compare first repetition trials after No-Go trials and switch trials after No-Go trials. Our results are, therefore in favor of the role of response selection in task switching to produce cost, but we can not discard a role of response execution (see general discussion).

4. GENERAL DISCUSSION

The comparison between the Go and the No-Go conditions provides a severe test of our hypothesis. We have explored systematically the role played by: 1) Attention to the stimulus (No-Go trials, Experiment 1); 2) Response selection (No-Go and Go trials, Experiments 1 and 2); 3) Execution of relevant responses (Go trials, Experiments 1 and 2) in the process of mental reconfiguration necessary to switch between two simple cognitive tasks under predictable conditions. The following points summarize the main effects obtained in the experiments. The residual switch cost is a very robust effect with predictable sequences; it seems to be a real cognitive limitation, even found with a very long period of task pre-knowledge and even with 500 milliseconds of response fore-knowledge (Experiment 2). The results obtained in Rogers and Monsell (1995, Experiment 6) and Tornay and Milán (2001, Experiment 3) have been replicated in the Go Condition (Experiments 1 and 2): Residual cost disappears with first repetition trials under predictable conditions. Our results indicate that response selection is the key factor to produce the cost of task switching (no residual cost in No-Go trials of Experiment 1 (with–Go-Signal frequency of 50%) versus significant residual cost in the No-Go trials of Experiment 2 (Go-Signal frequency of 80%), but paying attention to the stimulus (without execution of a response in No-Go switch trials) is not enough to complete the process of mental set reconfiguration (no residual cost in switch trials after n-1 No-Go-trials in Experiment 1). About the response cued completion hypothesis, our results indicate that response execution could be a significant factor to complete mental set reconfiguration (¿Is there a displaced residual cost in the first repetition trials after No-Go switch trials in Experiment 2?) Cues in favour of a role of response execution are: The significant cost in No Go trials but the non significant difference between No Go switch trials and No Go first repetition trials in experiment 2, together with the slower RT in No Go first repetition trials with respect to Go switch trials, and the different RT pattern of No go trials in experiments 1 and 2 plus the gradual offset of cost in No Go trials with respect to the abrupt offset of cost in Go trials in experiment 2. However, we recognize that the empirical evidence is far from conclusive, but sequential effects and the usual effects on RTs after using the Go/No-Go methodology (slower RTs after No-Go trials) can not explain the different results in experiment 1 and 2.

In general terms, we partially agree with Rogers and Monsell's (1995) stimulus-cued completion hypothesis, but we go further in the exploration of the nature of the residual cost and the role played by exogenous factors in the process of reconfiguration. For example, there could be a different preparatory strategy in both experiments. That is, participants are more likely to prepare for a specific task in experiment 2 (the process of stimulus encoding and stimulus categorization could be more efficient in experiment 2), but we do not see how this speculative difference between experiment 1 and experiment 2 can explain the pattern of results (a significant cost with gradual offset in No Go trials of experiment 2). The critical difference between experiments seems response related (the hypothesis of Schuch and Koch

(2003) about the role of response selection and the response cued completion hypothesis of Milán et al. (2005) can predict the pattern of results) and not stimulus related. We partially agree with Meiran's (1996) explanation of the residual cost ("the residue of the task-shift cost probably reflects retroactive adjustment" Meiran, 1996, p. 1439). But we do not conceive a full explanation of our results based on the micro-practice hypothesis, because the adjustment takes place in an abrupt way, and does not show a gradual decreasing pattern (at least in Go trials). The most important conclusion from these two experiments is: To confirm Schuch and Koch's (2003) hypothesis about the role of response selection in producing the cost of task switching, but under different conditions. Regular switch instead of random switch, with a better control of the number of repetitions (in an unpublished replication of Experiment 1 with a four-trial sequence, our results remained the same) and sequential effects. The role of response execution was also addressed in the study by Schuch and Koch (2003). They used double-press trials instead of No-Go trials to show that the execution of any response does not change the pattern of results. We consider that it is important to go further in the exploration of the role played by the relevant responses, and pilot studies are being carried out in this regard. For example, if switch cost has a special relationship with response negative feedback, we predict a higher cost if the instructions to the participants emphasize speed (when accuracy is the main dependent variable) than if the instructions advise against errors (when RT is the main dependent variable). Data from pilot experiments support this new hypothesis. Rogers and Monsell (1995) also reported an interesting relationship between switch cost and repetition priming. Repetition priming refers to the fact that responses are usually faster and more accurate when the correct response on a trial is the same as that of the previous one, than when the sequential responses are different. Rogers and Monsell found that repetition priming disappeared (and sometimes even reversed) when there was a task switch. The authors proposed three possible explanations for the effect and concluded by noting that "A phenomenon as robust as this interaction between response repetition and task-switching must be telling us something interesting about control processes!" (p. 227). Our purpose is to take the interaction reported by Rogers and Monsell as a starting point to study the relationship between response factors and task switch.

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GO-SIGNAL IN N-1	SWITCH TRIALS	FIRST REPETITION TRIALS	SECOND REPETITION TRIALS
NO-GO	5.7 %	5.2 %	5.8 %
GO	6.0 %	6.8 %	3.7 %

TABLE 1

GO-SIGNAL IN N-1	SWITCH TRIALS	FIRST REPETITION TRIALS	SECOND REPETITION TRIALS
NO-GO	5.8 %	5.4 %	5.6 %
GO	6.5 %	4.2 %	3.4 %

TABLE 2

FIGURE CAPTION

FIGURE 1.- Mean reaction times for n trials after conditions “Go” and “No-Go” in trial n-1 in Experiment 1. The circles represent the results from “Go” condition. The squares represent the results from “No-Go” condition. X-axis - the number of consecutive trials that the same task is repeated.

FIGURE 2.- Mean reaction times for n trials after conditions “Go” and “No-Go” in trial n-1 in Experiment 2. The circles represent the results from “Go” condition. The squares represent the results from “No-Go” condition. X-axis - the number of consecutive that the same task is repeated.

TABLE 1.- Accuracy data in Experiment 1. Values represent the percentage of errors for each condition in Experiment 1.

TABLE 2.- Accuracy data in Experiment 2. Values represent the percentage of error for each condition in Experiment 2.

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