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A sentence to remember: Instructed language switching in sentence production.

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Abstract

In the current study, we set out to investigate the influence of a sentence context on language switching. The task required German-English bilinguals to produce responses based on an alternating language sequence (L1-L1-L2-L2- ...) and concepts in a specific sequential order. The concept sequence was either a sentence which was syntactically correct in both languages (language-unspecific sentence), a sentence which was correct in just one language (language-specific sentence) or a sentence which was syntactically incorrect in both languages (scrambled sentence). No switch costs were observed in language-unspecific sentences. Consequently, switch costs were smaller in those sentences than in the language-specific or scrambled sentences. The language-specific and scrambled sentence did not differ with respect to switch costs. These results demonstrate an important role of sentence context for language switch costs and were interpreted in terms of language interference and preparation processes.

(words: 140)

Second language (L2) learners typically start out with learning individual words of a foreign language before communication naturally progresses into the use of these single words in sentences. Due to the use of sentences, L2 learners are no longer restricted to simple questions or demands, but can converse on a higher level. Further, they are able to switch between their languages in a sentence context, for example, by including words or phrases from the foreign language into sentences produced in the native language (i.e., code-switching, for reviews, see Heredia & Altarriba, 2001; van Hell, Litcofsky, & Ting, in press). Yet, language switching studies have typically been limited to the investigation of single words. In the current study, we set out to examine whether a difference in language switching can be obtained by implementing a sentence context.

From a psycholinguistic point of view, word production and sentence production have certain differences. With respect to models of language production, the process of word production is assumed to take place in the following order (Levelt, Roelofs, & Meyer, 1999): A nonlinguistic concept is formed, which entails information that the speaker wants to convey. At the lexical level, the corresponding lemma (i.e., semantic-syntactic representation of a word) is selected, after which the sound representations of the response are added (i.e., phonological encoding). Finally, the word can be produced through articulation, which involves activation of the necessary muscles.

In sentence production, there is the additional process of integrating single words into the more complex context of sentences. Combining single words into a sentence sequence is assumed to be lexically driven (e.g., Pickering & Branigan, 1998). This entails that syntactic information directs the construction of a sentence through activation of syntactically corresponding lemmas.

Bilingual language control

The processes of word production and sentence construction already indicate that lemma activation and lexical (i.e., lemma) selection play a crucial role for language

production. Therefore, it is important to note that, at least for bilinguals, language control (Green, 1998) is another process that guides lexical selection. Bilingual language control is necessary to ensure that production takes place in the target language, even though representations of the non-target language might be competing for selection (e.g., Gollan, Sandoval, & Salmon, 2011; Poulisse, 2000; Poulisse & Bongaerts, 1994; Schulpen, Dijkstra, Schriefers, & Hasper, 2003).

A prominent task to investigate the language control process is language switching (e.g., Christoffels, Firk, & Schiller, 2007; Declerck, Koch, & Philipp, 2012; Green, 1998; for a review, see Bobb & Wodniecka, 2013). During a typical language switching task an object and a language cue are presented to indicate, respectively, which concept has to be produced in which language. This set up allows for different concepts and languages to follow one another. A vast array of studies have shown that when two consecutive trials require production in a different language, performance is worse than repeating the same language (e.g., Costa & Santesteban, 2004; Declerck et al., 2012; Meuter & Allport, 1999; Philipp, Gade, & Koch, 2007; Verhoef, Roelofs, & Chwilla, 2009). This decrease in performance is known as switch costs and is considered to be a measure of language control (e.g., Christoffels et al., 2007; Declerck et al., 2012; Green, 1998).

Switch costs are usually explained with the notion of persisting inhibition (Green, 1998): When on trial n-1 a certain language has to be produced, the non-target language will be inhibited. Yet, when the previously inhibited language is required for production on trial n (i.e., switch trial), the inhibition that was exercised on trial n-1 will persist into trial n and thus will have to be overcome. This is not the case when producing in the same target language on trial n-1 and trial n (i.e., repetition trial). Hence, it should be harder to switch between languages than repeating the same language due to persisting inhibition in switch trials.

Language switching in sentences

These robust language switch costs raise the question why bilinguals switch between languages during natural bilingual language production (i.e., code-switching; Heredia & Altarriba, 2001; van Hell et al., in press) when it is costly. However, it might be that no switch costs occur in a language switching task if, as during natural bilingual language production, bilinguals can choose when to switch to another language. Gollan and Ferreira (2009) used a variant of the language switching paradigm described above, which allowed participants to freely choose when to switch to another language. Switch costs were still observed in this study, which indicates that voluntary language switching does not abolish switch costs ¹.

Another feature of natural bilingual language production that might reduce switch costs concerns the fact that upcoming responses are predictably known to the speaker and can thus be prepared, whereas this is generally not the case during a language switching task. Previous language switching studies have shown that language preparation can reduce switch costs (Costa & Santesteban, 2004; Fink & Goldrick, in press). A recent language switching study investigated whether switch costs could be abolished by producing predictable responses with abundant preparation time (Declerck et al., 2013). To this end, a novel language switching paradigm was used: the sequence-based language switching paradigm. In contrast to other language switching studies, no visual objects or language cues were used. The bilingual participants had to produce one of seven weekdays, numbers or a novel sequence in the correct sequential order. Additionally, they had to switch languages after every second trial (i.e., alternating language sequence). This resulted in the following possible sequence: Montag (meaning Monday in German) - Dienstag (meaning Tuesday in German) – Wednesday – Thursday - Freitag (meaning Friday in German) – ... Similar to language switching results with unpredictable responses (e.g., Declerck et al., 2012; Meuter & Allport, 1999; Philipp et al., 2007), switching between languages resulted in switch costs in this study. Hence, although Declerck et al. (2013) demonstrated that switch costs can be reduced when responses are predictable and, thus, could be prepared in advance, they also showed that

switch costs under these conditions were not abolished (see also Declerck, Koch, & Philipp, in press).

Whereas voluntary language switching and predictable responses do not seem to abolish switch costs, there are other differences between language switching in a laboratory and natural code-switching. Van Hell et al. (in press), have argued that the use of a sentence context is one of the major differences between standard language switching experiments (in which usually isolated words are used) and code-switching.

Evidence along these lines comes from a recent language switching study that investigated single word production in a sentence context (Gullifer, Kroll, & Dussias, 2013). In this study, participants had to silently read sentences and produce one marked word from the sentence. The sentences were always in one language, but after two sentences, the language would change (i.e., alternating language sequence). Interestingly, no switch costs were observed for the produced words. However, there were always several words between the actual language switch, at the beginning of the sentence, and the marked word that had to be produced. This entails that in this study, responses were not measured immediately after switching from one language to another, but later on, which could have deteriorated the switch costs to the point that they were not observed anymore.

Tarłowski, Wodniecka, and Marzecová (2013) also investigated language switching between sentences instead of between isolated words. Importantly, in this production study, switch costs were measured at the onset of the language switch (i.e., at the beginning of the sentence). More specifically, Polish-English bilinguals had to describe an action depicted in a drawing in either Polish or English, depending on an auditory cue, so that language switches and language repetitions occurred between sentences. The study revealed that switch costs can still be obtained when bilinguals switch languages between sentences, which indicates that switch costs can be obtained in a sentence context.

Taken together, the study of Gullifer et al. (2013) indicates that switch costs can be abolished in a sentence context, whereas Tarłowski et al. (2013) showed substantial switch costs with sentences. Furthermore, sentence comprehension studies appear to be conflicting as well, with some studies finding no switch costs (Dussias, 2003; Ibáñez, Macizo, & Bajo, 2010) and other studies that do find switch costs in a sentence context (Philipp & Huestegge, in press; Proverbio, Leoni, & Zani, 2004).

These results lead to the question of whether a sentence context can reduce or even abolish switch costs or not. Hence, in the present study, we examined the effect of a sentence context on language switching in language production. In order to do so, we compared language switching in the context of a syntactically structured sentence against scrambled sentences. Furthermore, in contrast to the study of Gullifer et al. (2013) and Tarłowski et al. (2013), who investigated language switching between sentences, the main focus lay on language switching within sentences, which is more closely related to intra-sentential code-switching (cf. van Hell et al., in press).

In the current study we implemented a similar set-up to that of Declerck et al. (2013) in which the language had to be switched after every second trial (i.e., word). Unlike Declerck et al. (2013), however, the German-English bilingual participants had to either produce responses in a syntactically structured sentence sequence or produce responses in a scrambled sentence sequence (for examples see Table 1). The syntactically structured sentences consisted either of syntactically correct sequences in both language, which entails that the sentences can be translated word-to-word to the other language (language-unspecific sentences), or sentences which are syntactically correct in just one language, but not in a word-to-word translation to the other language (language-specific sentences).

Table 1. Complete list of sequences used in the main experiment

	Concept sequence A	Concept sequence B
Language- unspecific sentence	dieser Junge rennt sehr schnell (German) this boy runs very fast (English)	er mag kleine gelbe Blumen (German) he likes small yellow flowers (English)
Language- specific sentence	heute kannst du einkaufen gehen (German) today can you shopping go (English)	heute du kannst gehen einkaufen (German) today you can go shopping (English)
Scrambled sentence	kleine mag Blumen gelbe er (German) small likes flowers yellow he (English)	rennt Junge schnell sehr dieser (German) runs boy fast very this (English)

If a sentence context helps to reduce the size of switch costs, we expect to observe smaller switch costs in syntactically structured sentences as compared to scrambled sentences. Such a finding would suggest that language switching within sentences is less costly than switching between isolated words. Thus, such an observation would also indicate that natural code-switching is not as costly as one might derive from previous language switching studies. Furthermore, the comparison between language-unspecific and language-specific sentences allows us to investigate whether switch cost obtained with sentences that are syntactically correct in both languages, could also be obtained with sentences that are syntactically correct in just one language. With respect to code-switching in natural speech production, this would give us some information about the role of syntactical correctness in a code-switched sentence, further elaborating the question whether and under which circumstances language switching in sentences results in switch costs.

Method

Participants

Forty-eight native German participants (37 female) that spoke English as their second language took part. Prior to the experiment they were asked to fill in a questionnaire regarding

their age (mean = 23.5), years of formal English education (mean = 9.4), amount of other languages they knew (mean = 1.1, excluding German and English) and their self-rated level of spoken English, with 1 being very bad and 7 being very good (mean = 5.0).

Apparatus and concepts

Six different concept sequences were used, each consisting of five concepts (for a complete list see Table 1). This entails that each of the three sentence types (language-unspecific sentences, language-specific sentences, and scrambled sentences) were represented by two concept sequences (set A vs. set B, see Table 1) and the use of either concept sequence was counterbalanced across participants.

In the language-unspecific sentences, the two concept sequences resulted in a sentence that was syntactically correct in both German and English when translating it word-to-word. The two scrambled sentences implemented the same concepts as those in the language-unspecific sentences, but their position in the sequence were scrambled, which led to syntactically incorrect sequences in both German and English. Hence, identical concepts were used in the language-unspecific sentences and the scrambled sentences. Yet, the participants only used one of the two possible sequences of each sentence type (i.e., either concept sequence A or B), with the restriction that during the language-unspecific sentences the participants used different concepts than during the scrambled sentences, which would reduce any interference across sentence types.

In the language-specific sentences, both sentences were correct in either German or English but the word-to-word translation had an incorrect syntactic structure in the other language. For half of the participants the sentence was correct in German, for the other half of participants it was correct in English. In the language-specific sentences, different concepts were used than in the other two sentence types. However, the same concepts were used for the German-specific sentence as for the English-specific sentence. Similar to the concepts in the language-unspecific sentences and the scrambled sentences (1661 per million in German and

1902 per million in English), high frequency words were also implemented in the language-specific sentences (1365 per million in German and 2680 per million in English; Baayen, Piepenbrock, & Guliker, 1995)². Furthermore, the concepts in all three sentence types were non-cognates and both language-unspecific sentences and language-specific sentences had a similar syntactic structure.

The trials were presented using E-prime, while the speech-onset times were registered using a voice-key (Realtalk High Definition Audio Microphone). All utterances were recorded with a Zoom H2 Handy Portable Stereo Recorder so that the recorded files could be consulted for accuracy. All errors were marked by the experimenter in a subject file.

Procedure

The instructions were presented both orally and visually to the participants prior to the experiment, with an emphasis on both speed and accuracy. These entailed that participants had to produce one of five concepts in a specific sequential order, after hearing an auditory response-signal in each trial. Additionally, the task required the participants to switch languages every second trial (e.g., L1-L1-L2-L2-L1-L1; cf. Declerck et al., 2013, in press; Jackson, Swainson, Mullin, Cunnington, & Jackson, 2004). Examples for the resulting trial sequences in each of the three sentence types are provided in Table 2. Since both the language sequence and concept sequence were memory-based, no visual stimuli or language cues were presented (see also Declerck et al., 2013, in press).

Following the instructions, one of three experimental sentence types was presented. The order of the sentence types was counterbalanced across participants. All three sentence types started with two practice blocks, which consisted of 20 trials each (every verbal response is considered as an individual trial so that 20 trials means repeating the concept sequence of five words for four times). During the first practice block the participants had a card in front of them with the responses in written form on it, in the correct order in both languages. During the second practice block they had to respond without the card. These

practice blocks were followed by six experimental blocks, consisting of 20 trials each, using the same concept sequence. The starting language of each of these blocks alternated from one block to the next. The order of the starting language of each block was counterbalanced across participants.

Table 2. Example of the first seven trials (out of 20) for all three sentence types (language-unspecific sentence, language-specific sentence, and scrambled sentence) starting with German.

Sentence type	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7
Language-unspecific	dieser	Junge	runs	very	schnell	dieser	boy
Language-specific	heute	kannst	you	shopping	gehen	heute	can
Scrambled	rennt	Junge	fast	very	dieser	rennt	boy

By using a sequence of five concepts and a language switch every second trial, we made sure that in a block of 20 trials each concept was named equally often in each language (German and English) and with each language transition (switch and repetition trials).

Each block was preceded by information on the screen about the language that the participants had to start with (German vs. English) and the correct concept sequence of that block in written form in both languages. When the block was started by the participant, a fixation cross (+) became visible that stayed in the centre of the screen throughout the block. During each trial an auditory response-signal (50 ms) indicated when to produce a verbal response (i.e., one concept in the correct language). After every response there was a pacing-

interval, constituting the time between the previous response-onset and the current response-signal, of 1500 ms.

Design

The independent variables were sentence type (language-unspecific sentence vs. language-specific sentence vs. scrambled sentence), language (German vs. English) and language transition (switch vs. repetition), while the dependent variable was reaction time (RT).

Results

The first trial of each block and the error trials, which constituted the production of a wrong concept and/or production in the wrong language, were excluded from RT analyses, as were trials following an error. Furthermore, for the calculation of RT outliers, RTs in all trials were z-transformed and trials with a z-score of $-2/+2$ were discarded as outliers. These criteria led to the exclusion of 13.5% of the data in the RT analysis. No analysis was performed on the error rates, due to the very low amount of errors. Yet, both RT data and error rates are displayed in Table 3.

An ANOVA of the RT data revealed a main effect of sentence type, $F(2, 94) = 13.56$; $p < .001$; $\eta_p^2 = .224$, with the slowest responses generated in scrambled sentences (576 ms), followed by language-specific sentences (519 ms), and the fastest responses generated in language-unspecific sentences (453 ms, see Table 3). Separate post-hoc t-tests revealed that RT in language-unspecific sentences was significantly faster than those obtained in language-specific sentences, $t(47) = 3.14$; $p < .01$, and scrambled sentences, $t(47) = 4.77$; $p < .001$. Further, RT in language-specific sentences was significantly faster from those obtained in scrambled sentences, $t(47) = 2.29$; $p < .05$.

There was also a main effect of language transition, $F(1, 47) = 11.49$; $p < .01$; $\eta_p^2 = .196$, with switch trials (529 ms) being slower than repetition trials (503 ms). There was no significant effect of language, $F < 1$, or an interaction between language and language

transition, $F(1, 47) = 1.11$; ns.; $\eta_p^2 = .023$. This absence of asymmetrical switch costs could be explained with the relatively large inter-trial interval implemented in the current study.

Previous research has shown that asymmetrical switch costs can be abolished due to a longer time to prepare the upcoming trial (Verhoef et al., 2009; yet, see Fink & Goldrick, in press). The interaction between sentence type and language and the three-way interaction were also not significant, $F_s < 1$.

Table 3. Overall RT in ms and percentage of errors (PE) (SD in parenthesis) as a function of sentence type (language-unspecific sentence vs. language-specific sentence vs. scrambled sentence), language transition (switch vs. repetition), and language (German vs. English).

		<u>Language</u>					
		German			English		
		<u>Sentence type</u>					
	Language- unspecific	Language- specific	Scrambled	Language- unspecific	Language- specific	Scrambled	
R T	Switch	460 (21)	539 (31)	601 (33)	452 (19)	532 (31)	590 (33)
	Repetition	452 (23)	504 (22)	551 (25)	449 (22)	502 (30)	561 (26)
P E	Switch	0.4 (0.1)	0.3 (0.1)	0.4 (0.1)	0.4 (0.1)	0.4 (0.1)	0.5 (0.1)
	Repetition	0.1 (0.0)	0.2 (0.1)	0.2 (0.1)	0.1 (0.1)	0.4 (0.1)	0.4 (0.1)

Importantly, the interaction between sentence type and language transition was significant, $F(2, 94) = 3.40$; $p < .05$; $\eta_p^2 = .067$, with smaller switch costs in language-unspecific sentences (6 ms) than during language-specific sentences (32 ms) and scrambled sentences (40 ms; see Figure 1). Separate post-hoc t-tests revealed that switch trials were significantly different from repetition trials in language-specific sentences, $t(47) = 3.27$; $p <$

.01, and scrambled sentences, $t(47) = 2.76$; $p < .01$, but not in language-unspecific sentences, $t < 1$. Correspondingly, switch costs in language-unspecific sentences were significantly different from those in language-specific sentences, $t(47) = 2.05$; $p < .05$, and scrambled sentences, $t(47) = 2.48$; $p < .05$, whereas there was no significant difference between the switch costs obtained in language-specific sentences and scrambled sentences, $t < 1$. These results indicate that switch costs are smaller in a language-unspecific sentence than in a language-specific sentence or a scrambled sentence. It also indicates that there were no switch costs in language-unspecific sentences, which provides evidence that language switch costs can be abolished in a sentence context.

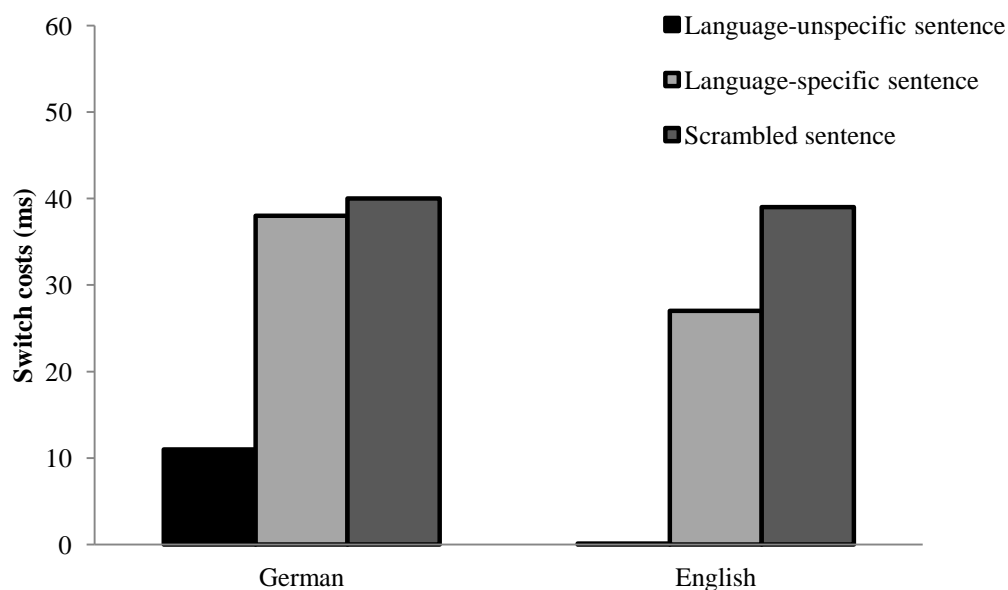


Figure 1. Switch costs (in ms) as a function of sentence type (language-unspecific sentence vs. language-specific sentence vs. scrambled sequence), and language (German vs. English).

Discussion

In the present study we investigated whether language switching would be influenced by a sentence context. The task required German-English bilinguals to alternate between languages within a syntactically structured sentence or within a scrambled sentence. The

results revealed smaller switch costs in syntactically structured sentences than in a scrambled sequence of words. However, this was only the case for language-unspecific sentences (i.e., sentences that were syntactically correct in both languages), not with language-specific sentences (i.e., sentences which were syntactically correct in just one of the two languages). Interestingly, switch costs in language-unspecific sentences were not only smaller than in language-specific and scrambled sentences, but were not even significant.

In the following, we first discuss how smaller switch costs could be elicited in a sentence context, which will be followed by a discussion on the consequences of our findings for language switching in a natural setting (i.e., code-switching).

The influence of a sentence context on language switch costs

The main finding of the current study was the difference in switch costs across sentence types. This finding clearly suggests a critical role of the sentence context for the size of language switch costs. Yet, one might argue that a difference in switch costs between language-unspecific, language-specific and scrambled sentences might not be due to the sentence type per se but because a correct sentence (i.e., language-unspecific sentence) has a meaning, which is less so in language-specific and scrambled sentences. The meaning of the language-unspecific sentences might have decreased switch costs, since it makes the concept sequence easier to remember, and thus decreases working memory load. Previous studies have shown that a decrease in working memory load could result in smaller switch costs (Declerck, et al., 2013, in press).

To be sure that a difference in working memory load, due to the meaning of sentences, did not cause the switch cost difference in the current study, we conducted a control experiment with sixteen participants. The set-up of the control experiment was similar to the experiment presented above. The only difference was that participants had to switch languages using a concept sequence that constituted a sentence that was syntactically correct in both languages (i.e., language-unspecific sentence), but made no semantic sense (my coat

has big chairs (English) / mein Mantel hat große Stühle (German) OR your Tuesday loves fast spoons (English) / dein Dienstag liebt schnelle Löffel (German); counterbalanced across participants). These language-unspecific sentences were contrasted against scrambled sentences that made no syntactic or semantic sense (fast loves Tuesday spoons your (English) / schnelle liebt Dienstag Löffel dein (German) OR big has coat chairs my (English) / große hat Mantel Stühle mein (German)). The results showed that no switch costs were observed in the language-unspecific sentences and, thus, were smaller than those observed in the scrambled sentence ³, which provides evidence that the difference in switch costs observed in the present experiment was not due to the meaning of the sentence and consequently was not due to working memory load.

A more probable explanation for the switch cost difference found between language-unspecific, language-specific, and scrambled sentences revolves around a difference in lemma interference, since previous studies have shown that there is a difference in lexically driven lemma activation (i.e., syntactic information guides the construction of a sentence through activating syntactically corresponding lemmas) between these sentence types. Hatzidaki, Branigan, and Pickering (2011) found that during language-specific sentence production, the sentence structures of both languages are activated. This entails that we can assume that there will be a general increase in the number of highly activated lemmas compared to language-unspecific sentences, both related to the correct sentence structure of the target language and the correct sentence structure of the non-target language. Hence, due to the differences in sentence structure between the target and the non-target language, more lemmas of the non-target language are activated in language-specific sentences than in language-unspecific sentences (in which the sentence structure is identical for target and non-target language). As a consequence, there would be a higher amount of language interference in language-specific sentences than in language-unspecific sentences.

According to the findings of Ivanova, Pickering, McLean, Costa, and Branigan (2012), lemma selection in syntactically incorrect sentences, like our scrambled sentences, is also lexically driven (see also Ivanova, Pickering, Branigan, McLean, & Costa, 2012). So, similar to language-specific sentences, lexically driven lemma activation would also lead to a higher amount of language interference in scrambled sentences than in language-unspecific sentences.

Taken together, both language-specific sentences and scrambled sentences should evoke a higher degree of language interference between lemmas. This is interesting since it is assumed that the aim of language control is to reduce language interference between translation-equivalent lemmas (e.g., Green, 1998). When more non-target language lemmas are activated, more inhibition will be needed to suppress their activation (e.g., Green, 1998; Philipp et al., 2007; Philipp & Koch, 2009). Thus, our results could be explained by assuming that increased activation of non-target language lemmas in language-specific sentences and scrambled sentences, due to lexically driven lemma activation, would result in an increase of inhibition and thus an increase in switch costs (Green, 1998; Meuter & Allport, 1999).

Alternatively, the difference in the size of switch costs between the sentence types may – at least partially - be caused by preparatory planning. Previous research on sentence processing has indicated that preplanning and thus preparation is an essential part of sentence production (Ford & Holmes, 1978; Gillespie & Pearlmutter, 2011; Lee, Brown-Schmidt, & Watson, 2013; Wheeldon, Ohlson, Ashby, & Gator, 2013). This entails that preparation processes are a common occurrence in a sentence context and thus might result in enhanced preparatory processes in language-unspecific sentences compared to language-specific and scrambled sentences. In turn, one might argue that enhanced preparatory planning in sentences reduces switch costs in a sentence context because language switch costs are known to be smaller due to preparation (Costa & Santesteban, 2004; Fink & Goldrick, in press) albeit preparation does not seem to abolish switch costs (Declerck et al., 2013; in press).

Evidence for the influence of preparatory planning further comes from language switching studies that implemented sentences. The study of Tarłowski et al. (2013), who found switch costs with sentences, had a relatively small preparation time of 375 ms. Gullifer et al. (2013) and the current study, on the other hand, found no switch costs in a sentence context with much longer preparation time (average of 3300 ms and 1200 ms respectively). Hence, it could be that language switch costs are reduced in a sentence context due to more effective preparation processes during sentence production.

Language switching in a natural setting

Since we demonstrated that a sentence context decreases language switch costs, our results provide, at least partially, an explanation why bilinguals may switch between languages during natural bilingual sentence production (i.e., code-switching). Yet, even though sentences were used instead of single, unrelated words in the present study, there are still a number of differences between the approach that was used in this study and natural code-switching. First, participants did not choose when to switch to another language (e.g., Gollan & Ferreira, 2009; for a review, see van Hell et al., in press). This is assumed to be important, as Green and Wei (2014), for example, proposed in a novel code-switching model that no switch costs should occur when a bilingual is in a language setting without any restrictions on which language to produce.

Another difference to natural code-switching is that the same sentence was repeated several times in the current study. Hence, practice effects might have reduced the switch costs to a higher extent. Similarly, the interval between the offset of a word and the onset of the next word was around 1200 ms, which is much higher than during natural language production. This entails that participants could have benefited from this additional time to prepare for the upcoming word and consequently could have led to smaller switch costs (Costa & Santesteban, 2004; Declerck et al., 2013, in press; Fink & Goldrick, in press). However, it is interesting to note that even with substantial preparation time and highly

practiced, predictable responses, switch costs were still observed in non-sentence sequences (e.g., weekdays and numbers in Declerck et al., 2013, in press). Therefore, these factors might have contributed to a reduction of switch costs but cannot explain the elimination of switch costs in language-unspecific sentences.

Finally, some of the language switches of the current study would not occur during natural code-switching according to some models (i.e., matrix language frame model; e.g., Myers-Scotton, 1993). More specifically, according to the matrix language frame model, functional words are typically produced in the first language and thus would not typically be switched to another language. To account for these ungrammatical code-switches, we reanalyzed the data by adding an additional variable, named code-switch type (grammatical vs. ungrammatical code-switch)⁴. This reanalysis showed that code-switch type did not significantly interact with language transition, $F < 1$, and that the influence of ungrammatical code-switches on the switch cost difference across sentence types was not significant, $F < 1$. The latter result indicates that the switch cost difference between the sentence types was not modulated by whether the code-switch was grammatical or not in terms of the matrix language frame model.

Even though these differences indicate that the switch costs found in the current study might not be a perfect representation of the potential switch costs found in natural bilingual language production, the reduced switch costs found in the context of a syntactically correct sentence demonstrate that the cost to switch between languages might not be that high during natural bilingual language production. Moreover, the results of the experiment and the control experiment even demonstrated that switch costs could be abolished when implemented in a language-unspecific sentence context (see also Gullifer et al., 2013). Further evidence for small performance costs when switching between languages in sentences comes from studies that show that language switching occurs even though the bilingual participants were instructed to produce speech in one particular language (Gollan et al., 2011; Poulisse, 2000;

Poulisse & Bongaerts 1994). This indicates that switching languages could be fairly easy during natural bilingual language production.

Yet, the results also reveal that the benefit of language switching due to a sentence context is not applicable for all sentence types. More specifically, language-specific sentences do not provide a beneficial context for language switching, but only for language-unspecific sentences. This finding is in line with the equivalence constraint of code-switching (Sankof & Poplack, 1981), which assumes that code-switching mainly occurs when there is syntactic convergence between the two languages (i.e., language-unspecific sentences).

Conclusion

In sum, the present study revealed that language switching in a sentence context can reduce or even eliminate switch costs, since smaller switch costs were found in language-unspecific sentences than in scrambled sentences. This led to the conclusion that either less language interference occurs within a sentence and/or that active preparation processes are more effective in a sentence context.

Notes

¹ However, no switch costs were observed when participants had to produce 50% of the trials in either language (Gollan & Ferreira, 2009, Experiment 2).

² A t-test indicated that word frequency was not significantly different between the sentence types, $t < 1$.

³ An ANOVA with sentence type (language-unspecific sentence vs. scrambled sentence), language (German vs. English) and language transition (switch vs. repetition), revealed a significant interaction between sentence type and language transition, $F(1, 15) = 5.05$; $p < .05$; $\eta_p^2 = .252$, with larger switch costs during the scrambled sentences (40 ms) than during the language-unspecific sentences (3 ms). Separate t-tests revealed that switch trials were significantly different from repetition trials in the scrambled sentences, $t(15) = 2.74$; $p < .05$, but not in the language-unspecific sentences, $t(15) = 0.58$; ns..

⁴ We did not include the variable language (German vs. English) in this analysis, in order to keep an acceptable amount of observations per cell.

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Appendix.

Complete list of sequences used in the control experiment.

	Concept sequence A	Concept sequence B
Language- unspecific sentence	dein Dienstag liebt schnelle Löffel (German) your Tuesday loves fast spoons (English)	mein Mantel hat große Stühle (German) my coat has big chairs (English)
Scrambled sentence	schnelle liebt Dienstag Löffel dein (German) fast loves Tuesday spoons your (English)	große hat Mantel Stühle mein (German) big has coat chairs my (English)