

**Exploring the functional locus of language switching:
Evidence from a PRP paradigm**

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This article was accepted in Acta Psychologica. This article may not exactly represent the final published version. It is not the copy of record.

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The authors would like to thank David W. Green and Michael Kaschak for helpful comments on an earlier version of this article.

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Abstract

To explore the stages of language processing at which language switching takes place, we examined the effect of partially temporally overlapping language processing on language switch costs in a dual-task study, in which we varied the stimulus onset asynchrony (SOA), the language (German-English), and the language sequence (language repetition trials and language switch trials). Using language comprehension tasks, the data revealed an effect of SOA (i.e., the “PRP” effect) and language switch costs. However, we did not find any influence of SOA on language switch costs, which suggests that language switches occur at the stages of lexical selection or post-selection processing. Thus, the findings of the present study provide evidence for models that assume language control to occur during or after lexical selection. (*123 words*)

Keywords: language switch costs; PRP effect; locus of language switching

1. Introduction

In recent decades, increasing interest has been seen in exploring cognitive control processes that enable bilinguals to keep their languages separate but also to switch between their languages in a context-appropriate manner. The cognitive control mechanisms that contribute to this flexibility in language processing are often investigated using the language switching paradigm (for reviews, see Abutalebi & Green, 2008; Bobb & Wodniecka, 2013; Declerck & Philipp, in press). Based on the findings of, among others, language switching studies, researchers developed several models of language control. On the one hand, there are models that assume a pre-lexical functional locus of language control (e.g., La Heij, 2005; Poulisse & Bongaerts, 1994; see also Schwieter & Sundermann, 2008, with highly proficient bilinguals) and on the other hand, there are models that assume that language control occurs during lexical selection (e.g., Declerck, Koch, & Philipp, 2015; Grainger, Midgley, & Holcomb, 2010; Green, 1998). Hence, the investigation of the locus of language switching allows us to evaluate the validity of these language control models.

In the present study, we aimed to examine whether language switching occurs prior to or during/after lexical selection. To this end, we investigated language switching in a dual-task approach, more specifically the psychological refractory period paradigm (PRP paradigm; see Pashler, 1994, for a review), to explore the effect of temporally overlapping language processing on language switch costs. Indeed, dual-task approaches have already been used as a methodological tool to investigate lexical processing (e.g., Dell'Acqua, Job, Peressotti, & Pascali, 2007; Ferreira & Pashler, 2002; Paucke, Oppermann, Koch, & Jescheniak, 2015; Piai & Roelofs, 2013); however, in contrast to our study, these studies addressed word production in the monolingual domain, whereas we extended such studies to the bilingual domain. In the following, we first describe the language switching paradigm and the PRP paradigm. Then, we turn to the relationship between these paradigms and derive our

hypotheses as to whether language switch costs should vary, that is, are smaller, equal, or larger, as a function of temporal overlap of two linguistic tasks (i.e., word categorization).

1.1. The language switching paradigm

The language switching paradigm represents an established tool for studying flexibility in bilingual language processing. Since this paradigm comprises stimuli in at least two languages—usually originating from the first acquired language (L1) and the second learned language (L2)—a distinction between repetition trials and switch trials can be drawn. In repetition trials, the task-relevant language is the same as that in the previous trial, whereas in switch trials, the target language differs from that in the preceding trial. Typically, reaction times (RTs) and error rates are increased in switch trials compared to repetition trials (e.g., Meuter & Allport, 1999). The performance difference between switch trials and repetition trials is called language switch cost, and this cost turned out to be a reliable finding in both the language production (e.g., Declerck, Koch, & Phillip, 2012) and the language comprehension domain (e.g., Thomas & Allport, 2000).

Language switch costs can be explained in various ways. Green's Inhibitory Control Model (ICM; Green, 1998) is an influential model, which proposes inhibition as a cognitive control mechanism enabling the selection of the intended language representations. In the ICM, the assumption that inhibition of the interfering language persists into the next trial forms the basis for the explanation of switch costs. In switch trials, the activation of the target language is initially reduced because this language represented the non-target language in the preceding trial and was therefore inhibited. The inhibition has to be overcome, resulting in performance deterioration. In contrast, in repetition trials, the target language is initially activated to a higher degree than the irrelevant language because the irrelevant language was suppressed in the preceding trial and this inhibition persists into the subsequent trial. Consequently, there is no re-adjustment of language activation levels necessary, leading to faster responses in repetition than in switch trials.

The ICM assumes that the bilingual lexico-semantic system contains simultaneously activated lexical representations of both languages. According to this model, inhibition is administered by language schemes that are defined as an already stored or newly developed program of mental operations that are carried out to achieve a certain action goal (e.g., lexical decision). Thus, language schemes determine whether this task-relevant operation sequence has to be performed based on lexical representations of L1 or on those of L2. At the lemma level (where semantic and syntactic characteristics of words are stored; Kroll & de Groot, 1997), the representations of both languages are equipped with a language tag, denoting it as L1 or L2. To execute a task in a certain language, all representations containing the non-target language tag are inhibited by the language schema with the aim of reducing the interference arising from these currently activated but task-irrelevant representations.

In short, the ICM assumes language control to occur during lexical selection. This is also proposed by several other language control models (e.g., Declerck et al., 2014; Grainger et al., 2010). However, there are also models that assume that language control occurs at a pre-selection stage, such as the “complex access, easy selection” approach of La Heij (2005).

The “complex access, easy selection” approach assumes that the intention to express a concept in a specific language results in an increased activation of lexical representations belonging to this language. Consequently, only lexical representations of the target language are considered in the lexical selection process. This model can account for language switch costs by its assumption that there is increased activation of the target language in repetition trials, which should lead to facilitation. In switch trials, on the other hand, a reactivation of the other language is required, so that language switch costs should be observed.

1.2. The PRP paradigm

In addition to language switching studies, information about language processing can also be obtained from studies using the PRP paradigm (see Pashler, 1994, for a review). In this paradigm, two stimuli, Stimulus 1 (S1; e.g., circle vs. square) and Stimulus 2 (S2; e.g.,

low-pitch tone vs. high-pitch tone), are presented in rapid succession, and subjects are asked to respond separately to both according to their order of presentation. The extent to which the processing of Task 1 (T1; e.g., shape discrimination task: to decide whether a symbol is a circle or a square) and Task 2 (T2; e.g., tone discrimination task: to decide whether a tone is low or high in pitch) temporally overlaps is specified by the stimulus onset asynchrony (SOA), which is defined as the interval between the presentation of S1 and that of S2. Typically, T1 performance is largely unaffected by the SOA variation, whereas T2 performance deteriorates with decreasing SOA (see Pashler, 1994, for a review). The increase in RTs and error rates in T2 with shortened SOA is referred to as “PRP” effect (Telford, 1931).

In addition to accounts of instruction-triggered sequential processing (e.g., Navon & Miller, 2002) and strategic allocation models of limited resources (e.g., Logan & Gordon, 2001), structural limitations of the cognitive architecture have been proposed as a major source for the occurrence of the PRP effect (e.g., Pashler, 1994). In the following we restrict the description of the PRP accounts to this view because the logic of our study is based on predictions derived from structural limitation models.

According to models of structural limitations, such as the response selection bottleneck hypothesis (Pashler, 1994), task processing is subdivided into three main stages, namely perceptual processes (e.g., perceptual encoding), decision and response selection (e.g., stimulus-to-response mapping), and motor processes (e.g., response execution). Processes involved in the selection of responses due to structural limitations of the cognitive system only proceed for one stimulus at a time, thereby resulting in a processing bottleneck on the central stage of decision and response selection. Thus, response selection for T2 cannot begin until response selection processes are finished for T1, leading to a situation of increasing RTs for T2 (RT2) with decreasing SOA. In contrast to this processing restriction, perceptual

processes and motor processes can be carried out in parallel to each other and in parallel to response selection operations.

PRP paradigms and the response selection bottleneck hypothesis have been used predominantly to explore cognitive processing in non-linguistic tasks (for a review, see Pashler, 1994). Over the past few years, however, the number of PRP studies exploring lexical processing, especially in language production of the monolingual domain, has increased significantly. These studies can be subdivided into two groups.

On the one hand, there are PRP studies that investigate whether cognitive processes involved in language performance represent specialized linguistic processes, or whether these processes are language-unspecific and also underlie performance of non-linguistic tasks. These studies generally look at whether performance delays in a linguistic T1 (i.e., tasks requiring language processing: e.g., semantic categorization task, in which subjects decide whether visually presented words belong to a specific category, such as animate or inanimate) resulting from manipulations of processing demands at different stages of language processing propagate into an unrelated non-linguistic T2 (i.e., tasks involving no language processing: e.g., tone discrimination task). Based on this approach, it has been shown, for example, that when T1 performance slows down due to increased processing demands at early word production stages—such as lemma and phonological word-form selection—performance in the non-linguistic T2 also decelerates by a comparable amount, indicating a central processing bottleneck. Hence, it seems that linguistic processes involved in lemma retrieval and morphological encoding use central processing mechanisms shared with non-linguistic tasks (Ferreira & Pashler, 2002). With regard to phoneme selection as a late stage of word production, the existing findings look more heterogeneous (Cook & Meyer, 2008; Ferreira & Pashler, 2002; Roelofs, 2008).

On the other hand, there are PRP studies that explore the language processing stage where linguistic effects, such as semantic interference (Levelt, Roelofs, & Meyer, 1990) and

stroop-like interference (Stroop, 1935), emerge. With regard to lexical processing, a distinction is made between pre-lexical stages, including perceptual and conceptual encoding, the lexical selection stage, and post-selection stages, such as word-form encoding (Piai, Roelofs, & Schriefer, 2014). Generally employing a non-linguistic T1 and a linguistic T2, these studies focus on interactions of linguistic effects and SOA and interpret these interactions based on the “locus of slack” logic (Schweickert, 1980). If a linguistic effect in T2 (e.g., semantic interference) has its functional locus at pre-lexical stages, then in the case of a short SOA, the period during which the response selection bottleneck is occupied by T1 and the response selection for T2 has to wait until T1 is finished (i.e., slack period) can be used to “absorb” this linguistic effect. In other words, according to the locus of slack logic, performance costs resulting from a linguistic phenomenon should decrease with decreasing SOA. In contrast, if a linguistic effect is located at or after the lexical response selection stage, then the long period of waiting in the case of a short SOA cannot be employed to absorb the effect. Thus, performance costs arising from a linguistic phenomenon should not differ between SOAs. On the basis of this locus of slack logic, a number of studies found semantic and stroop-like interference to be additive with the effects of SOA, leading to the conclusion that semantic interference arises during lexical response selection or at post-selection stages (Jescheniak, Matushanskaya, Mädebach, & Müller, 2014; Piai & Roelofs, 2013; Piai et al., 2014; Schnur & Martin, 2012).

1.3. The present study

With regard to the question at which stage of language processing a language switch emerges, there are models that assume a pre-lexical functional locus of language control (e.g., La Heij, 2005; Poulisse & Bongaerts, 1994; Schwieter & Sundermann, 2008) and models that assume that language control occurs during lexical selection (e.g., Declerck et al., 2014; Grainger et al., 2010; Green, 1998), so that the specific processing stage for language switching remains a contentious issue. In the present study, we aimed to explore the stage at

which language switching occurs by implementing language switching into PRP trials. Specifically, we examined the effect of temporally overlapping language processing on language switch costs in T2.

A PRP trial with two linguistic tasks requires a language repetition in T2 when both tasks are based on the same language (e.g., a German word as S1 in the first semantic categorization task [T1] and a German word as S2 in the second semantic categorization task [T2]). In contrast, a language switch occurs in T2 when the two linguistic tasks within a PRP trial are based on different languages (e.g., T1 with a German word as S1 and T2 with an English word as S2). Thus, a PRP study requiring language switching between T1 and T2 represents a variation of the language switching paradigm. However, in contrast to language switching studies, in which the languages are processed sequentially, in the PRP paradigm, the languages are processed simultaneously.

Conclusions about the locus of language switching can be drawn by interpreting the interaction of language sequence and SOA. If the effects of language switching have their functional locus at pre-selection stages, then there should be an underadditive interaction of language sequence and SOA (i.e., switch costs get smaller with shorter SOA). Such an interaction would suggest that the time period in which T2 response selection waits until the response selection bottleneck becomes available can be used for the language switch and this time gets larger with decreasing SOA. This would be in line with models that assume the functional locus of language control to be at the pre-selection stage, such as the models of La Heij (2005), Poulisse and Bongaerts (1994), and Schwieter and Sundermann (2008).

In contrast, if language switching is located at or after the response selection stage, then switch costs should not differ across SOAs. Thus, the interaction of language sequence and SOA should be additive. This would be in line with the models of Green (1998), Declerck et al. (2014), and Grainger et al. (2010).

A final possibility is an overadditive interaction of language sequence and SOA, indicating that switch costs increase with shorter SOA. Such an interaction pattern could result from dissipating carry-over effects of language sets (proactive interference account; Allport, Styles, & Hsieh, 1994; Kiesel et al., 2010). That is, with a long SOA, the activation of the previously used language set can decay (set dissipation), leading to reduced interference and switch costs. In contrast, with a short SOA, there is only little time available for language set dissipation, resulting in strong interference and increased switch costs.

In summary, in the current study, we assumed to find—in addition to a language-based PRP effect—language switch costs for temporally overlapping language processing. The critical question, though, referred to whether and, if so, how these costs were affected by SOA.

2. Method

2.1. Participants

Twenty-six German-English bilinguals (14 women; $M = 25$ years; $SD = 4.0$) participated in the experiment. In addition to a language background survey (see Table 1 for main results), they completed the Oxford Quick Placement Test (OQPT; Syndicate, 2001). They were all unbalanced late bilinguals, exposed to English at the age of 10 on average. German was their dominant language and their proficiency in English ranged from level A1 to level C1 with respect to the Common European Framework of Reference for Language. They received on average 33.8 points ($SD = 12.06$) in the OQPT. This score represents a proficiency level B2 (i.e., upper intermediate level). They gained their English proficiency from, on average, nine years' formal education.

---Table 1---

2.2. Stimuli, tasks, and responses

The stimuli consisted of a fixation cross and German as well as English number words from one to nine¹, with the exception of *five* and its translation-equivalent German word *fünf*.

The fixation cross was shown in the center of the screen, where it stayed the entire experiment. The number words were displayed in lower case and appeared alternately to the left and right of the fixation cross. Number words appearing to the left of the fixation cross represented S1 and those occurring to the right of the fixation cross served as S2. The distance between the fixation cross and the words was 7.5 cm. All stimuli were presented in black 20-point Arial font on a white 17-inch screen placed at a distance of approximately 50 cm in front of the subjects.

T1 was to categorize number words to the left of the fixation cross as smaller or greater than 5 and T2 was to perform this magnitude categorization task for number words appearing to right of the fixation cross. Subjects were instructed to respond as quickly as possible while attempting to minimize errors. They responded by pressing either a left or a right response key on a QWERTZ keyboard with their left or right index finger, respectively². Responses to numbers smaller than 5 were collected from the *W* key, whereas responses to numbers greater than 5 were recorded from the *P* key³.

2.3. Procedure

After screening the language skills, participants received written and verbal instructions in German. The experiment started with a practice block of 12 trials, followed by four experimental blocks of 65 trials each⁴. Each trial began with the presentation of the first number word (S1) to the left of the centrally located fixation cross. After a randomly varied SOA of 100 ms or 600 ms, the second number word (S2) appeared to the right of the fixation cross. The offset of both words occurred 150 ms after the response to S2 was executed. An inter-trial interval (ITI) of 2,000 ms separated the trials within a block.

The language sequence within a trial was manipulated based on the following stimulus pairs: L1-L1, L1-L2, L2-L2, and L2-L1. These language pairs were presented in a random order with the restriction that all pairs occurred equally often and that there were the same number of language repetitions and switches between S2 of trial n and S1 of trial $n-1$.

S1 and S2 alternated randomly and independently from each other. Their random selection was restricted insofar as each word was presented equally often as S1 and as S2 and no word was allowed to repeat on a given trial. The combination of a number word with its translation-equivalent word in the other language was also not permitted.

2.4. Design

Overlapping-task performance was examined using a 2x2x2 repeated-measure design with the within-subjects independent variables SOA (100 ms vs. 600 ms), language (German vs. English), and language sequence (repetition vs. switch). Based on this factorial design, performance in T1 and that in T2 were separately analyzed. RT and error rates were dependent measures.

3. Results

Practice trials and warm-up trials were eliminated from data analysis. Moreover, trials with RTs 3 *SD* above or below each individual's mean RT were discarded, separately for T1, T2, and for the two SOA condition levels (T1: 2.1%; T2: 2.0%). Trials on which any response was incorrect were also not included in the RT analysis.

3.1. T1 performance

First, we analyzed T1 performance by submitting the data into an ANOVA with the within-subjects independent variables SOA, language, and language sequence. There were no significant results either for RT or for the error data (all *ps* > .21).

3.2. T2 performance

The same ANOVA for T2 performance yielded a reliable main effect of SOA, $F(1, 23) = 140.11, p < .001, \eta_p^2 = .86$. Responses to S2 were faster with the long than with the short SOA (567 ms vs. 812 ms; see Figure 1), indicating a PRP effect of 245 ms. The main effect of language was also significant, $F(1, 23) = 7.49, p < .05, \eta_p^2 = .25$. Responses to English number words were 11 ms slower than to German words (695 ms vs. 684 ms). The interaction

of SOA and language was not significant, $F < 1$, indicating that the PRP effect did not differ much across languages.

Moreover, the main effect of language sequence was significant, $F(1, 23) = 50.87, p < .001, \eta_p^2 = .69$. Responses were slower in switch trials than in repetition trials (700 ms vs. 679 ms), resulting in language switch costs of 21 ms. Switch costs were significant for both languages (German: 20 ms; $t(23) = -5.23, p < .001, d = .15$; English: 21 ms; $t(23) = -5.19, p < .001, d = .15$). However, the interaction of language sequence and language was non-significant, $F < 1$.

Most importantly, the interaction of language sequence and SOA was not significant, $F < 1$. Thus, language switch costs did not differ depending on the SOA (short SOA: 19 ms; long SOA: 23 ms). We also tested this switch-cost difference between the SOA levels directly with a two-tailed paired t -test, which revealed no significant effect, $t(23) = 0.56, p = .57^5$. The interaction of SOA, language sequence, and language was non-significant, too, $F(1, 23) = 1.96, p = .18, \eta_p^2 = .07$.

For the error rates, we replicated the main effect of SOA, $F(1, 23) = 4.61, p < .05, \eta_p^2 = .17$. Responses were more error-prone at the short SOA than at the long SOA (2.4% vs. 1.7%; see Table 2). All other effects were non-significant, $F_s < 1$.

---Figure 1---

---Table 2---

4. Discussion

The objective of the present study was to explore the processing stage at which language switching takes place. To this end, we assessed the effect of temporally overlapping language processing on language switch costs in a dual-task study using the PRP paradigm.

In the current study, we found a PRP effect and language switch costs. Importantly, the SOA did not modulate switch costs, indicating lexical selection processes or post-selection processes to be the locus of language switching. Although there was a global slowing of

responses to English number words in T2, the PRP effect and switch costs were not affected by this slowing.

4.1. The effect of temporally overlapping language processing on language switch costs

While T1 performance was unaffected by the SOA, we found T2 performance to be worse after a short than a long SOA, reflecting a PRP effect (Pashler, 1994). Hence, we replicated the PRP effect using two linguistic stimuli (visually presented number words) and tasks in a bilingual setting. The occurrence of the PRP effect in the context of language processing indicates that response selection could not be carried out in parallel for two words. However, we exclusively used visual stimuli in the present study, so that some part of the PRP effect might be based on visual processing limitations occurring before the response selection bottleneck (see e.g., Arnell & Duncan, 2002; Hein & Schubert, 2004; for empirical evidence for perceptual processing limitations in dual-task performance).

Moreover, we found performance in switch trials to be worse than in repetition trials, indicating language switch costs. The majority of the studies reporting language switch costs used the language switching paradigm in which a sequential type of language processing is required (e.g., Declerck & Philipp, in press, for a review). In the current study, we were able to expand the demonstration of these costs from strictly sequential language processing to situations requiring partially simultaneous language processing. Since the PRP effect did not differ between repetition and switch trials, we can further conclude that parallel response selection can take place neither for words originating from the same language nor for words belonging to different languages, representing a processing bottleneck.

Furthermore, the experimental methodology used in the present study allowed us to explore the stages of language processing at which language switching takes place. The conclusion about the locus of language switching can be drawn by interpreting the interaction of language sequence and SOA under the assumption of a processing bottleneck at the stage of response selection. Since we did not find language switch costs to differ depending on the

SOA, language switch costs were not absorbed at the short SOA (i.e., during the time period in which the assumed lexical selection bottleneck was occupied by T1). This suggests that language switching does not occur prior to lexical selection. Hence, this finding provides evidence against models of a pre-selection locus of language control and provides evidence for language control models that assume language control to occur at the stage of lexical selection or post-selection processing. However, based on the used dual-task approach, we cannot distinguish whether language switching takes place at or after the stage of lexical selection.

4.2. Conclusions

The present study allows us to draw two important conclusions that contribute to the understanding of bilingual language processing. First, we could show that parallel response selection can take place neither for words originating from the same language nor for words belonging to different languages, representing a processing bottleneck. Second, the data suggests that the functional locus of language switching is located at the lexical selection or post-selection processing stage.

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Footnotes

¹ In the present study, there was an extensive stimulus word repetition due to the use of a small number of stimuli. However, since language switching studies report consistently language switch costs, regardless of whether they used a small stimulus set (e.g., number from 1 to 9; Jackson, Swainson, Cunnington, & Jackson, 2001; Jackson, Swainson, Mullin, Cunnington, & Jackson, 2004) or a large stimulus set (e.g., more than 100 stimuli; Macizo, Bajo, & Paolier, 2012; Orfanidou & Sumner, 2005), the same results and conclusions should be expected in more natural situations with rare or no stimulus repetitions.

² In the present study, subjects made a decision about a non-spatial stimulus attribute (i.e., magnitude) with spatially defined responses (i.e., left or right response key). Generally, responses are faster when the S-R arrangement is compatible (i.e., overlap between stimulus and response position: e.g., number words appearing to the left of the fixation cross require a left response key) than when it is incompatible (i.e., no overlap between stimulus and response position: e.g., number words appearing to the left of the fixation cross require a right response key), even when the stimulus position is task irrelevant. This finding is known as the “Simon effect” (Simon, 1969; see Proctor & Vu, 2006, for a review). Taking into account the influence of irrelevant spatial information on performance, compatibility between the stimulus location and the position of their required response was controlled in such a way that there was the same number of trials with two compatible tasks, two incompatible tasks, with a compatible T1 and an incompatible T2 as well as an incompatible T1 and a compatible T2.

³ Considering the spatial-numerical association of response codes effects (SNARC; Dehaene, Bossini, & Giroux, 1993), the response keys were not counterbalanced across subjects.

⁴ The original study comprised two parts, a language switching and a PRP part. Both parts were run in a single session with counterbalanced order of paradigms. Here we report only performance in the PRP experiment, which was not modulated by paradigm order, all F s < 1.

⁵ Given an alpha of .05 and a sample size of 24 subjects, a post-hoc power analysis for the two-tailed t -test using G-Power (Faul, Erdfelder, Lang, & Buchner, 2007) showed that the power to detect a large effect (Cohen's $d = .80$) was .96.

Table 1

Results of the language proficiency screening. The information consists of average scores received in each item. Self-reported scores of language abilities in English were obtained from a 7-point Likert scale, with 1 indicating *very bad* and 7 indicating *very good*.

Item	<i>M</i>	<i>SD</i>
Age of English acquisition	10.04	0.91
Formal English Education (in years)	9.00	1.89
Duration of stay in an English speaking country (in weeks)	2.29	4.98
Self-rated score of speaking ability in English	4.08	1.51
Self-rated score of comprehension ability in English	5.04	1.41
Self-rated score of reading ability in English	5.17	1.42
Self-rated score of writing ability in English	4.52	1.56
Percentage of daily use of English	15.41	10.62
Known foreign languages	1.54	0.89

Table 2

Mean error rates (in percentage; standard errors in parenthesis) for Task 1 (T1) and Task 2 (T2) as a function of stimulus onset asynchrony (SOA; 100 ms vs. 600 ms), language (German vs. English), and language sequence (repetition vs. switch).

	German		English	
	SOA 100 ms	SOA 600 ms	SOA 100 ms	SOA 600 ms
T1				
Switch trials	1.3 (0.6)	1.0 (0.6)	1.0 (0.4)	1.0 (0.2)
Repetition trials	1.0 (0.3)	1.2 (0.5)	1.2 (0.5)	1.0 (0.4)
T2				
Switch trials	2.4 (0.4)	1.8 (0.7)	2.5 (0.5)	1.8 (0.4)
Repetition trials	2.4 (0.4)	1.6 (0.5)	2.4 (0.3)	1.7 (0.3)

Figure Captions

Figure 1

Mean RTs (in ms) for Task 1 (T1) and Task 2 (T2) as a function of stimulus onset asynchrony (SOA; 100 ms vs. 600 ms), language (German vs. English), and language sequence (repetition vs. switch).

Figure 1

