Exploring the role of work-related language-switching experience and different tasks for language-switch costs:
An empirical study in the laboratory and within international companies

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Summary

As the world globalizes more and more, English has become very important in many areas of life. This is the reason why also many companies adopted English as their corporate language to make international work easier. Consequently, we often are unexpectedly forced to switch between our native language and English. Current theories agree that language switching is linked to mental effort and higher control activities (e.g. Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001) due to parallel activation of the two languages of a bilingual (e.g., Green, 1998). This parallel activity between languages is assumed to be solved via inhibition of the non-target language (Green, 1998).

This work at hand investigates two research fields concerning language switching that are rather unexplored until today. First, language-switching performance is compared between language production and language reception tasks by testing the same participants in both tasks. Secondly, the language-switching performance of participants with work-related language-switching experience is compared with participants that were not experienced in language switching.

In seven experiments participants switched between German (first/mother language = L1) and English (second learned language = L2) in different production and reception tasks. In Experiment 1 bilinguals participated in a productive digit-naming task and a receptive digit-categorization task. Results showed switch costs in both tasks, indicating slower reaction times (RTs) in switch trials (alternating languages within two consecutive trials) compared to no-switch trials (same language within two consecutive trials). Yet, switch costs were larger in the production than in the reception task. Besides that, participants
inhibited their L1 generally (i.e., slower responses in L1 than in L2) in the production task. To exclude the assumption that results were influenced by dissimilar tasks in Experiment 1, in Experiment 2 the production and reception tasks were made more comparable to each other (both tasks contained categorization). However, participants again showed larger switch costs in production than in reception. For the production task, no general inhibition of L1 was found. Experiment 3 served as a control experiment to show that the general inhibition of L1 in Experiment 1 was not caused by a different speech onset between L1 and L2 stimuli in Experiment 1 in contrast to Experiment 2. Rather, it is suggested that participants raise their activation threshold in L1 to prevent premature responses in easy production tasks. Experiment 4 contained a productive direct-naming task and a productive digit-categorization task. Results supported the idea of a general inhibition of L1 to prevent easy responses. Again, switch costs were found in both tasks. Experiment 5 investigated whether easy reception tasks also cause participants to inhibit their L1 generally. Participants were tested in a number-reception task as well as in a category-reception task. Switch costs were found in both tasks. However, a general inhibition of L1 was found in neither task. Experiment 6 and 7 concentrated on comparing the performance difference between participants that were experienced in language switching with those that had no experience. Contrary to expectation, results were similar between the two groups of participants. That is, employees with work-related language-switching experience still showed substantial switch costs.

The theoretical contribution of this work at hand lies in showing that language-switch costs which occur in different experimental settings and for participants with different language-switching experience are a robust empirical marker.
However, the size of switch costs seems to depend on the type of task as results of this work showed that switch costs were larger in production compared to reception tasks (concerning RTs and error rates). This is interpreted in terms of an influence of the different input and output modalities as well as a higher between-language interference when participants switch languages in production contrary to reception tasks. Furthermore, other empirical markers in language-switching studies depend on the specific task requirements. For instance, it is suggested that a general inhibition of the dominant language occurs only in easy tasks in which a response in either language is required (e.g. direct-naming production task).
Part I

Introduction and Theory
Chapter 1: General introduction and overview

Due to today's globalization English is a dominant language in many areas of life. We are constantly confronted with English words, slogans, and conversations. For example, on television some commercials are presented in the native language while others are in English. This leads to the fact that we switch spontaneously back and forth from our native language to English. Also many companies adopted English as their corporate company language to be able to work internationally and expand operations into other countries all over the world. This brings about a language problem since not all employees are able to speak English professionally. Next to this and even more important for this work, employees are permanently forced to switch between their native language and English.

Just recently the decision was made on one of the largest psychological research conferences in Germany - the TeaP (Tagung experimentell arbeitender Psychologen) - to change the official conference language from the country language German into English (Teap, n.d.). This means that presentations will be held in English in most of the cases although most participants are German native speakers. The circumstance that participants are German leads to a language-switching problem. That is, presentations are in English; however, conversations between the participants of the conference will be carried out in German. This implies that people have to switch between English and German a lot. There might be a lot of problems arising with this circumstance.

The present study aims at exploring this language-switching ‘problem’. A language-switch can occur in language production and in language reception. In
other words, a person can switch between languages while *producing* language (e.g. say a word in English and then in German) or while *receiving* language (e.g. listen to English and German words). However, the examination of possible differences between switching in language production versus language reception has been neglected so far. Furthermore, the language-switching performance of persons that have a lot of experience in language switching, like employees working in international companies, has never been researched before. Thus, the present study explores these two fields of research – first, whether there is a difference between language switching in language production versus language reception and, second, whether language-switching experience has an effect on the performance in language switching.

In the following, a short overview on the contents of this work is given. Before describing the empirical findings of this study, a thorough theoretical treatment of the language-switching topic is given. The theoretical section starts with a general introduction about research on bilingualism. Next, a more specific introduction is given into the research on language switching. Then, two influential models of bilingual language processing are introduced and compared, followed by presenting differential aspects of language switching. That is, an introduction into language switching in language production and language reception is given. This section is followed by a focus on the effect of language-switching experience on switch costs. Finally, the last section of the theoretical part presents a short description of the main goal of the present study.

The empirical section includes seven experiments that examine language-switching performance in different language-switching tasks. The section is
divided into two experimental parts. The first experimental part focuses on the difference between switching performance in language production versus language reception tasks whereas the second experimental part tests whether participants that are proficient in language switching show better switching abilities than participants that have no experience in language switching.

In the final section of this work, the main results of this study are summarized and discussed by putting them into context with findings of related studies by other researchers. Furthermore, theoretical accounts are discussed. Finally, open issues as well as limitations of this work conclude this work at hand.
Chapter 2: Research on bilingualism

2.1 General research on bilingualism

Until recently the understanding of the representations and the use of a single language (Abutalebi & Green, 2007) was investigated in research. Some years ago the topic of bilingualism was not a major research topic. However, due to the global economy and the increasing multilingual presence everywhere the interest in approaches to bilingualism has grown (Kroll & De Groot, 2005). For example, 1500 million people speak English next to their mother language (Weltsprachen, n.d.). Furthermore, the awareness that research on bilingualism provides methods to uncover constraints within the cognitive architecture, has drawn attention to this research field. Consequently, lately there has been an enormous increase in the activity within this field. Today there are numerous papers, books, and conference meetings concerning the research on bilingualism. In comparison to other research topics (for instance the ‘mental lexicon’) the development within the research field on bilingualism has been much more rapid within the last years (Kroll & De Groot, 2005).

Over the past years there has been a special interest in exploring the way in which more than one language is represented and processed in a bilingual’s mind (Abutalebi & Green, 2007). The representation of two languages in a bilingual’s mind should make lexical selection more difficult than for monolinguals (French & Jacquet, 2004). Therefore, monolingual language models fail to explain bilingual-language behavior and a bilingual speaker should not be considered as the sum of two monolingual speakers. It is widely assumed that words in different languages compete for selection and bilinguals face the
problem of resolving such competition (e.g., Green, 1998). Therefore, researchers were especially interested in finding out how bilinguals are able to speak one language without intrusion of the other one.

General cognitive studies with bilinguals showed that bilinguals’ ability to ignore irrelevant stimuli and select goal-relevant information is enhanced. Bilinguals seem to have cognitive advantages compared to monolinguals as bilinguals need to pursue a stronger maintenance of goals in their working memory (Colzato et al., 2008). Researchers explained these discoveries by the circumstance that bilinguals constantly need to keep two languages separated (see, e.g. Hernandez et al., 2001). To use one language, the other one must somehow be ‘neglected’.

2.2 Research on language switching

In the past years there has been a lot of research in order to explore the mechanism that enables bilinguals to restrict their lexicalization process to only one language. In order to do so, researchers concentrated on conducting studies in which bilinguals were asked to switch between two languages. These so called language switching studies provide most of the evidence (next to the picture-word interference paradigm) about the nature of bilingual language selection (Costa, Santesteban, & Ivanova, 2006). Language-switching studies typically contain a simple production task. In these tasks participants are asked to name, for instance, digits, pictures, or other stimuli in either their L1 (first/mother language) or their L2 (second learned language). The language switch happens either voluntarily or involuntarily. In the latter case the language in which the participant should switch to is indicated by a cue (for instance a colored rectangle). There
are different trials in a language-switching study that can either be defined as no-switch trials or switch trials. In no-switch trials the response language remains the same within two consecutive trials whereas in switch trials the response language alters from the previous to the current trial. The difference between reaction times (RTs) in switch and no-switch trials in each language is referred to as switch costs (Meuter & Allport, 1999).

Based on these language-switching studies, researchers developed bilingual language-processing models to explain how bilinguals are enabled to select only one language. Two prominent models will be introduced in the following.
Chapter 3: Bilingual language-processing models

There are several ways to explain how bilinguals are able to choose one out of two languages. Some models favour the idea of language-selective access - both languages are active within bilinguals and only one language is selected (e.g., Costa et al., 2006; Schwieter, 2007). However, such an assumption was questioned as later empirical work demonstrated that bilinguals can be distracted by the non-selected language that apparently was ignored (Green, 1998). Furthermore, special studies on language switching with bilinguals showed that language switching results in costs (switch costs) for a person’s RT and error rate (see, e.g., Kroll, Bobb, Misra, & Guo, 2008; Meuter & Allport, 1999; Philipp, Gade, & Koch, 2007). Therefore, the general view at present favors a non-selective access and asserts a crucial role to inhibitory mechanisms in language switching. That is, it is assumed that both languages are activated in parallel to each other. But this parallel activity creates competition that has to be resolved. Therefore, researchers assume that one language can only be selected by inhibiting the other one (e.g., Green, 1998). This view can actually explain the appearing switch costs (see also Price, Green, & von Studnitz, 1999). In the following, two models are discussed that represent one type of each view. First, the language-specific selection model is discussed that prefers the view of language-selective access; and later in the chapter the inhibitory control model is introduced - which favors non-selective access.
3.1 Language-specific selection hypothesis

A prominent example of a language-specific selection view has been proposed by Costa (2005; see also Costa, Miozzo, & Caramazza, 1999; Costa et al., 2006). Costa (2005) assumes that the semantic system activates lexical entries in both languages parallel to each other during speech planning. However, the languages do not compete for selection as the intention to speak one language is sufficient to select only one of the two languages. That is, only the activation levels of the lexical nodes of the desired language are considered by the specific selection process (Costa et al., 1999). To be able to select the desired language, lexical representations must be integrated into a lexicon and marked for the language they belong to (Costa et al., 2006). The most highly activated lexical node in the target language is chosen. It is assumed “that lexical selection is sensitive to lexical properties” (Costa et al., 2006, p. 1058). The only words selected are those that match the grammatical category of the desired word. The selection process depends on the activation levels of other lexical nodes. The greater the difference between the strength of activation is, the easier it is for the system to select the target node. This selection process does not rely on inhibition as competition occurs only within but not between languages.

The idea that lexical selection is language specific was tested in a picture-word interference paradigm. Costa et al. (1999) found that bilinguals name pictures (e.g. picture of a table) that are accompanied by the picture’s name in the non-target language (i.e. “Tisch” - German word for table) faster than when the picture was accompanied by a distracter word that was semantically related (e.g., “chair”) in the target language. The word “Tisch” was activated and facilitated the
response of the word “table” since the lexical selection mechanism only regarded the lexicon programmed for response (in this case English). If the distracter word was a semantically related word in the same language, interference occurred because selection of the target word was much harder since there were two lexical nodes activated in the same language that competed for selection. These results indicate that the activation of the word in the non-target language facilitated responding in the target language. The authors stated that this between-language facilitation effect must be interpreted in terms of a model that assumes that only one of the two languages is considered for selection.

The between-language facilitation effect has been replicated in other studies (e.g., Costa & Caramazza, 1999; Hermans, 2004). However, the interpretation of this effect in terms of a language-specific selection hypothesis is under dispute. Some researchers (see especially Hermans, 2004) argue that this effect cannot be solely interpreted in terms of language-specific selection, but also in terms of a language non-specific selection account. Hermans (2004) found that the presentation of the picture’s name in the non-target language facilitates the phonology of the naming of the picture through translation. That is, the picture’s name in the non-target language activates the phonological representation of their translation equivalents. Consequently, this phonological contribution to the between-language facilitation effect might have caused the faster response latencies. According to this interpretation, the non-target language is, yet, also considered for selection.

There is further empirical evidence that poses a challenge to an interpretation in form of language-specific selection. Costa and Caramazza (1999) tested bilinguals by asking them to name both the picture’s name and the distracter
word in a picture-word interference paradigm. Results showed that the identical
distracters in the other language now produced inhibition instead of facilitation.
That is, in this experimental switch situation participants showed slower RTs as
soon as the distracter word was the same word in the other language as the
target picture. Before, Costa and Caramazza (1999) had argued that this
situation facilitates responses in contrast to the same language condition in which
the distracter word was a semantically related word in the same language (see
above). The authors concluded that, possibly, the language-selection mechanism
is incapable of a complete switch between languages. Furthermore, the authors
admit that it is unclear at which point in second language learning the mechanism
of specific selection becomes active. At a very early stage of language learning it
is speculated that language selection is not specific and bilinguals need to revert
to inhibition of the non-target language because competition between the two
languages can be hardly avoided. Later, Costa and Santesteban (2004b) stated
that especially highly proficient bilinguals succeed in only activating the words
belonging to the intended language and not having to suppress words belonging
to the other language. Schwieter and Sunderman (2008) restrict this assumption
even more by arguing that bilinguals are not able to rely on language-specific
control before they reach a particular level of L2 lexical robustness. The authors
note that L2 lexical robustness is a specific form of L2 proficiency and that both
terms are not interchangeable. The authors further claim that bilinguals have to
reach a specific threshold of L2 proficiency to gain L2 representation strength and
the ability to access L2 lexical items to reach this lexical robustness. As soon as
this is achieved, bilinguals should have the ability to select one language without
being hindered by the other one. However, Schwieter and Sunderman (2008)
also mention that bilinguals revert back to inhibitory mechanisms to restrict their lexicalization process to one language in situations in which language-specific selection may not work and that further research is needed to explore this.

Kroll, Bobb, and Wodniecka (2006) go even further and support the notion that language-specific selection is used only in specific situations. However, in most of the situations there seems to be an influence of the non-target language and the bilingual has to negotiate the competition between languages. The authors finally state that competition for selection is the rule and that selective lexical selection is the exception.

All in all, results show that that there seem to be numerous restrictions to the language-specific selection hypothesis. It is still unclear under which circumstances bilinguals can rely on language-specific selection. In the following section a language-non-specific selection account is introduced that might account for a broader range of empirical findings.

3.2 The Inhibitory Control Model

The Inhibitory Control Model (ICM) is a very influential model by Green (1998; see also Green, 1986) and is opposed to the language-specific selection hypothesis. The ICM favors non-specific language selection. Green (1998) assumes that there is cross-language activity and that languages compete for selection. The basic idea of the model is that the selection of one language can only be supported by inhibiting the non-target language. In other words, to be able to speak one language, the lemmas of the target language must be active
and selected and, additionally, the lemmas of the non-target language must be inhibited. This inhibition occurs after the activation of the lemmas that are linked to active language concepts. Accordingly, in a language-switch situation the effects of prior inhibition have to be overcome to select the target language. Besides that, those language lemmas of the non-target language that were previously active have to be inhibited now. The process of overcoming inhibition takes time and results in longer RTs and more errors (i.e. switch costs) than when a person uses the same language again. Therefore, switch costs can be defined as an empirical marker for inhibition in terms of Green (1998).

Green (1998) further asserts that inhibition is reactive. The strength of inhibition is dependent on the strength of activation. This means that the language that is more activated needs stronger inhibition in order to select the weaker language. Consequently, asymmetrical switch costs are predicted to arise in language-switching studies (see Figure 1). Asymmetrical switch costs are a combination of slower response latencies in the more dominant language and faster response latencies in the weaker language in switch trials. In a German (L1)/English (L2) switch task, participants usually respond faster in German if there is no switch. But in a switch trial the L1 is more inhibited than the L2 since L1 is more dominant. Therefore, it should be easier to switch into the less dominant language due to reactive inhibition than to switch into the stronger language. The more similar the strength between the two languages in a switch task is, the less asymmetrical is the expected response pattern as switch costs should be more similar in both languages (Green, 1998). Besides that, switch costs in general might be smaller as the higher switch costs for the dominant language are
diminished. That is, the dominant language needs less inhibition than when the two languages are dissimilar in their strength. This might reduce switch costs.

Figure 1. Asymmetrical switch costs in a productive language-switching study shown by Meuter and Allport (1999).

With reference to the issue of this work at hand it should be noted that constant switching between languages should lead to a more similar dominance of both languages. That is, when a person has to switch between L1 and L2 very often, L2 should be improved automatically as it is used frequently. Consequently, the dominance difference between L1 and L2 is reduced. According to Green (1998) this should result in less asymmetry and possibly smaller switch costs than when the dominance of the two languages is very different.

There are several experimental studies that provide evidence for Green’s idea of an inhibitory mechanism in language selection. For example, Meuter and Allport
(1999) tested the proposal of cross-language competition and the inhibition involved by asking bilinguals to name digits in either their L1 or L2 rapidly, cued by a colored background. They found that the RTs in switch trials were slower than in no-switch trials. Furthermore, the authors reported asymmetrical switch costs which they explained by means of an inhibitory mechanism in which L1 is inhibited more strongly to allow production in the weaker L2. This is in line with predictions made by Green (1998).

Gollan and Ferreira (2009) also found inhibitory mechanisms in their language-switching task in the form of longer RTs for switch trials compared to no-switch trials. The task was to switch voluntarily between L1 and L2 during picture naming. However, bilinguals showed a symmetrical switch-cost pattern instead of an asymmetrical pattern. The authors argued that the asymmetry of the language-switch costs per se does not uncover the type of lexical selection that is used. That is, bilinguals showed lexical inhibition in their study. Therefore, the lexical selection type was language-non-specific selection combined with inhibition but no asymmetry.

Another study that was conducted by Wodniecka, Kroll, Bobb, and Green (in preparation; as cited in Kroll et al., 2008) used a different method (i.e. a competitor priming paradigm; see also Lee and Williams (2001) for further evidence in a competitor priming paradigm) to investigate the relationship between inhibition and the presence of asymmetry in the switch pattern. The authors’ motivation was to show that inhibitory mechanisms are processed albeit switch costs are symmetrical. Wodniecka et al. (in preparation; as cited in Kroll et al., 2008) demonstrated that participants made use of inhibition independent of the asymmetry or symmetry of the switch-cost pattern. That is, both balanced and
unbalanced bilinguals were subject to inhibitory processes as they showed longer RTs in switch trials compared to no-switch trials. These results again show that inhibition as suggested by Green (1998) is obligatory in language switching. However, the occurrence of an asymmetrical response pattern is not consistent and does not necessarily give information about whether inhibition is used or not.

Evidences for inhibitory mechanisms according to Green (1998) reported so far were all found in productive language-switching tasks. However, there are also results that support Green’s (1998) idea of cross-language lexical competition in receptive language-switching tasks. According to Dijkstra (2005), a review of empirical studies showed that words from the non-target language often are activated when bilinguals read texts. The author further notes that evidence for language non-specific lexical access was found for different stimulus material. For instance, Beauvillain and Grainger (1987) showed cross-language effects in a lexical decision task. Participants were influenced by interlingual homographs (words with two different meanings for one graphemic form common to two languages) presented as primes in the non-target language (i.e. French) that were related in their English reading to the target word presented in English. The authors (Beauvillain & Grainger, 1987) noted that participants still considered the meaning of the word in English although they were told that it is a French word. That is, access to the non-target language was not blocked and the prime activated lexical representations in both languages. Therefore, participants responded faster when the homograph presented as a French word was related in the English reading to the English target word than when it was not related. The authors conclude that the results reveal interference between the two
language lexicons which supports the notion that lexical access of a bilingual seems to be non-selective.

Physiological evidence for inhibitory mechanisms in a receptive language-switch situation was provided by Jackson, Swainson, Mullin, Cunnington, & Jackson (2004). The authors tested bilinguals in a parity judgment task using ERPs as well as behavioral data. Results of the event-related potential (ERP) data were interpreted in terms of language inhibition, which indicates that the lexical selection mechanism was language non-specific. The behavioral data supported this notion by showing longer RTs in switch trials than in no-switch trials (on average). These results are compatible with Green’s (1998) ICM of language switching.

There are also other brain imaging studies that give indirect evidence for inhibitory control involved in language switching. For example, Wang, Xue, Chen, Xue, and Dong (2007) scanned participants while they were switching between languages in a picture-naming task. Results showed that the frontal cortex elicited greater activation bilaterally during language switching than during language non-switching (see also Hernandez, Martinez, & Kohnert, 2000). Note that researchers agree that the frontal cortex is involved bilaterally in general executive functioning and that inhibition is a form of executive functioning.

In sum, the results of each of these studies, using different tasks, provide evidence for the inhibitory mechanisms suggested by Green (1998) to solve the competition between languages. However, concerning asymmetry, empirical results seem to be divergent. Although some authors assume that only the asymmetry is an empirical marker for inhibition, the author of this work
hypothesizes that longer RTs in switch trials compared to no-switch trials per se provide evidence for Green’s inhibitory mechanism as this shows that the non-target language is inhibited while the target language is in use. In the following section the main difference between both models just introduced will be described to oppose the two models to each other.

### 3.3 Comparison between the two models

The most important difference between the language-specific selection hypothesis and the ICM is that, according to the first view, the bilingual is functionally a monolingual for the purpose of speech planning (Kroll et al., 2006). That is, lexical competition does only take place between alternatives within the target language (Costa & Caramazza, 1999). The ICM, however, assumes lexical competition between the two languages. The production of speech according to the first view is achieved by selection of the target language without intrusion of the non-target language whereas according to the latter view, selection of the target language is only possible by means of inhibition of the non-target language.

The following illustration (see Figure 2) is intended to further clarify the difference between both models.
Figure 2. A schematic depiction of the different lexical selection mechanisms according to the language-specific selection hypothesis (left) versus the language non-specific selection hypothesis (right) taken from Costa and Caramazza (1999). This figure presents the effect of the picture word interference paradigm (see above). Note that the arrows indicate activation.

In detail, the figure represents the picture-word interference paradigm. The participant’s task is to name the picture of a table in English. The parallel presentation of the picture’s name in the non-target language activates the phonological output of the non-target lexicon next to the phonological output of the target lexicon. However, according to the language-specific selection account (left side) only that lexicon that was intended by the speaker (in this case English) is regarded for response whereas the language non-specific selection hypothesis
(right side) inspects both lexicons for lexical selection. Therefore, the main difference between the models is based on the \textit{selection} of the output lexicon.

This crucial difference between the two models is that the latter view can predict phenomena that cannot be explained by the first view. For instance, bilinguals report that they accidentally code-switch between languages. This means that suddenly a word of the other language becomes active and comes to an output. This is at odds with Costa and Caramazza (1999) as they favor language-specific selection and state that the lexical nodes of the non-target language do not interfere with the selected target language. However, the ICM is able to explain this as the model assumes that both languages are activated and enable the person to choose one language by inhibiting the other one. But, still interference can take place if the suppressed lexical nodes suddenly become active by chance. Therefore, code-switching between languages is not ruled out.

To summarize, the ICM can explain findings that cannot be clarified by the language-specific selection theory. Consequently, the hypotheses of this work will be based on Green’s ICM and not on the language-specific selection hypothesis. In the next section, lexical selection mechanisms according to Green will be specified for language production and language reception.
Chapter 4: Differential aspects of language switching

4.1 Language production versus language reception

The cross-language activity that is assumed by the ICM appears to be persistent in both language production and language reception (Linck, Hoshino, & Kroll, 2008). Moreover, according to the model of Green (1998), language-switch costs should emerge in language production and in language reception tasks. In language production the target-language schema must dominate the non-target schema in order to allow word production in the target language. Thus, a successful switch requires inhibition of the previously active language schema. In language reception, switch costs occur because a switch implies that the language schema of the preceding trial must be inhibited in order to be able to respond to a word received in the target language of the current trial. Consequently, the basic mechanism that underlies switch costs - namely the inhibition of the irrelevant language schemas - appears to be comparable in language production and in language reception tasks.

In general, the focus of the ICM is on language production. However, the ICM also makes predictions for language reception. Please note that the Bilingual Interactive Activation (BIA) model (cf. Dijkstra & Van Heuven, 1998) makes similar assumptions as the ICM. Yet, the BIA is only a reception model as it focuses on bilingual word recognition whereas the ICM can be applied to language selection in reception and production. As this work focuses on language switching in production and reception, the underlying assumptions in this work at hand will be made based on the ICM (Green, 1998).
However, there might be differences in switching between languages in language production and language reception tasks that are based on differences in the processes of language production and language reception themselves. Indefrey and Levelt (2004) describe the core process of language production as follows. To generate a word the speaker activates a lexical concept and selects the corresponding lemma for expression. After this, the form encoding takes place. In the first stage of form encoding the speaker accesses the phonological codes for all the target word’s morphemes (morpho-phonological code retrieval). In the next stage the phonology is encoded; that is, syllabification and metrical encoding. In the third stage, the speaker turns the syllables into motor action instructions (phonetic encoding). Finally, the articulation occurs (see Figure 3). For the reception of spoken words, the processing stages are the other way round (it is only referred to spoken words as in the experiments within this work stimuli were presented orally in the reception tasks). Processing starts with the phonetic features of the spoken word. After analyzing the phonetic features, the segments of the word are converted into a lexical phonological input code. This input code leads to a lemma retrieval of multiple lemmas and, finally, to lemma selection of the target lemma. The target lemma activates the lexical concept as a last stage (Indefrey & Levelt, 2004; see Figure 4).
Figure 3. Schematic depiction of processing components involved in language production (derived from Indefrey & Levelt, 2004).
Language production and language reception can be assumed to interact in specific ways at different levels of processing. For example, Levelt, Roelofs, and Meyer (1999) assume that the production and reception networks “are shared from the lemma level ‘upwards’, i.e. for the lemma stratum and the conceptual stratum” (p. 110). Yet, though language production and language reception interact and share levels of processing, there are of course important differences. Whereas a lemma is bottom-up activated by perceptual input and activates its conceptual context in language reception, the lemma is actively selected by the speaker in language production. More specifically, in language reception the
chance that only those lemmas are activated that match completely or at least partially the input signal is much higher than in language production. Furthermore, the target language should be encoded in the input stimulus itself in language reception (Costa & Santesteban, 2004a). In language production, the speaker intentionally chooses top-down the target language and is able to exert control on the activation of the lemmas. Consequently, one could argue that cognitive control processes are quite different in language production and language reception (cf. Costa, 2005).

This difference in the processes of language production and language reception also might affect language switching in production and reception tasks. Due to Costa and Santesteban (2004a) one should be careful with making the same assumptions for language production and reception. Furthermore, Thomas and Allport (2000) note that language switching can be considered separately in production and reception. On the one hand, language switching in production tasks involves a switch in both language representations and language-specific motor-responses (Jackson et al., 2004), whereas language switching in reception tasks involves language representations only. On the other hand, in word production, the speaker has to choose not only between multiple lemmas but also between multiple lemmas in at least two languages, resulting in interference between languages. In word reception, the relevant stimulus is already presented in the relevant language so that the chance is much lower that lemmas of competing languages are activated. Thus, between-language interference is probably lower when switching languages in language reception tasks than in language production tasks. As a consequence, language switching in production tasks indeed seems to be more demanding and probably requires more cognitive
control than language switching in reception tasks. Similarly, the inhibition of irrelevant languages should be larger when switching between production tasks than when switching between reception tasks. Linck et al. (2008) also suggest that inhibitory control may be more critical in language production than in language reception. They explain this by the fact that in language production a person needs to select information actively, and, therefore, inhibition of non-target information is more necessary than in language reception.

The larger inhibition in production as compared to reception tasks could not only result in larger switch costs but may also affect the asymmetry between switch costs in L1 and L2. According to the ICM (Green, 1998), inhibition of irrelevant languages is reactive and depends on the activity of the corresponding language. The dominant L1, which is usually activated more, thus is also inhibited more strongly, resulting in larger switch costs in L1 than in the non-dominant L2 (cf. Meuter & Allport, 1999). Therefore, if inhibitory processes play a larger role when switching languages in production than in reception tasks, one would expect a switch-cost asymmetry with larger switch costs for L1 than for L2 in production tasks. In contrast, in language reception tasks, in which between-language interference is smaller, the asymmetry might be less likely to occur. However, it is important to take into account that switch-cost asymmetries appear to depend on many different factors like language proficiency or dominance difference between L1 and L2, so that specific predictions are difficult (see, e.g., Costa & Santesteban, 2004b). And, as stated above, asymmetry is not necessarily linked to inhibition as shown by several studies (e.g., Wodniecka et al., in preparation; as cited in Kroll et al., 2008).
Concerning research, most of the studies that examined language-switch costs so far used production tasks (see, e.g., Costa & Santesteban, 2004b; Meuter & Allport, 1999). For reception, there are only a few studies (e.g., Grainger & Beuvillain, 1987; Orfanidou & Sumner, 2005; Thomas & Allport, 2000) that explored language-switch costs. When comparing participants' performance between different experiments that used either production or reception to scrutinize language switching, it appears that switch costs are higher in production than in reception tasks. For example, Meuter and Allport (1999) found switch costs of 143 ms (L1) and 85 ms (L2) in their production task compared to 27 ms (L1) and 20 ms (L2) in Grainger and Beuvillain's (1987) reception task. Also Jackson, Swainson, Cunnington, and Jackson (2001) found switch costs of 102 ms (on average) in a production task study compared to switch costs of only 25 ms (on average) in Jackson et al.'s reception task study in 2004. However, it is difficult to compare the absolute size of switch costs across studies and there has not been any direct comparison between language-switching performance in production and reception tasks within participants.

So far, the first main issue of this work has been introduced. However, the present work focuses not only on differences in language-switching performance for production versus reception tasks, but also on differences in language-switching performance between participants that are experienced in language switching compared to those who are not experienced. In the next section this latter issue is introduced by demonstrating why this is an interesting field of research.
4.2 The effect of language-switching experience on switch costs

According to the ICM by Green (1998) inhibitory mechanisms should occur when switching between languages in production and reception. This should also be the case when a person is experienced in language switching. The reason for this is that the ICM states that language switching is only possible by inhibiting the non-target language. Yet, due to the ‘dominance-difference’ theory (see above) switch costs and the asymmetry should be smaller when a person is proficient in L2 due to constant language switching.

Authors like Colzato et al. (2008) assume that bilinguals compared to monolinguals have acquired a better ability in goal-maintenance. In detail, the constant exercise of keeping two languages separated leads to an enhanced ability to ignore stimuli that are not goal-relevant. Concerning the performance in language-switching studies, this enhanced ability in selecting goal-relevant information by persons that are used to switch between languages should lead to less inhibition and, consequently, to reduced switch costs. However, this is only a speculation. As far as the author of this work is concerned, there are no studies that directly tested participants who are experienced in language-switching. Moreover, there are no studies that compared the performance of participants that are experienced in language switching with those that are not experienced. To the author of this work this is a very interesting and important field of research. The crucial question is if the former group of bilinguals shows less switch costs than others or if switch costs are still robust no matter how experienced a person is.
This question should be interesting for international companies, especially, where numerous employees switch between two or more languages again and again every day. The need to switch between languages constantly arises from the fact that numerous international companies decided to change their corporate language from the nation’s language to English - the language that is spoken by the business world. International business deals are usually carried out in English. Besides that, mergers and acquisitions by international companies force the companies to change their corporate language. Therefore, employees should speak English most of the time. However, there are certainly many situations where they switch to their mother tongue to feel more comfortable and self-confident. These constant language-switching situations might cause costs the companies have never paid attention to. For example, employees might work more slowly and cause more errors after a language-switch. However, there is no research that can give an answer to this. According to Marschan-Piekkari, Welch, and Welch (1997, 1999) the language topic, in general, has almost been forgotten in companies and in academic research although it seems to become more challenging due to globalization. Moreover, Feely and Harzing (2004) note that the fact that the cultural problem can be a barrier in business processes is widely accepted. However, a much more basic problem – language – has been largely neglected. The authors further note that language is a very important issue in international company management (see also Feely & Harzing, 2002). Note that these authors pointed at the language problem in international companies in general (i.e., communication problems), but to the author of this work the language problem in international companies also includes problems that arise from the language-switch. However, all these factors related to the
language problem in international companies seem to be unexplored. This work at hand might give answers to the question if the constant language switching at work also poses a challenge to employees next to communication problems.
Chapter 5: Goal of this study

Concluding from these two missing or incomplete fields of research two main goals will be pursued in this work at hand. The first main goal of this study is to compare switch costs directly in language production and in language reception tasks. To do so, the same participants in language production tasks as well as in language reception tasks were tested. Results were to show language-switch costs in both types of tasks. Yet, the interesting question is whether the pattern of results is comparable across both types of language tasks. Thus, this study is intended to explore whether results observed with language production tasks (i.e. digit or picture naming) can be generalized across a wider range of language-related tasks.

The second goal of this study is to test whether language-switching results are comparable between participants that have either no or sufficient language-switching experience. By testing participants working in international companies the circumstance is given that participants are used to constant language switching. The question is whether experience of language switching leads to better switching performance compared to participants that are not used to constant language switching. Furthermore, the study aims at finding out whether participants that are used to language-switching still need to make use of inhibitory mechanisms or whether they are able to select only the target language. Results might be interesting for companies as switch costs could hinder normal work flow.
Part II

Empirical Part
Chapter 6: Overview of the experiments

The work at hand reports on seven experiments that are divided into two parts. The first experimental part comprises five experiments that focus on exploring the effect of the type of task on language switch-cost patterns. Experiment 1 contained a production as well as a reception task to find out whether switch costs are comparable between tasks. However, as there were slight differences between tasks - the production task was a direct-naming task whereas the reception task was a categorization task - Experiment 2 was conducted to compare switching performance in a production and a reception task in which the tasks were more similar. Both tasks in Experiment 2 required categorization. Experiment 3 served rather as a control experiment and established whether different results between Experiment 1 and 2 were caused by different speech onset between stimuli in L1 and L2. In Experiment 4 two production tasks were conducted that differed with respect to the specific type of task - one task included direct naming whereas the other task included categorization. The goal was to find out whether different types of production tasks (with respect to task difficulty) cause diverse patterns in a language-switching task. The same applies to Experiment 5. However, Experiment 5 tested two different reception tasks – one task was a numbering task whereas the other task asked for categorization. The goal was to test the role the type of reception task plays for the response pattern in language switching.

The second empirical part comprises two experiments - Experiment 6 and 7. These experiments were run to disentangle the effect of language-switching experience on switch-cost patterns. Both experiments included the same tasks as
used in Experiment 1. However, in contrast to participants of Experiment 1, participants of Experiment 6 worked in an international company where they were used to constant language switching. To present a direct comparison with employees that worked in an international company where language switching was not required, Experiment 7 was conducted. Thus, a comparison between participants with different language-switching experience was possible that gives information about the role language-switching experience plays for switch-cost patterns.
Chapter 7: Experimental Part I: Language switching in production versus reception

7.1 Introduction

Typical language-switching studies focus on production tasks to examine switch costs (e.g., Meuter & Allport, 1999). Language-switching studies that use reception tasks are rather rare. Nevertheless, it seems to be accepted that results obtained in production tasks are generally speaking and provide answers for performance after a language-switch. However, based on theoretical accounts that concentrate on comparing processes involved in production versus reception (see, e.g., Levelt et al., 1999, Indefrey & Levelt, 2004) one should conclude that results of language production studies cannot be generalized to language reception studies. Language switching in production seems to be more demanding and seems to call for higher control activities compared to language reception. Thus, it is suggested that language switching in production tasks is more difficult than language switching in reception tasks.

To provide evidence for performance differences in language switching in production versus reception studies, the following five experiments were conducted. Experiment 1 compared language switching in a direct-naming production task and a categorization task. In Experiment 2, the production and receptions task were more similar. That is, both tasks included a categorization task. Experiment 3 was conducted as a control experiment to find out that the difference between results of Experiment 1 and 2 was not due to confounding variables. The next experiment (Experiment 4) specifically concentrated on
performance in two different production tasks whereas Experiment 5 focused on the performance in two different reception tasks to further disentangle how the specific task type influences participants’ performance.

Results of these five experiments should provide evidence whether performance in production versus reception tasks differs and whether the specific task requirements influence response patterns in language-switching studies.

7.2 Experiment 1

In Experiment 1, participants switched between their dominant language German (L1) and their non-dominant language English (L2). Participants performed a language production task (i.e., digit naming) and a language reception task (i.e., digit categorization). In accordance with the ICM by Green (1998) switch costs are expected.

7.2.1 Method

Participants

Fourty-one German-English bilingual speakers participated in the experiment. Twenty-one were female, the others were male. Their ages ranged from 16 to 32 years. Participants were paid 6 € or received partial course credit for their participation. They were all native speakers of German and they reported that they had experience of speaking English as their L2. They learned English at school for at least five years ($M = 8.21, SD = 1.25$). Their mean self-assessment
score concerning their English skills was 5.22 ($SD = 1.01$) on a 7-point scale, where 7 was very good.

**Stimuli, tasks, and responses**

The stimuli were single digits ranging from 1 to 9, except 5. Both tasks were conducted using E-Prime (http://www.pstnet.com/eprime.cfm). In the production task digits were presented visually on a computer screen in the center of a colored rectangle measuring 21 x 13 cm. The font of the digit was Arial and the font size was 80. The color of the digit was black on a white background. The color of the rectangle was either red or blue and indicated in which language (L1 or L2) the participant was to produce the digit. Participants were instructed which color belonged to which language, an instruction sheet indicating the color-to-language mapping was located in front of each participant throughout the experiment. The participants’ task was to name the digit in the appropriate language depending on the color of the rectangle as fast and as accurately as possible. A microphone was placed right in front of the person that was used to record the person’s response. The correctness of response was coded manually by the experimenter.

In the reception task digits were presented auditorily. The digits were recorded in L1 and L2 via Audacity (http://audacity.sourceforge.net/) with a person who grew up multilingually in English, Dutch, and German. The auditory presentation of each digit had about the same length (500 to 600 ms), pitch, and volume. Stimulus onset for each digit was 50 ms. A colored rectangle in red or blue with a centered picture of a loudspeaker was presented on the computer screen simultaneously with the auditory presentation. Although a color cue indicating the
relevant language in each trial was not necessary for the reception task, this cue was used in order to keep the tasks as similar as possible. The color-to-language mapping for each participant was constant in both tasks but counterbalanced across participants.

In the reception task, participants had to categorize digits as smaller or larger than five by pressing one of two response keys. To record RTs the E-Prime serial response box (SR box) was used with five keys. The first key from the left was used for “smaller than five” and the last key from the left was used for “larger than five”. The participants’ response as well as the correctness of the response were recorded by the SR box/computer.

**Procedure**

Each participant took part in both tasks individually. Task order was counterbalanced between participants to control the confounding variable order effect.

Participants were seated in front of the computer screen of 33 x 25 cm at a distance of approximately 50 cm. Each experimental session (production task versus reception task) began with a practice block of eight trials. For the production task the practice block was also used to test the accuracy of the voice key. The main part of the experiment for each task (production versus reception) consisted of three experimental blocks with 96 trials each. Each of the three blocks had a unique sequence of 96 digits. Language switches and no-switches were unpredictably for the participant. Trial lists for the three experimental blocks in each experiment were generated randomly with the constraint that the same digit could not be repeated immediately in a sequence. The sequence of trials in
each block was controlled for an equal frequency of each language, digit, and transition (no-switch versus switch).

In each trial, the stimulus (i.e. visual digit in the production task, auditory digit in the reception task) was presented simultaneously with the color cue. The cue and the visual stimulus remained on the screen until a response was given. The interval between the response and the next cue/stimulus was 1000 ms in both tasks, independent of the correctness of the answer. In both tasks, RTs were recorded by the computer from stimulus onset until the triggering of the response.

**Design and Analysis**

In a first step, both tasks were analyzed individually. For these analyses, two within-subject independent variables were used: (1) language (L1 versus L2) and (2) transition (no-switch versus switch). In a second step, task (production versus reception) was included as a third within-subject variable to compare both tasks directly. RT and error rates were measured as dependent variables. In all experiments significance was tested at $\alpha = .05$.

Trials that fell into any of the following categories were excluded from the analyses: (1) the practice block, (2) the first two trials in each block, (3) RTs below 150 ms and above 1350 ms for the production task and below 150 ms and above 1150 ms for the reception task (i.e., 99th percentile each), and (4) errors and trials following an error (for RT analyses). For the production task errors were either defined by a production in the wrong language (4.8 %), of the wrong number (0.1 %), or an error that was due to the sensitivity of the microphone (0.9 %); for the reception task errors were false key presses (2.9 %). The percentage
of trials that had to be discarded was 17.2 % in the production and 11.0 % in the reception task.

7.2.2 Results of the production task

RT analysis

Mean RTs and error rates as well as standard deviations for no-switch and switch trials are shown in Table 1.

Table 1. Experiment 1: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the language production task.

<table>
<thead>
<tr>
<th></th>
<th>RT (in ms)</th>
<th></th>
<th>Error rates (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td>L1</td>
</tr>
<tr>
<td>Switch trials</td>
<td>669 (108)</td>
<td>655 (93)</td>
<td>9.0 (4.5)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td>611 (89)</td>
<td>603 (75)</td>
<td>4.9 (3.1)</td>
</tr>
<tr>
<td>Switch costs</td>
<td>58</td>
<td>52</td>
<td>4.1</td>
</tr>
</tbody>
</table>

A repeated measures analysis of variance (ANOVA) was conducted with the independent within-subject variables language (L1 versus L2) and transition (no-switch versus switch). The effect of language \((F(1,40) = 5.26, p = .03)\) and the
effect of transition \( F(1,40) = 84.63, p < .001 \) were both significant. That is, responses produced in L1 \( (M = 640 \text{ ms}) \) were slower than those produced in L2 \( (M = 629 \text{ ms}) \) and responses in no-switch trials \( (M = 607 \text{ ms}) \) were faster than responses in switch trials \( (M = 662 \text{ ms}) \). The two-way interaction of language and transition was not significant \( F(1,40) = .61, p = .44 \), indicating that switch costs for L1 (58 ms) and L2 (52 ms) were about the same size.

## Error analysis

The following error ANOVA was conducted with all types of errors (6.8 %). Please note that analyses for language errors only brought up the same results on average. In the error analysis, a similar pattern of results as in the RT analysis was found. Both, language \( F(1,40) = 20.64, p < .001 \) and transition \( F(1,40) = 46.93, p < .001 \) showed significant main effects. With reference to the variable language, participants produced more erroneous responses in L1 (7.0 %) compared to L2 (4.5 %). For the variable transition, less errors were made in no-switch trials (3.8 %) than in switch trials (7.7 %). A significant interaction between language and transition was not found; \( F(1,40) = .18, p = .67 \).

## 7.2.3 Results of the reception task

### RT analysis

An ANOVA was conducted for the independent within-subject variables language (L1 versus L2) and transition (no-switch versus switch). The results showed that the main effect language \( F(1,40) = 50.63, p < .001 \) was significant, indicating that participants reacted faster in L1 \( (M = 521 \text{ ms}) \) in contrast to L2 \( (M = 540 \text{ ms}) \);
see Table 2). As expected, the main effect transition \((F(1,40) = 69.60, p < .001)\) reached significance as well. The data pattern shows that responses in no-switch trials \((M = 523 \text{ ms})\) were faster than responses in switch trials \((M = 537 \text{ ms})\). The two-way interaction between these two variables was significant; \(F(1,40) = 4.13, p = .05\). That is, language-switch costs were larger for L1 (18 ms) than for L2 (10 ms).

**Error analysis**

The same ANOVA was conducted for error percentages. There was no significant difference between error percentages in L1 (2.8 %; see Table 2) and L2 (3.0 %); \(F(1,40) = .51, p = .48\). The variable transition was significant \((F(1,40) = 4.57, p = .04)\) and revealed less errors in no-switch trials (2.6 %) than in switch trials (3.2 %). The interaction between language and transition was not significant; \(F(1,40) = .25, p = .62\).

**Table 2.** Experiment 1: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the language reception task.

<table>
<thead>
<tr>
<th></th>
<th>RT (in ms)</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>530 (69)</td>
<td>545 (67)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>512 (70)</td>
<td>535 (65)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>18</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>(B) Error rates (in %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>3.1 (3.3)</td>
<td>3.4 (2.6)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>2.6 (2.4)</td>
<td>2.6 (2.4)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>0.5</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>
7.2.4 Comparison between production and reception task

To compare switching performance in the language production and the language reception task, analyses include three within-subject independent variables: (1) language (L1 versus L2), (2) transition (no-switch versus switch), and (3) task (production versus reception). Only those effects and interactions that include the variable task are reported.

The main effect of task was significant for RTs ($F(1,40) = 75.45, p < .001$) as well as for error rates ($F(1,40) = 42.68, p < .001$), demonstrating that participants responded more slowly and made more errors in the production task (RTs: $M = 635$ ms; errors: 5.7 %) than in the reception task (RTs: $M = 530$ ms; errors: 2.9 %). The interaction of transition and task was also significant for RTs ($F(1,40) = 42.16, p < .001$) and error rates ($F(1,40) = 25.73, p < .001$), indicating that switch costs were larger in the production task (RTs: 55 ms; errors: 3.9 %) compared to the reception task (RTs: 14 ms; errors: 0.6 %).

Results further showed a significant interaction of language and task for RTs ($F(1,40) = 29.92, p < .001$) and error rates ($F(1,40) = 20.14, p < .001$). That is, participants were slower and made more errors in L1 than in L2 in the production task, but in the reception task it was the other way round. The three-way interaction between language, transition, and task was not significant, neither for RTs ($F(1,40) = .02, p = .89$) nor for errors ($F(1,40) = .41, p = .53$).

To examine whether higher switch costs in the production task than in the reception task can be explained by the generally higher RT level in production versus reception, a post-hoc ANOVA was conducted in which relative switch costs were used as dependent variable with the RT in no-switch trials as baseline.
The ANOVA, then, was conducted with the within-subject independent variables language and task. The ANOVA revealed a significant main effect of task ($F(1,40) = 40.71, p < .001$), indicating that even relative switch costs were larger in the production task (9.0 % increase) than in the reception task (2.8 %). The main effect of language ($F(1,40) = 3.16, p = .08$) and the interaction of language and task ($F < 1$) were not significant.

### 7.2.5 Discussion

In contrast to former studies that tested either language production or language reception, Experiment 1 examined language switching performance with both types of tasks (production and reception) in order to compare performance directly within participants. Participants showed switch costs (for RTs as well as for errors) in the production as well as in the reception task. However, there were also differences between language switching in production vs. reception tasks. First, switch costs were larger in the production than in the reception task. Second, no switch-cost asymmetry in the production task but in the reception task (L1 > L2) was found. Finally, higher RTs and more errors in the dominant L1 than in the non-dominant L2 for the production task were observed, which are attributed to a general inhibition of L1 (cf. Christoffels, Firk, & Schiller, 2007). A comparable general inhibition of L1 could not be attested for the reception task.

The observation of generally higher switch costs in production than in reception tasks is in line with the visual inspection of previous studies (see, e.g., Meuter & Allport, 1999, vs. Grainger & Beauvillain, 1987). However, before discussing the results of Experiment 1 in more detail, it is important to note that the production
and the reception task were different, for example, with respect to the number of
response alternatives. Thus, a second experiment was conducted, in which
production and reception task were more similar.

7.3 Experiment 2

Although the production and the reception task were similar in terms of the timing
of trials, the stimuli, and the cues, there were two dissimilarities between tasks in
Experiment 1. First, the production task required direct naming whereas the
reception task required categorization of the digits. Consequently, also the
number of response alternatives differed between the production and reception
task. Whereas there were sixteen unique responses in the production task, there
were only two response buttons in the reception task.

The main goal of Experiment 2 thus was to compare language switching
performance between a language production and a language reception task in
which the number of response alternatives was the same. To obtain this, a
number categorization task with four response alternatives for both types of tasks
was used. In the production task, participants categorized digits orally as smaller
or larger than five in either L1 or L2. In the reception task, participants
categorized digits by pressing one of four response keys (corresponding to
smaller or larger than five in either L1 or L2).
7.3.1 Method

Participants

Participants were 28 native German speakers (13 female, 15 male) that were paid 6 € for participation or received partial course credit. They reported that they had experience of speaking English as their L2. Their ages ranged from 19 to 30 years. They categorized their English skills with a mean score of 4.68 (SD = .99) on a 7-point scale, where 7 was very good. Participants learned English at school for at least five years (M = 8.0, SD = 1.22).

Stimuli, tasks, and responses

Stimuli, tasks, and responses were the same as in Experiment 1 with the following exceptions: In the production task, participants categorized digits orally into “kleiner” (smaller) or “größer” (larger) than five in L1 or into “smaller” or “larger” than five in L2 instead of directly naming them. In the reception task, four keys instead of two were used: Two keys for L1 (kleiner and größer) and two for L2 (smaller and larger). To record RTs again the SR box was used. The position of the keys for L1/L2 was counterbalanced across participants so that L1 was on the left side and L2 on the right side for half of the participants and for the other half it was vice versa. The key for “smaller” was always the left one of the two keys and the key for “larger” was always the right one.

Procedure

The procedure was the same as in Experiment 1 except that in the production task the colored rectangle (cue) was presented 50 ms before the digit. In the reception tasks of Experiments 1 and 2 the onset of the digit was 50 ms after the
onset of the auditory presentation to avoid a noisy start. Therefore, the colored rectangle was visible for 50 ms on the computer screen before the digit was heard, whereas cue and stimulus onset were simultaneous in the production task of Experiment 1. To eliminate this slight difference between the production and reception task in Experiment 2, a 50 ms cue-stimulus interval (CSI) was used in the production task.

**Design and Analysis**

The design was the same as in Experiment 1. The following categories were again excluded from analyses: (1) the practice block, (2) the first two trials in each block, (3) RTs below 150 ms and above 1900 ms for the production task and below 150 ms and above 1800 ms for the reception task (i.e., 99th percentile each), and (4) errors and trials following an error (for RT analyses). Errors in the production task consisted of 2.1% production in the wrong language, 2.3% wrong categorization, and 3.0% due to the sensitivity of the microphone. In the reception task, errors were false key presses (4.7%). The percentage of trials that had to be rejected was 17.9% in the production task and 16.5% in the reception task.

**7.3.2 Results of the production task**

**RT analysis**

An ANOVA was conducted with the independent variables language (L1 versus L2) and transition (no-switch versus switch). Both the effect of language ($F(1,27) = 56.81, p < .001$) and the effect of transition ($F(1,27) = 156.16, p < .001$) were
significant. RTs were faster in L1 \((M = 774 \text{ ms})\) than in L2 \((M = 836 \text{ ms})\) and in no-switch trials \((M = 730 \text{ ms})\) compared to switch trials \((M = 879 \text{ ms})\). Also the interaction between these variables was significant \((F(1,27) = 27.89, p < .001)\), showing that participants had smaller switch costs in L1 (120 ms) than in L2 (178 ms).

**Error analysis**

The error ANOVA again was conducted with all types of errors \((7.2 \%; \text{ see Table } 3)\). As in the RT analysis, both variables language \((F(1,27) = 7.66, p = .01)\) and transition \((F(1,27) = 8.71, p = .01)\) showed significant effects. Participants showed less errors in L1 (5.8 \%) than in L2 (8.5 \%) and in no-switch trials (5.6 \%) than in switch trials (8.7 \%). The language by transition interaction was not significant; \(F(1,27) = .69, p = .41\).

**Table 3.** Experiment 2: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the language production task.

<table>
<thead>
<tr>
<th>(A)</th>
<th>RT (in ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
</tr>
<tr>
<td>Switch trials</td>
<td>834 (121)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td>714 (74)</td>
</tr>
<tr>
<td>Switch costs</td>
<td>120</td>
</tr>
<tr>
<td>(B)</td>
<td>Error rates (in %)</td>
</tr>
<tr>
<td></td>
<td>L1</td>
</tr>
<tr>
<td>Switch trials</td>
<td>7.0 (5.5)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td>4.7 (5.5)</td>
</tr>
<tr>
<td>Switch costs</td>
<td>2.3</td>
</tr>
</tbody>
</table>
7.3.3 Results of the reception task

RT analysis

An ANOVA was conducted with the independent variables language (L1 versus L2) and transition (no-switch versus switch). The analysis revealed that the effect of language was not significant; $F(1,27) = .08, \ p = .78$. The variable transition was significant ($F(1,27) = 46.36, \ p < .001$), indicating that RTs were again faster in no-switch trials ($M = 651 \text{ ms}$; see Table 4) than in switch trials ($M = 721 \text{ ms}$). Participants showed significantly smaller switch costs in L1 (57 ms) than in L2 (82 ms) which was attested by means of a significant interaction between the two variables language and transition; $F(1,27) = 5.01, \ p = .03$.

Error analysis

An error ANOVA showed no significant effects. Neither language ($F(1,27) = .79, \ p = .38$), nor transition ($F(1,27) = 3.47, \ p = .07$), nor the interaction between these variables ($F(1,27) = .01, \ p = .92$) were significant. Mean error rates as well as standard deviations for no-switch and switch trials are shown in Table 4.
Table 4. Experiment 2: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the language reception task.

<table>
<thead>
<tr>
<th>(A)</th>
<th>RT (in ms)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>713 (97)</td>
<td>728 (105)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>656 (91)</td>
<td>646 (77)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>57</td>
<td>82</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(B)</td>
<td>Error rates (in %)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>5.1 (3.3)</td>
<td>5.4 (4.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>3.9 (3.8)</td>
<td>4.4 (2.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>1.2</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.3.4 Comparison between production and reception task

The design for the following analyses was the same as in the first experiment. Again, only those effects or interactions are reported that include the additional variable task (production versus reception).

Again results showed slower RTs and more errors in the production task (RTs: $M = 805$ ms, errors: 7.2 %) than in the reception task (RTs: $M = 686$ ms; errors: 4.7 %) which was attested by a significant main effect of task (RTs: $F(1,27) = 62.55$, $p < .001$; errors: $F(1,27) = 14.11$, $p < .001$). Additionally, as in the previous experiment, the transition by task interaction was significant for RTs ($F(1,27) = 46.83$, $p < .001$), indicating that participants showed larger switch costs in the production task (149 ms) than in the reception task (69 ms). For error rates, this interaction was not significant; $F(1,27) = 2.79$, $p = .11$. 
The significant interaction between the variables language and task for RTs ($F(1,27) = 58.13, p < .001$) and error rates ($F(1,27) = 4.37, p = .05$) indicates that there was no difference between performance in L1 and L2 in the reception task, whereas responses in L1 were faster and resulted in less errors than responses in L2 in the production task. Furthermore, this interaction was qualified by the significant three-way interaction for RTs between language, transition, and task, $F(1,27) = 4.30, p = .05$, demonstrating that L1 was faster than L2 in both switch and no-switch trials in the production task as well as in switch trials in the reception task, whereas the data pattern was reversed in no-switch trials in the reception task. For error rates this three-way interaction was not significant; ($F(1,27) = .65, p = .43$).

Again, a separate ANOVA was conducted with relative switch costs (baseline: RT in no-switch trials) as dependent variable. This analysis revealed a significant main effect of task ($F(1,27) = 35.41, p < .001$), indicating that, as in Experiment 1, relative switch costs were higher in the production task (20.2 %) than in the reception task (10.8 %). Additionally, the main effect of language was significant ($F(1,27) = 24.24, p < .001$), demonstrating smaller switch costs in L1 than in L2. The interaction of language and task ($F(1,27) = 2.39, p = .13$) was not significant.

7.3.5 Discussion

To summarize the main results of the second experiment, participants again showed language-switch costs in both the production and the reception task. Yet, there was also a different switch-cost pattern for the production and the reception task. As in Experiment 1, switch costs were higher in the production than in the
reception task. Thus, it is supposed that language switching in production tasks generally leads to higher switch costs than language switching in reception tasks. This, most likely, is due to a higher between-language interference and more demand for control processes when switching languages in production as compared to reception tasks (cf. Costa, 2005).

With respect to switch-cost asymmetries, a rather unexpected pattern in both the production and the reception task was observed. That is, for both tasks the switch costs were smaller in L1 than in L2. Currently, there is no explanation for this finding but there will be speculations about it in the General Discussion.

In contrast to the first experiment, no general inhibition of L1 in the production task of Experiment 2 was found. That is, RTs and error rates were always better for the native language L1 as compared to the foreign language L2. It is suggested that this difference between experiments is based on the different nature of the production task (i.e. digit naming in Experiment 1 vs. digit categorization in Experiment 2). However, one might also argue that this difference between Experiment 1 and 2 was due to the fact that the speech onset of the stimuli in L1 versus L2 was different. That is, the L2 responses in the first experiment might have been recognized faster by the microphone than the L1 responses. In Experiment 2 it might have been vice versa. To exclude this assumption, Experiment 3 was conducted and serves as a control experiment.
7.4 Experiment 3

In Experiment 1, digit naming was performed more slowly in the dominant L1 than in the non-dominant L2. It is assumed that this finding, which did not occur in the language production task of Experiment 2, is due to a general inhibition of naming responses. However, one might argue that the pattern of results was caused by the fact that the speech onset of the stimuli in L1 versus L2 was different. That is, the L2 stimuli in the first experiment might have been recognized faster by the microphone than the L1 stimuli. In Experiment 2 it might have been vice versa. Experiment 3 was conducted to exclude this argument.

7.4.1 Method

Participants

Participants were 8 unpaid participants (7 women, 1 man), ages ranging from 22 to 33 years.

Stimuli, tasks, responses, and procedure

Stimuli were single digits and digit words (e.g., “one”) ranging from 1-9 except five as well as the words “kleiner”, “größer”, “smaller”, ”larger”. Stimuli were presented visually on a computer screen in the center of a black rectangle measuring 21 x 13 cm. The font of the stimuli was Arial and the font size was 80. The color of the stimuli was black against a white background.

The experiment consisted of three conditions. In the first condition (“digit condition”), participants were asked to name digits in L1 (one block of 24 trials)
and in L2 (one block of 24 trials). In the second condition (“categorization condition”), they named the words “kleiner” and “größer” (one block of 20 trials) and the words “smaller” and “larger” (one block of 20 trials). In the third condition (“number word condition”), participants read aloud number words in L1 and in L2 (one block of 24 trials for each language). The order of languages was counterbalanced across participants so that half of the participants started with a L1 block and the other half with a L2 block. The sequence of trials for each block was generated randomly with the constraint that the same stimulus could not be repeated immediately in a sequence. The stimulus remained on the screen until a response was provided. There was an interval of 1000 ms between a response and the next stimulus. RTs were recorded by the computer from stimulus onset until the triggering of the response. The response was given via a microphone that was placed in front of the person. The correctness of the response was listed manually by the experimenter.

**Design and Analyses**

For each condition, L1 responses and L2 responses were compared with paired two-tailed t-tests. The following categories were excluded from analyses: (1) the first two trials of each block, (2) RTs below 150 ms and above 2600 ms (i.e., 99th percentile), and, (3) errors and trials following an error (for RT analyses). All errors (3.0 %) except one were due to the sensitivity of the microphone. Therefore, an error analysis was not carried out. The percentage of trials that had to be rejected was 10.6 %.
7.4.2 Results and Discussion

Results showed that responses in L1 were faster than responses in L2 in the digit condition ($t(7) = 2.60, p = .04$) and in the categorization condition ($t(7) = 2.97, p = .02$). In the number word condition, the difference between L1 and L2 was not significant; $t(7) = .14, p = .89$. Mean RTs as well as standard deviations are shown in Table 5.

Table 5. Experiment 3: Mean response latencies and standard deviations (SD) in milliseconds in L1 and in L2 for each experimental condition.

<table>
<thead>
<tr>
<th>Condition</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit condition</td>
<td>454 (73)</td>
<td>493 (52)</td>
</tr>
<tr>
<td>Categorization condition</td>
<td>389 (29)</td>
<td>421 (39)</td>
</tr>
<tr>
<td>Number word condition</td>
<td>433 (61)</td>
<td>430 (26)</td>
</tr>
</tbody>
</table>

Results demonstrate that responses in L1 were faster than in L2 in the digit condition as well as in the categorization condition. These two conditions were used in Experiment 1 and 2. Thus, results suggest that the longer RTs in L1 than in L2 that were found in the production task in the first experiment were not due to a different speech onset in L1 versus L2. Rather, it is supposed that premature responses might have been prevented by constantly inhibiting L1. Concluding, it seems possible that the type of task in Experiment 1 influenced language switch patterns. To provide converging evidence for this finding, a fourth experiment was conducted.
7.5 Experiment 4

Experiment 4 was conducted to test if the type of production task gives rise to a general inhibition of the dominant language. Experiment 4 contained two different production tasks. In the first task (direct naming), participants directly named single digits. In the second task (categorization), participants categorized the same digits into smaller or larger than five by speaking into the microphone. There were only two digits as stimuli to ensure that the same number of answer alternatives was used in both tasks. If the general inhibition of L1 was indeed due to prevent premature responses, one should find a general inhibition of L1 in the direct name-production task of Experiment 4 but not in the more complex category-production task of Experiment 4.

7.5.1 Method

Participants

16 participants with German as native language took part, 12 women and 4 men. They received 5 € or partial course credit. They reported that they used English as their L2. Ages ranged from 20 to 35 years. On average, they categorized their English skills as 4.86 (SD= 1.12) on a 7-point scale, where 7 was very good. They learned English at school for at least five years ($M = 8.19$, $SD = 1.05$).

Stimuli, tasks, and responses

Participants performed two different language production tasks: A name-production task (direct naming of visually presented digits) and a category-
production task (categorization of visually presented digits as smaller or larger than five). The name-production task was comparable to the production task of Experiment 1 with the exception that only the digits 4 and 6 were used. In the category-production task, participants were asked to categorize the visually presented digits 4 and 6 into “kleiner”, “größer”, “smaller”, or “larger” than five (vocal responses) like in the production task of Experiment 2.

Procedure

The procedure was the same as in previous experiments. The only exception was that this time the same digit could be repeated immediately within two trials. Furthermore, only two experimental blocks with 96 trials each were used for each of the production tasks. The sequence of production tasks (name-production vs. category-production) was counterbalanced across participants.

Design and Analyses

The design was the same as in previous experiments. The following categories were again excluded from analyses: (1) the practice block, (2) the first two trials in each block, (3) RTs below 150 ms and above 1600 ms for the name-production task and below 150 ms and above 1925 ms for the category-production task (i.e., 99th percentile each), and (4) errors and trials following an error (for RT analyses). Errors in the name-production task consisted of 3.4 % production in the wrong language, 0.3 % production of the wrong digit and 0.6 % due to the sensitivity of the microphone. In the category-production task 1.9 % errors were due to naming the wrong language, 1.5 % were categorization errors and 1.0 % errors were due to the sensitivity of the microphone. The percentage
of trials that had to be rejected was 18.4% in the name-production task and 17.9% in the category-production task.

### 7.5.2 Results of the name-production task

#### RT analysis

An ANOVA was conducted with the independent variables language (L1 versus L2) and transition (switches versus no-switches). The variable language was significant with slower RTs in L1 ($M = 729$ ms; see Table 6) than in L2 ($M = 686$ ms); $F(1,15) = 11.65, p < .001$. No-switches ($M = 675$ ms) were faster than switches ($M = 740$ ms); $F(1,15) = 43.33, p < .001$ for the significant effect of transition. The language by transition interaction was also significant ($F(1,15) = 12.14, p < .001$) indicating larger switch costs for L1 (90 ms) than for L2 (42 ms).

#### Error analysis

An error ANOVA was conducted. As in the RT analysis, the variable language was significant ($F(1,15) = 21.00, p < .001$), indicating larger error rates in L1 (6.0%; see Table 6) than in L2 (2.6%). Participants made less errors in no-switches (2.8%) than in switches (5.8%); $F(1,15) = 13.66, p < .001$ for the significant effect of transition. The interaction between these two variables was significant; $F(1,15)= 5.93, p = .03$. As already shown in the RT analysis, switch costs were larger for L1 (4.6%) than for L2 (1.5%).
Table 6. Experiment 4: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the name-production task.

<table>
<thead>
<tr>
<th></th>
<th>RT (in ms)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>774 (149)</td>
<td>707 (127)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>684 (111)</td>
<td>665 (113)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>90</td>
<td>42</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Error rates (in %)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>8.3 (3.9)</td>
<td>3.3 (4.7)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>3.7 (4.5)</td>
<td>1.8 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>4.6</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

7.5.3 Results of the category-production task

RT analysis

For this task, independent variables were again language (L1 versus L2) and transition (no-switch versus switch). The ANOVA showed significant effects of language ($F(1,15) = 4.62, p = .05$) and transition ($F(1,15) = 51.66, p < .001$). The data pattern demonstrated faster RTs for L1 ($M = 772$ ms; see Table 7) than for L2 ($M = 818$ ms) and faster RTs in no-switch trials ($M = 723$ ms) than in switch-trials ($M = 867$ ms). A significant interaction between language and transition could not be found; $F(1,15) = 1.93, p = .19$.

Error analysis

The calculated error ANOVA only showed a significant effect for the variable transition with less errors in no-switches (2.7 %; see Table 7) than in switches
(5.8 %; see Table 7); $F(1,15) = 11.24$, $p < .001$. Neither the variable language ($F(1,15) = 1.73$, $p = .21$) nor the language by transition interaction ($F(1,15) = 1.35$, $p = .26$) were significant.

Table 7. Experiment 4: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the category-production task.

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>RT (in ms)</th>
<th></th>
<th>(B)</th>
<th>Error rates (in %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
<td>L1</td>
<td>L2</td>
</tr>
<tr>
<td>Switch trials</td>
<td></td>
<td>838 (163)</td>
<td>897 (198)</td>
<td></td>
<td>4.3 (5.2)</td>
<td>7.3 (6.5)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td></td>
<td>707 (106)</td>
<td>738 (119)</td>
<td></td>
<td>2.5 (2.0)</td>
<td>2.9 (3.3)</td>
</tr>
<tr>
<td>Switch costs</td>
<td></td>
<td>131</td>
<td>159</td>
<td></td>
<td>1.8</td>
<td>4.4</td>
</tr>
</tbody>
</table>

7.5.4 Discussion

As in the previous experiments, participants showed substantial language-switch costs in both types of production tasks in Experiment 4. Thus, switch costs can be considered to be a robust empirical marker when switching between languages - independent of the specific type of task. In contrast, the asymmetry of switch costs (i.e., L1 > L2) is not as robust as switch costs themselves. In Experiment 4, larger switch costs for L1 than for L2 were found only in the name-production task, whereas no difference was found in the category-production task.
Furthermore, participants showed longer RTs and higher error rates in their dominant L1 than in L2 in the name-production task. This data pattern, which is attributed to a general inhibition of L1, did not occur in the category-production task. Like in the production task of Experiment 1, participants in the name-production task might have tried to prevent easy responses (direct naming) by inhibiting lexical selection in L1. The category-production task did not tempt to such premature responses as participants had to categorize digits into one of two categories before giving the response.

In this context, it is also interesting to note that only two stimuli were used in the production tasks of Experiment 4 - so that it would have been easy to learn the stimulus-category mapping in the category-production task. If such a mapping was learned, one could argue that the task was no longer a categorization task but more like a (learned) direct-naming task. Nevertheless, participants showed no general inhibition in this production task. It seems that the additional step to transfer a number into a category is enough to prevent premature responses.

7.6 Experiment 5

The data of previous experiments suggest that participants inhibit their L1 in general to prevent premature responses. Authors like Christoffels et al. (2007) as well as Costa and Santesteban (2004b) propose that bilinguals especially adjust their activation level of L1 to give advantage to selection of the weaker language in a language-switching situation. However, in this work at hand this effect was only found in easy direct-naming tasks. Productive categorization as well as receptive categorization tasks showed faster RTs for the dominant compared to
the weaker language. Therefore, the crucial question is whether this effect can also be found in an easy reception task in which no further step like categorization is needed. To find an answer, two different reception tasks were conducted. The first task (number-reception task) was an easy task. Participants listened to auditory digits that were presented via loudspeakers and were asked to press the appropriate number key on the keyboard. In the second task (category-reception task), participants categorized the auditory digits into smaller or larger than five by using the four keys on a SR box. Both tasks included only four digits to make sure that the same number of answer alternatives was used in either task. If participants automatically inhibit their L1 in easy tasks, slower RTs in L1 than in L2 should show in the first task. In the second task, however, no general inhibition of L1 is expected as participants have to go through one more step (categorization) before giving the response.

7.6.1 Method

Participants

Participants were 16 native German speakers. 10 are female and 6 are male, ages ranging from 20 to 31. They received 5 € or partial course credit for participation. Participants had experience with English as their L2. They judged their English skills with a mean score of 4.83 (SD = 1.0) on a 7-point scale, where 7 was very good. They learned English at school for at least 5 years (M = 8.06, SD = 1.18).
Stimuli, tasks, and responses

Participants performed two different language-reception tasks: A number-reception task and a category-reception task. Stimuli were the same as in the reception tasks of previous experiments with the exception that only the single digits 3, 4, 6, and 7 were used. In the number-reception task participants were asked to press the matching digit key on the column of numbers of the keyboard. In the category-reception task the task was the same as in the reception task of Experiment 2.

Procedure

The procedure was the same as in previous experiments. The only exception was that only two experimental blocks with 96 trials each were used for each of the reception tasks. The sequence of reception tasks (number-reception vs. category-reception) was counterbalanced across participants.

Design and Analyses

The design was the same as in previous experiments. The following categories were excluded from the analyses: (1) the practice block, (2) the first two trials in each block, (3) RTs below 150 ms and above 1280 ms for the number-reception task and below 150 ms and above 1950 ms for the category-reception task (i.e., 99th percentile each), and, (4) errors and trials following an error (for RT analyses). Participants made 3.9 % errors in the number-reception task and 5.7 % errors in the category-reception task. 17.4 % of the trials had to be discarded in the number-reception task and 20.5 % in the category-reception task.
7.6.2 Results of the number-reception task

RT analysis

An ANOVA with the independent variables language (L1 versus L2) and transition (no-switch versus switch) was conducted. The variable language was significant and showed that RTs for L1 (M = 603 ms; see Table 8) were faster than RTs for L2 (M = 636 ms); F(1,15) = 41.08, p < .001. The variable transition was also significant (F(1,15) = 6.79, p = .02), indicating faster RTs for no-switch trials (M = 614 ms) than for switch trials (M = 624 ms). No asymmetry was found, which was attested by a non-significant interaction between the variables language and transition; F(1,15) = .03, p = .86.

Error analysis

The error ANOVA showed no significant results. Neither the variable language (F(1,15) = 1.74, p = .21), nor the variable transition (F(1,15) = .00, p = .96) nor the language by transition interaction (F(1,15) = 2.21, p = .16) were significant. Mean error rates as well as standard deviations for no-switch and switch trials are shown in Table 8.
**Table 8.** Experiment 5: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the number-reception task.

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<th>RT (in ms)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>608 (67)</td>
<td>640 (67)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>598 (66)</td>
<td>631 (65)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>10</td>
<td>9</td>
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<table>
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<tr>
<th></th>
<th>Error rates (in %)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>4.4 (4.6)</td>
<td>3.4 (3.1)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>2.9 (2.8)</td>
<td>5.0 (4.0)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>1.5</td>
<td>-1.6</td>
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</table>

### 7.6.3 Results of the category-reception task

**RT analysis**

The ANOVA with the independent variables language (L1 versus L2) and transition (no-switch versus switch) showed that the variable language was not significant; $F(1,15) = 2.57, p = .13$. The variable transition was significant ($F(1,15) = 34.45, p < .001$) and showed that no-switches ($M = 733$ ms; see Table 9) were faster than switches ($M = 805$ ms). Furthermore, there was a significant interaction between language and transition ($F(1,15) = 5.43, p = .03$), indicating that switch costs were smaller for L1 (46 ms) than for L2 (98 ms).
Error analysis

The error ANOVA showed that neither the variable language ($F(1,15) = 1.54, p = .23$) nor the variable transition ($F(1,15) = 3.18, p = .10$) nor the interaction between language and transition ($F(1,15) = .33, p = .57$) were significant. Mean error rates as well as standard deviations for no-switch and switch trials are shown in Table 9.

Table 9. Experiment 5: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the category-reception task.

<table>
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<th>RT (in ms)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>783 (80)</td>
<td>827 (94)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>737 (90)</td>
<td>729 (58)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>46</td>
<td>98</td>
<td></td>
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<table>
<thead>
<tr>
<th></th>
<th>Error rates (in %)</th>
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<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>5.9 (3.8)</td>
<td>7.4 (5.3)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>4.5 (3.7)</td>
<td>4.8 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>1.4</td>
<td>2.6</td>
<td></td>
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</table>

7.6.4 Discussion

Taken together, Experiment 5 was conducted to further test the occurrence of a general inhibition of the dominant language. To this end, the influence of the difficulty of two different reception tasks on the activation threshold of L1 was tested. Although the first task (number-reception task) was a very easy task and
with respect to stimulus-response mappings comparable to a productive direct-naming task, no general inhibition of L1 was found. Obviously, participants did not raise the activation threshold of L1 to facilitate lexical selection of L2 (as suggested by, e.g., Christoffels et al., 2007) in this task. As expected and in line with findings from previous experiments, there was also no general inhibition effect for L1 in the category-reception task.

In line with other results, a robust switch-cost pattern was found in Experiment 5 that was already demonstrated in previous experiments. That is, both tasks showed faster RTs in no-switch trials than in switch trials. Another result that also replicates findings from previous experiments is the lack of a homogeneous asymmetrical switch-cost pattern. In detail, switch costs were symmetrical in the number-reception task whereas switch costs were asymmetrical with smaller switch costs for L1 than for L2 in the category-reception task.

To summarize the first empirical part, significant language-switch costs were found in all experiments and in all types of tasks. This suggests that switch costs are a robust finding in language-switching studies. The size of switch costs, however, seems to depend on the specific type of task. That is, experiments within this first empirical part showed that switch costs were higher in language production than in language reception tasks. Furthermore, a general inhibition of the dominant L1 was only found in those production tasks that included direct naming. Results concerning the asymmetry of switch costs were heterogeneous.
Chapter 8: Experimental part II: Language-switching experience

8.1 Introduction

The first experimental part demonstrated that switch costs are a very robust empirical marker and occur in different language-switching tasks - independent from the type of task. The experiments showed that switch costs arise in different production as well as in different reception tasks. However, participants that were tested in previous experiments did not have any experience in constant language switching. One interesting question might be whether switch costs are still robust when participants are experienced in language switching. As mentioned before, by visual inspection of the literature it becomes obvious that past research never directly addressed persons who are constantly confronted with language switching like employees working in international companies. Yet, there are studies that examined the performance of simultaneous interpreters in basic language and working memory tasks (i.e. Christoffels, de Groot, & Kroll, 2006). Christoffels et al. (2006) showed that professional interpreting is linked to a high verbal memory capacity. However, the question whether persons with language-switching experience (e.g. interpreters or employees working in an international company) show better language-switching skills has been unanswered so far.

Therefore, the following experiments aim at providing answers for this question. It will be surveyed whether participants with language-switching experience still show language switch costs and need to make use of inhibitory mechanisms to switch between languages. The author of this work supposes that the occurrence of switch costs provides evidence for inhibitory mechanisms as switch cost
indicate that one language is inhibited while the other one is in use. Note that according to Green (1998) a reduced dominance difference between L1 and L2 should lead to a smaller switch cost asymmetry and, possibly, decreased switch costs. This reduced dominance difference is assumed to result from improved L2 proficiency due to constant language switching between L1 and L2. Besides that, bilinguals’ enhanced ability to ignore goal-irrelevant stimuli might lead to reduced switch costs (cf. Colzato et al., 2008).

The question whether language-switch costs are reduced by constant language switching should also be interesting for international companies. Given the fact that language-switching experience reduces switch costs, companies might consider training methods where employees get used to the language-switching situation. However, if switch costs are robust against experience in language switching, companies face the problem that language-switch costs will always be present. In this case, companies may think about diminishing the language switching situations. For example, employees speaking the same mother tongue should work together predominantly.

The following section includes two experiments as well as between-experiment comparisons. Experiment 6 was conducted in an international company where English is the corporate language. Participants of this experiment are used to daily language switching between L1 and L2. Experiment 7 tested participants working at a company where German is the corporate language and, therefore, participants do not language-switch at work. Each experiment contained a production and a reception task. Tasks were the same as in Experiment 1. The primary goal of this second experimental part was to find out if language-switch costs are weaker for participants that are used to numerous, spontaneous
language switches at work every day than for participants that are not used to daily language switching.

### 8.2 Experiment 6

Experiment 6 was realized within the company Toyota Motorsport GmbH. Toyota Motorsport GmbH is a company that works in the automotive sector. It is an international working testing and development facility that offers its service to external clients as well as members of the Toyota family (Toyota Motorsport GmbH, n.d.). The company language is English. Therefore, meetings and most of the conversation made within the company are in English. This leads to the fact that employees often have to switch between their native language and English. Thus, employees participating in this experiment were experienced in language switching.

Tasks used in this experiment were the same as those in Experiment 1 to make a between-experiment comparison possible. The experiment included a production as well as a reception task. The production task included naming (orally) of single digits by speaking into a microphone; the reception task included digit categorization into smaller or larger than five by pressing one of two response keys.
8.2.1 Method

Participants

All participants were employees working at Toyota Motorsport. They reported that they are used to spontaneous language switches between German and English at work. 53 German native speakers voluntarily took part, 17 women and 36 men. Ages ranged from 27 to 57. They reported that they used English as their L2. On average, participants used their L2 daily at work. They categorized their English skills with a mean score of 5.11 ($SD = 1.06$) on a 7-point scale, where 7 was very good, and learned English at school for 7.24 years ($SD = 2.33$), on average.

Stimuli, tasks, responses

Stimuli, tasks, and responses were the same as in Experiment 1.

Procedure

The procedure was the same as in Experiment 1 except that the testing location was at work in this experiment. Participants were tested in a separate room in the Toyota Motorsport building.

Design and Analyses

Design and Analyses were the same as in Experiment 1. The following categories were excluded from analyses: (1) the practice block, (2) the first two trials in each block, (3) RTs below 150 ms and above 2200 ms for the production task and below 150 ms and above 1300 ms for the reception task (i.e. 99th percentile each), and (4) errors and trials following an error (for RT analyses). For the production task errors were either defined by a production in the wrong
language (3.4 %), of the wrong number (0.1 %), or an error that was due to the
sensitivity of the microphone (3.9 %). For the reception task errors were false key
presses (1.8 %). The percentage of trials that had to be discarded was 17.9 % in
the production task and 11.3 % in the reception task.

8.2.2 Results of the production task

RT analysis

An ANOVA was conducted with the independent within-subject variables
language (L1 versus L2) and transition (no-switch versus switch). There was a
significant effect of language ($F(1,52) = 12.71, p < .001$) with slower RTs for L1
($M = 722$ ms; see Table 10) than for L2 ($M = 704$ ms). There was also a
significant effect of transition ($F(1,52) = 92.01, p < .001$) with faster RTs for no-
switch trials ($M = 687$ ms) than for switch trials ($M = 739$ ms). The interaction
between language and transition was not significant; $F(1,52) = .39, p = .53$.

Error analysis

The error ANOVA revealed similar results as already shown for the RT data.
There were significant effects for the variables language ($F(1,52) = 4.76, p = .03$)
and transition; $F(1,52) = 28.90, p < .001$. For the variable language, the data
showed that more errors occurred in L1 (5.9 %; see Table 10) than in L2 (4.7 %).
With reference to the variable transition, participants made less errors in no-
switch trials (4.2 %) than in switch trials (6.4 %). There was no significant
interaction of language and transition; $F(1,52) = .49, p = .49$. 
Table 10. Experiment 6: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the production task.

<table>
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<th>RT (in ms)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>747 (115)</td>
<td>732 (112)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>697 (101)</td>
<td>677 (95)</td>
<td></td>
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<tr>
<td>Switch costs</td>
<td>50</td>
<td>55</td>
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<tr>
<th></th>
<th>Error rates (in %)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>6.9 (5.0)</td>
<td>5.9 (3.6)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>4.9 (3.3)</td>
<td>3.4 (3.2)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>2.0</td>
<td>2.5</td>
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</table>

8.2.3 Results of the reception task

RT analysis

Again, an ANOVA with the independent variables language (L1 versus L2) and transition (no-switch versus switch) was conducted. There was a significant effect of language ($F(1,52) = 55.21, p < .001$), indicating faster RTs for L1 ($M = 570$ ms; see Table 11) than for L2 ($M = 590$ ms). The variable transition was also significant ($F(1,52) = 41.59, p < .001$), showing faster RTs in no-switch trials ($M = 574$ ms) than in switch trials ($M = 586$ ms). The interaction between language and transition showed no significant results; $F(1,52) = 1.41, p = .24$. 
Error analysis

For errors, neither the variable language ($F(1,52) = 2.09, p = .16$), nor the variable transition ($F(1,52) = .29, p = .60$), nor the interaction between these two variables ($F(1,52) = .03, p = .86$) was significant. Mean error rates as well as standard deviations for no-switch and switch trials are shown in Table 11.

Table 11. Experiment 6: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the reception task.

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<th>RT (in ms)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>578 (82)</td>
<td>595 (81)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>563 (77)</td>
<td>586 (77)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>15</td>
<td>9</td>
<td></td>
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<tr>
<th></th>
<th>Error rates (in %)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
</tr>
<tr>
<td>Switch trials</td>
<td>1.5 (1.7)</td>
<td>1.9 (2.0)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td>1.7 (2.1)</td>
<td>1.9 (2.4)</td>
</tr>
<tr>
<td>Switch costs</td>
<td>-0.2</td>
<td>0</td>
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8.2.4 Comparison between production and reception task

Performance was compared between the production and the reception task. Analyses included three within-subject independent variables: (1) language (L1 versus L2), (2) transition (no-switch versus switch) and (3) task (production versus reception). Only those effects and interactions are reported that include the variable task.
Significant results were found for the variable task for RTs \(F(1,52) = 129.11, p < .001\) as well as for error rates \(F(1,52) = 113.79, p < .001\). Participants showed larger RTs and more errors in the production task (RTs: \(M = 713\) ms; errors: 5.3 %) than in the reception task (RTs: \(M = 580\) ms; errors: 1.7 %). The interaction between transition and task was also significant for RTs \(F(1,52) = 61.02, p < .001\) and error rates \(F(1,52) = 25.55, p < .001\), indicating that switch costs were larger in the production (RTs: 52 ms; errors: 2.2 %) than in the reception task (RTs: 12 ms; errors: -0.1 %). Additionally, the interaction between language and task was significant for RTs \(F(1,52) = 41.96, p < .001\) and error rates \(F(1,52) = 6.50, p = .01\). The data pattern showed that participants were slower and made more errors in L1 than in L2 in the production task, but in the reception task it was vice versa. The analysis revealed no significant three-way interaction between language, transition, and task; neither for RTs \(F(1,52) = 1.43, p = .24\) nor for error rates \(F(1,52) = .31, p = .58\).

As already shown for Experiment 1 and 2, a post-hoc ANOVA was conducted to calculate relative switch costs (dependent variable) with the RT in no-switch trials as baseline. The ANOVA was conducted with the within-subject independent variables language and task. The goal was to exclude the possibility that the general higher RT level in the production task is responsible for higher switch costs in production than in reception. Results showed a significant main effect of task \(F(1,52) = 60.30, p < .001\), indicating that even relative switch costs were larger in the production (7.7 % increase) than in the reception task (2.1 %). Neither the main effect of language \(F(1,52) = .01, p = .92\) nor the interaction between language and task \(F(1,52) = 2.05, p = .16\) were significant.
8.2.5 Discussion

In sum, results showed that switch costs occurred in the production as well as in the reception task. In line with previous results, switch costs were larger in the production than in the reception task. Symmetrical switch costs were found in both tasks. Besides that, results gave additional evidence for the general inhibition found in the production task of Experiment 1 as well as in the name-production task of Experiment 4. Both, RTs and error rates were larger in the dominant L1 than in the non-dominant L2 in the production task. This underlines the hypothesis that an easy task (direct naming) tempts to premature responses that have to be suppressed. Concerning the reception task (categorization), performance was better in L1 than in L2. According to the hypothesis mentioned above, categorization includes an additional decision that participants have to make. Therefore, premature responses were not likely in the reception task.

8.3 Between-experiment comparison of Experiments 1 and 6

A between-experiment analysis was conducted to focus specifically on possible differences in the language-switching performance between participants of Experiment 1 and those of Experiment 6. Participants of Experiment 1 reported that they had no experience in language switching whereas participants of Experiment 6 worked at Toyota Motorsport where language switching is a daily task. The crucial question is whether language-switching experience influences language-switching performance. Based on the ‘dominance-difference’ theory by
Green (1998) and according to Colzato et al. (2008) participants of Experiment 6 should show less switch costs compared to participants of Experiment 1.

**Design and Analyses**

First, an ANOVA was conducted with two within-subject independent variables: (1) language (L1 versus L2), and (2) transition (no-switch versus switch) and one between-subject independent variable: (1) experiment (Experiment 1 versus Experiment 6). Additionally, an analysis of covariance (ANCOVA) was conducted to remove variations in the dependent variable that could be caused by the covariate age. The reason for this is that the mean age of participants of Experiment 1 ($M = 24.15, SD = 3.81$) and Experiment 6 ($M = 40.32, SD = 7.67$) was heterogeneous. Note that only those effects are reported that include the variable experiment.

### 8.3.1 Results of the comparison between production tasks

The ANOVA revealed that the main effect of experiment was significant for RTs ($F(1,92) = 15.40, p < .001$), showing faster RTs for participants of Experiment 1 ($M = 635$ ms) than for participants of Experiment 6 ($M = 713$ ms). For error rates, this main effect was not significant; $F(1,92) = .62, p = .44$. However, according to the ANCOVA this main effect of experiment was neither significant for RTs ($F(1,91) = 3.25, p = .08$) nor for error rates ($F(1,91) = 2.45, p = .12$).

For the language by experiment interaction the ANOVA showed that there was no significant effect; neither for RTs ($F(1,92) = .88, p = .35$), nor for error rates
(F(1,92) = 2.31, p = .13). This non-significance was attested by the ANCOVA (RTs: F(1,91) = 2.15, p = .15; error rates: F(1,91) = .01, p = .94).

The transition by experiment interaction was significant for error rates (F(1,92) = 5.63, p = .02) according to the ANOVA, indicating that switch costs were larger in Experiment 1 (3.9 %) than in Experiment 6 (2.2 %). This interaction was not significant for RTs; F(1,92) = .11, p = .74. Yet, in the ANCOVA there was no significant interaction between transition and experiment; neither for RTs (F(1,91) = 1.98, p = .16), nor for error rates (F(1,91) = .00, p = .97).

For the three-way interaction between language, transition, and experiment the ANOVA revealed non-significance (RTs: F(1,92) = .91, p = .34; error rates: F(1,92) = .60, p = .44). This non-significance for the three-way interaction was underlined by the ANCOVA (RTs: F(1,91) = .38, p = .54; error rates: F(1,91) = .15, p = .70).

### 8.3.2 Results of the comparison between reception tasks

As already shown by means of the ANOVA for the production task, the main effect of experiment was significant for RTs (F(1,92) = 10.73, p = .001) and for error rates (F(1,92) = 8.67, p = .004). Participants of Experiment 1 were faster (M = 530 ms) but made more errors (2.9 %) than participants of Experiment 6 (RTs: M = 580 ms, error rates: 1.7 %). But, the ANCOVA revealed that this main effect of experiment was non-significant; neither for RTs (F(1,91) = 3.49, p = .07), nor for error rates (F(1,91) = .18, p = .67).
The ANOVA showed that there was no significant interaction between the variables language and experiment (RTs: $F(1,92) = .10, p = .75$; error rates: $F(1,92) = .06, p = .80$). Also the ANCOVA showed that this interaction was non-significant (RTs: $F(1,91) = 1.82, p = .18$; error rates: $F(1,91) = 2.57, p = .11$).

The ANOVA further revealed that the transition by experiment interaction was only significant for error rates ($F(1,92) = 4.58, p = .04$), indicating that switch costs were larger in Experiment 1 (0.6 %) than in Experiment 6 (-0.1 %) as already shown for the production task. For RTs this interaction was not significant; $F(1,92) = .66, p = .42$. The ANCOVA revealed similar effects. For error rates this interaction was significant ($F(1,91) = 7.11, p = .009$), indicating that participants of Experiment 1 showed more switch costs (1.0 %) than participants of Experiment 6 (-0.4 %). However, concerning RTs, no significant effect was found for the interaction between transition and experiment; $F(1,91) = .00, p = .92$.

Besides that, the ANOVA showed that the three-way interaction between language, transition, and experiment was not significant; neither for RTs ($F(1,92) = .10, p = .76$), nor for error rates ($F(1,92) = .13, p = .72$). This was attested by the ANCOVA (RTs: $F(1,91) = .76, p = .39$; error rates: $F(1,91) = .25, p = .62$).

**8.3.3 Discussion**

Basically, the results show that the data patterns of Experiment 1 and Experiment 6 were very similar for both tasks. Due to the fact that the group of participants was very different, this similar data pattern is unexpected. Please note that concerning language-switching experience, participants of Experiment 6 were
much more advanced than participants of Experiment 1. The only effect found for the ANOVA was that participants of Experiment 1 showed larger switch costs in error rates than participants of Experiment 6 in both the production and reception task. This could not be attested for RTs. However, in the production task this effect was obviously confounded by the covariate age as the ANCOVA yielded no difference between participants of the two experiments concerning switch costs in error rates. One might point out that the testing environment was too different between experiments as only Experiment 6 was tested within a company. Next to that, when comparing the self-rated L2 proficiency between Experiment 1 \((M = 5.22, SD = 1.01)\) and Experiment 6 \((M = 5.11, SD = 1.06)\) one might argue that the similar L2 proficiency gave rise to a similar data pattern. Therefore, another experiment was conducted. The following experiment was realized within an international company where employees are not used to language switching.

### 8.4 Experiment 7

The between-experiment comparison of Experiments 1 and 6 had the disadvantage that Experiment 1 was conducted at the university within a laboratory whereas Experiment 6 was conducted within a company. Furthermore, the group of participants was rather heterogeneous between experiments. That is, Experiment 1 tested mostly younger participants still going to university whereas Experiment 6 tested participants that were older on average and already worked in a company. Consequently, to be able to compare results of two experiments that were both conducted within a similar environment (an international company) and with a similar sample size (employees), Experiment 7 was conducted.
Experiment 7 was realized at the Commerzbank. Commerzbank is the second largest credit institution in Germany, and one of Europe’s major banks (Commerzbank, n.d.). Here, employees do not switch languages at work as the company language is German. Tasks were the same as in Experiment 1 and 6. The production task included direct naming whereas the reception task was a categorization task.

8.4.1 Method

Participants

All participants were employees working at the Commerzbank. Participants were not used to language switches at work as the company language is German. Eighteen German native speakers voluntarily took part; 8 women, 10 men. Their ages ranged from 30 to 55 years. Participants had experience of speaking English as their L2 and used English at school for at least three years ($M = 6.72$, $SD = 1.67$). Their mean self-assessment score concerning their English skills was 3.51 ($SD = 1.02$) on a 7-point scale, where 7 was very good.

Stimuli, tasks, responses

Stimuli, tasks, and responses were the same as in Experiment 1.

Procedure

The procedure was the same as in Experiment 1 except that the testing location was at work in this experiment. Participants were tested in a separate room in the Commerzbank building.
**Design and Analyses**

Design and analyses were the same as in Experiment 1. The following categories were excluded from analyses: (1) the practice block, (2) the first two trials in each block, (3) RTs below 150 ms and above 1470 ms for the production task and below 150 ms and above 1070 ms for the reception task (i.e. 99th percentile each), and (4) errors and trials following an error (for RT analyses). For the production task errors were either defined by a production in the wrong language (2.4 %), of the wrong number (0.1 %), or an error that was due to the sensitivity of the microphone (0.6 %). For the reception task errors were false key presses (1.6 %). The percentage of trials that had to be discarded was 15.8 % in the production task and 11.1 % in the reception task.

### 8.4.2 Results of the production task

#### RT analysis

An ANOVA was conducted with the independent variables language (L1 versus L2) and transition (no-switch versus switch). The main effect of language was not significant; \( F(1,17) = .08, p = .78 \). The variable transition was significant \( F(1,17) = 58.91, p < .001 \) with faster RTs in no-switch trials \( (M = 702 \text{ ms}; \text{see Table 12}) \) than in switch trials \( (M = 763 \text{ ms}) \). The interaction between language and transition was also significant \( F(1,17) = 6.14, p = .02 \), indicating larger switch costs for L1 (72 ms) than for L2 (50 ms).
Error analysis

The error analysis showed a similar result pattern as the RT analysis. The variable language was not significant; $F(1,17) = 3.34, p = .09$. There was a significant effect of transition ($F(1,17) = 12.69, p = .002$), showing less errors in no-switch trials (1.8 %; see Table 12) than in switch trials (3.6 %). The significant interaction between language and transition ($F(1,17) = 6.45, p = .02$) indicated that switch costs were larger for L1 (2.8 %) than for L2 (0.6 %).

Table 12. Experiment 7: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the production task.

<table>
<thead>
<tr>
<th></th>
<th>RT (in ms)</th>
<th>Error rates (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
</tr>
<tr>
<td>(A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>767 (105)</td>
<td>759 (103)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td>695 (112)</td>
<td>709 (89)</td>
</tr>
<tr>
<td>Switch costs</td>
<td>72</td>
<td>50</td>
</tr>
<tr>
<td>(B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>4.6 (3.7)</td>
<td>2.5 (2.2)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td>1.8 (1.8)</td>
<td>1.9 (2.4)</td>
</tr>
<tr>
<td>Switch costs</td>
<td>2.8</td>
<td>0.6</td>
</tr>
</tbody>
</table>
8.4.3 Results of the reception task

RT analysis

Independent variables were again language (L1 versus L2) and transition (no-switch versus switch). The ANOVA showed that the variables language ($F(1,17) = 73.34$, $p < .001$) and transition ($F(1,17) = 9.15$, $p = .008$) were both significant. That is, participants reacted faster in L1 ($M = 558$ ms; see Table 13) than in L2 ($M = 598$ ms) and in no-switch trials ($M = 573$ ms) than in switch trials ($M = 583$ ms). A significant interaction between language and transition could not be found; $F(1,17) = 1.07$, $p = .32$.

Error analysis

The error ANOVA showed no significant results. Neither for language ($F(1,17) = .52$, $p = .48$), nor for transition ($F(1,17) = 3.59$, $p = .08$), nor for the language by transition interaction ($F(1,17) = 1.71$, $p = .21$). Mean error rates as well as standard deviations for no-switch and switch trials are shown in Table 13.
Table 13. Experiment 7: (A) Mean response latencies and standard deviations (SD) in milliseconds and (B) error rates and standard deviations (SD) for no-switch and switch trials as well as switch costs in L1 and in L2 in the reception task.

<table>
<thead>
<tr>
<th></th>
<th>RT (in ms)</th>
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<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Switch trials</td>
<td>564 (53)</td>
<td>602 (53)</td>
<td></td>
</tr>
<tr>
<td>No-switch trials</td>
<td>551 (51)</td>
<td>595 (45)</td>
<td></td>
</tr>
<tr>
<td>Switch costs</td>
<td>13</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Error rates (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
</tr>
<tr>
<td>Switch trials</td>
<td>1.8 (1.4)</td>
</tr>
<tr>
<td>No-switch trials</td>
<td>1.7 (1.6)</td>
</tr>
<tr>
<td>Switch costs</td>
<td>0.1</td>
</tr>
</tbody>
</table>

8.4.4 Comparison between production and reception task

The design for the following analyses was the same as in Experiment 6. Again, the additional variable task (production versus reception) was included. Only those effects that include the variable task are reported. Overall results support findings from previous experiments. In detail, a significant main effect of task (RTs: \( F(1,17) = 57.76, p < .001 \); errors: \( F(1,17) = 5.78, p = .03 \)) was found with slower RTs and more errors in the production task (RTs: \( M = 732 \) ms; errors: 2.7 %) than in the reception task (RTs: \( M = 578 \) ms; errors: 1.6 %). Furthermore, there was a significant interaction between transition and task for RTs (\( F(1,17) = 41.08, p < .001 \)), indicating that switch costs were larger in the production (60 ms) than in the reception task (10 ms). For error rates this interaction was close to significance; \( F(1,17) = 4.15, p = .06 \). The significant interaction between the variables language and task for RTs (\( F(1,17) = 15.33, p = .001 \)) indicates that
there was no difference between RTs in L1 versus L2 in the production task whereas performance in L1 was better than performance in L2 in the reception task. For error rates, this interaction was not significant; $F(1,17) = 1.00, p = .33$. However, for error rates there was a significant three-way interaction between transition, language, and experiment ($F(1,17) = 6.89, p = .02$), showing that switch costs were larger for L1 than for L2 in the production task whereas in the reception task there was no difference. For RTs the three-way interaction was not significant; $F(1,17) = 3.59, p = .08$.

To exclude the assumption that the general higher RT level in the production task is responsible for higher switch costs in production than in reception again a separate ANOVA with relative switch costs (baseline: RT in no-switch trials) as dependent variable was conducted. The within-subject independent variables were language and task. The analysis revealed a significant main effect of task ($F(1,17) = 33.99, p = < .001$) with larger switch costs in the production (8.9 % increase) than in the reception task (1.7 %). The main effect of language was also significant ($F(1,17) = 6.10, p = .02$) with larger switch costs in L1 than in L2. There was no significant interaction between language and task; $F(1,17) = 3.84, p = .07$.

### 8.4.5 Discussion

Results of Experiment 7 were in line with results from previous experiments, basically. That is, language-switch costs were found in both the production and the reception task. Yet again, switch costs were larger in the production than in the reception task. Switch costs were asymmetrical with larger switch costs in L1
than in L2 in the production task whereas switch costs were symmetrical in the reception task. There was no general inhibition of the dominant L1 found in the production task. But, there was no difference between L1 and L2 in the production task whereas in the reception task L1 was faster than L2. Therefore, one should be careful with interpreting this missing difference between L1 and L2 in the production task.

8.5 Between-experiment comparison of Experiments

6 and 7

The primary interest of running a between-experiment comparison of Experiments 6 and 7 was to find out if there is a difference in the language-switching performance between participants. A between-experiment comparison was already run between Experiments 1 and 6. However, Experiment 1 was conducted within a laboratory at university whereas Experiment 6 was conducted within an international company. Therefore, the environmental conditions might be too diverse. Concerning Experiment 7, participants were also tested within an international company. Participants of Experiment 6 were used to daily language switching at work whereas participants of Experiment 7 were not used to language switching. The between-experiment comparison of Experiments 1 and 6 showed that the data pattern of both experiments were very similar although participants were diverse and had different language-switching experience. However, the similar data pattern might have been caused by a similar L2 proficiency as participants at university read a lot of English literature. However, this is not valid for participants of Experiment 7. Consequently, one would expect
a better L2 proficiency as well as reduced switch costs for participants of Experiment 6 compared to participants of Experiment 7 according to the dominance-difference theory.

**Design and Analysis**

Analyses again included two within-subject independent variables: (1) language (L1 versus L2) and (2) transition (no-switch versus switch) and one between-subject independent variable: (1) experiment (Experiment 6 versus Experiment 7). Albeit the age difference between participants of Experiment 6 ($M = 40.32, SD = 7.67$) and Experiment 7 ($M = 46.33, SD = 7.85$) was not very severe, again an ANCOVA is calculated additionally to remove variations in the dependent variable that might be due to the covariate age. In the following only effects are reported that include the variable experiment.

### 8.5.1 Results of the comparison between production tasks

The ANOVA showed that there was a significant main effect of experiment for error rates ($F(1,69) = 15.61, p < .001$) with larger error rates in Experiment 6 (5.3 %) than in Experiment 7 (2.7 %). For RTs the main effect was not significant; $F(1,69) = .49, p = .49$. The ANCOVA underlined results already found by the ANOVA and showed that the main effect of experiment was still significant for error rates; $F(1,68) = 10.56, p = .002$. That is, overall error rates were larger in Experiment 6 (5.2 %) than in Experiment 7 (3.0 %). This main effect was non-significant for RTs; $F(1,68) = .14, p = .71$. 
For the interaction between the variables language and experiment, the ANOVA showed a significant effect for RTs \( (F(1, 69) = 4.03, p = .05) \), indicating that participants of Experiment 6 showed faster RTs in L2 than participants of Experiment 7 whereas for L1 the performance was more alike between participants of Experiment 6 and 7. However, for error rates this interaction was not significant; \( F(1, 69) = .07, p = .80 \). But, this was not in line with the ANCOVA. According to the ANCOVA, there was no significant interaction between language and experiment; neither for RTs \( (F(1, 68) = 2.17, p = .15) \) nor for error rates \( (F(1, 68) = .20, p = .65) \).

The transition by experiment interaction was also not significant (RTs: \( F(1, 69) = .61, p = .44 \); error rates: \( F(1, 69) = .38, p = .54 \)) according to the ANOVA. This non-significance was attested by the ANCOVA (RTs: \( F(1, 68) = .54, p = .47 \); error rates: \( F(1, 68) = .02, p = .89 \)).

The ANOVA found a significant three-way interaction between language, transition, and experiment for error rates; \( F(1, 69) = 4.11, p = .05 \). That is, switch costs were about the same size in L1 and in L2 for Experiment 6 whereas for Experiment 7 switch costs were larger in L1 than in L2. For RTs this three-way interaction was not significant; \( F(1, 69) = 3.46, p = .07 \). Yielding similar results as already found by the ANOVA, the ANCOVA revealed a significant three-way interaction for error rates \( (F(1, 68) = 7.84, p = .007) \), but not for RTs \( (F(1, 68) = 2.38, p = .13) \).
8.5.2 Results of the comparison between reception tasks

The ANOVA showed that, for this task, there was no significant main effect of experiment, neither for RTs \( F(1,69) = .02, p = .90 \), nor for error rates \( F(1,69) = .07, p = .79 \). The ANCOVA also yielded non-significance for the main effect of experiment (RTs: \( F(1,68) = .17, p = .68 \); error rates: \( F(1,68) = .81, p = .37 \)).

The ANOVA revealed a significant interaction between the variables language and experiment for RTs; \( F(1,69) = 14.63, p < .001 \). That is, in L1 participants of Experiment 6 reacted more slowly than participants of Experiment 7. However, in L2 it was vice versa. For error rates this interaction showed no significance; \( F(1,69) = 1.90, p = .17 \). Underlining results already found by the ANOVA the ANCOVA still showed a significant interaction between the variables language and experiment for RTs; \( F(1,68) = 8.60, p = .005 \). For error rates, this interaction was not significant; \( F(1,68) = .14, p = .71 \).

The transition by experiment interaction showed neither significance for RTs \( F(1,69) = .32, p = .57 \), nor for error rates \( F(1,69) = 3.43, p = .07 \) according to the ANOVA. These results are in line with the ANCOVA as results showed non-significance for this interaction (RTs: \( F(1,68) = .36, p = .55 \); error rates: \( F(1,68) = 2.68, p = .11 \)).

The ANOVA further showed no significant three-way interaction (RTs: \( F(1,69) = .03, p = .85 \); error rates: \( F(1,69) = 1.40, p = .24 \)). The ANCOVA also showed that the three-way interaction was not significant (RTs: \( F(1,68) = .01, p = .93 \); error rates: \( F(1,68) = 1.17, p = .28 \)).
8.5.3 Discussion

To summarize the main results, it is noticeable that the data pattern between Experiment 6 and 7 appears to be very similar. This is the case despite the fact that the group of bilinguals is very different between experiments. That is, although participants of Experiment 6 were skilled in language switching, they did not show a better switching performance with decreased switch costs compared to participants of Experiment 7.

There were only two slight differences between the experiments. First, participants of Experiment 6 showed faster RTs in L2 than participants of Experiment 7. However, the ANCOVA showed that this difference in the production task was confounded by the age difference between participants. More clearly, the faster RTs in L2 of participants of Experiment 6 than those of Experiment 7 could not be attested for the production task after removing variations in the dependent variable that were due to the covariate age.

Secondly, concerning the production task, switch costs in error rates were symmetrical in Experiment 6 whereas switch costs in error rates were asymmetrical with larger switch costs in L1 than in L2 in Experiment 7.

To summarize the second empirical part, a similar data pattern between participants with and those without language-switching experience was found. These results show that employees working in international companies where language switching is a daily task still cause substantial switch costs.
Part III

Discussion
Chapter 9: General Discussion

9.1 Summary of results

The present study aimed at exploring the occurrence of language-switch costs in production versus reception tasks. Moreover, the performance of participants with different language-switching experience (non-experienced versus experienced) was observed and compared. A visual inspection of the existing literature revealed that a direct comparison of switch costs between production and reception tasks as well as the consideration of language-switching experience and its influence on switch costs has been largely neglected so far.

To find some answers for this missing field of research, seven experiments were conducted. The first empirical part with five experiments in total concentrates on examining switch costs in different types of tasks. The second empirical part (containing Experiment 6 and 7) explores the influence of language-switching experience on the performance in language-switching studies.

The first experiment sets the stage for the present work and focused on the comparison between performance in a production versus a reception task. Both tasks showed switch costs. However, an interesting discovery was that switch costs were larger in the production than in the reception task. Concerning switch-cost asymmetries, asymmetrical switch costs with larger switch costs in L1 than in L2 were found only for the reception task. For the production task, switch costs were symmetrical. Another finding was the occurrence of a general inhibition of the dominant L1 in the production task. That is, higher RTs and more errors were observed in the dominant L1 than in the non-dominant L2. This suggests that
participants tried to prevent premature responses by constantly inhibiting their L1. For the reception task, no general inhibition of L1 was found. In sum, results of Experiment 1 give rise to the question if the type of task influences performance in a language switching study.

To find answers to this question, Experiment 2 was conducted to again compare switching performance in a production versus a reception task. Tasks were made more similar in contrast to Experiment 1 to exclude the assumption that the slight difference between tasks in Experiment 1 was responsible for a difference between tasks. But, results again showed that switch costs were larger in the production than in the reception task. Concluding from the results of Experiment 1 and 2 and based on theoretical accounts, it is proposed that the between-language interference in language production is higher than in language reception (cf. Costa, 2005; Jackson et al., 2004). In Experiment 2 no general inhibition of the dominant L1 was found. This is explained by the more complex task that was used in this experiment as a production task. Hereby, premature responses were not likely as the task was not easy enough. In contrast to the first experiment smaller switch costs were found in L1 than in L2 in both types of tasks. So far, with respect to switch-cost asymmetries, results seem to be heterogeneous.

Experiment 3 was conducted as a control experiment to exclude the assumption that the difference between Experiment 1 and 2 (the general inhibition found in Experiment 1 but not in Experiment 2) can be explained by a different speech onset of the stimuli in L1 versus L2. Results of Experiment 3 confirm that there was no different speech onset between L1 and L2 stimuli in Experiment 1 versus
Experiment 2. Therefore, it is suggested that the different type of production task caused the different response pattern in Experiment 1 versus Experiment 2.

To test the hypothesis further that the type of production task influences switch-cost patterns (and, specifically, the inhibition of L1), Experiment 4 was conducted. The results of two different production tasks (one easy and one more complex task) affirmed that an easy task leads to a general inhibition of the dominant L1. Again, switch costs were observed in both tasks and, furthermore, results concerning the asymmetry of response patterns were different between tasks.

So far, experiments showed that a general inhibition occurs in easy production tasks. Therefore, the goal of Experiment 5 was to find out if a general inhibition also arises in an easy reception task. To do so, an easy and a more complex reception task were conducted. However, results showed that neither showed a general inhibition of L1. It is speculated that a general inhibition occurs to prevent premature responses in L1 and not easy responses per se. In line with results from previous experiments, switch costs were robust (found in both tasks) and the asymmetry of response patterns was heterogeneous.

To test whether switch costs are still robust when participants are experienced in language switching, Experiment 6 was conducted. Experiment 6 was conducted within an international company with employees that were used to constant language switching at work. Contrary to expectation, a comparison between Experiment 1 and 6 revealed similar results despite a difference in the language-switching experience (not experienced versus experienced). However, it was speculated whether participants of Experiment 1 and 6 were similar in their L2 proficiency. Furthermore, the testing environment was different. That is,
Experiment 1 was conducted at university with younger participants whereas Experiment 6 was conducted at work with older participants. Therefore, Experiment 7 was conducted. Experiment 7 tested employees working in an international company where language switching is not required. A comparison between Experiment 6 and 7 revealed that results were similar, again. The only finding was that participants of Experiment 6 showed faster RTs in L2 than participants of Experiment 7 in the reception task. However, there was no difference in the size of switch costs between experiments.

To summarize, the data indicate that (1) switch costs are a very robust empirical marker in language-switching studies. However, the specific response pattern might be largely influenced by the type of task since (2) switch costs seem to be larger in language production than in language reception tasks (concerning RTs and error rates). (3) Moreover, easy production tasks (i.e. direct naming) caused participants to inhibit their L1 generally to prevent premature responses in L1 which could neither be attested for any reception task (also not a very easy reception task) nor for any category-production task. Moreover, based on the present results it can be concluded that (4) switch cost asymmetries seem to depend on several factors and can be hardly predicted. This last result poses a challenge to Green’s ICM (1998) as this model does not consider factors like the type of task or specific task requirements that might influence switch cost asymmetries. Another main finding is that (5) switch costs are still robust for participants that are experienced in constant language switching. This result provides the first empirical evidence that language-switching experience does not lead to a better switching ability. It was assumed that constant switching leads to a reduced dominance difference between L1 and L2. According to Green (1998)
a reduced dominance difference between languages should decrease switch costs. However, at least in this work, this could not be proven.

The following section focuses on a discussion based on these main results. Afterwards, limitations of this study and, consequently, open issues are mentioned that might be considered for future research.

### 9.2 Language-switch costs during production versus reception

When comparing studies that tested language switching using either a production or a reception task it appears that average switch costs are higher in production than in reception tasks. However, the advantage of the present design is that it allows us to draw a *direct* comparison between switch costs in production versus reception tasks as the same participants took part in both tasks. The experiments demonstrate that switching between languages in production tasks results in higher switch costs than in reception tasks.

However, one might argue that the higher switch costs in the production versus the reception tasks resulted from the higher overall RT level in the production tasks. On average, RTs are about 100 ms slower in the production tasks as compared to the reception tasks of the present study. This difference was still evident in Experiment 2, in which task requirements and the number of answer alternatives were similar between the production and the reception task. Yet, it has to be noted that the production and the reception tasks in the experiments always differed with respect to the stimulus modality and the response modality.
(visual/verbal for the production tasks and auditory/manual for the reception task). To see whether the overall RT difference was responsible for the difference in the size of switch costs, switch costs were also calculated as proportional scores rather than absolute RT differences. Again, substantially higher switch costs for the production than the reception tasks were found. Thus, the author of this work is confident that the difference in the overall RT level alone cannot account for the switch-cost difference between production and reception tasks.

A possible answer for the question why switch costs are higher in production than in reception tasks comes from studies that use a go/no-go design. Results showed that switch costs were smaller after no-go trials than after go trials (cf. Philipp, Jolicoeur, Falkenstein, & Koch, 2007; Schuch & Koch, 2003). This indicates that response-related processes (i.e. response selection and/or response execution) play a crucial role for the size of switch costs. Thus, one might argue that switch costs increase in tasks in which the distinction between L1 and L2 becomes relevant at response execution as compared with tasks in which the distinction between L1 and L2 is relevant at the stimulus level. In production tasks, participants usually have to act in L1 or in L2 whereas participants receive information in either L1 or in L2 in reception tasks. This difference might result in higher switch costs in production than in reception tasks.

Also authors like Thomas and Allport (2000) and von Studnitz and Green (2002) argued that the nature of the response required influences switch costs. That is, the language switching seems to interact with response type. In this context, it is also interesting to note that switch costs in the reception tasks of the present study were smaller in Experiment 1 (on average 14 ms) than in Experiment 2 (on
average 65 ms), in which four, language-specific response keys were used. In detail, in Experiment 1 the ‘productive’ cost of language switching was absent as the response keys were language non-specific. That means, the language of the input stimulus was irrelevant for the participant’s response. Therefore, the language switch was at a receptive level only. In contrast to that, in Experiment 2 the reception task also had a ‘productive’ language-switch component as participants were asked to produce their answer dependent on the input language (see also Jackson et al., 2004).

The same applies to Experiment 5. Here, switch costs were also larger in the category-reception task (on average 72 ms), where a language-specific response was required, than in the number-reception task (on average 10 ms), where the response was language-independent. To summarize, switch costs seem to be larger when participants’ response is language specific. This was also attested by von Studnitz and Green (1997) in a receptive language-switching study. They showed that switch costs were greater for the language-specific lexical decision task than for the language non-specific lexical decision task. Concerning the language-specific task (first experiment), participants were asked to decide whether or not the letter string was a word in a specific language. In the language non-specific task (second experiment) participants were to decide whether the letter string was a word or not independent of the language. Therefore, the participant’s response was language specific only in the first experiment.

Differences between language production and language reception also become evident when looking at the processes that are necessary for production and reception (see, e.g., Indefrey & Levelt, 2004; Levelt et al., 1999). Next to the input
and output modalities, the most important difference with respect to language switching can be ascribed to interference between language schemas. That is, an unspecific digit stimulus might activate the corresponding lemmas in both L1 and L2 simultaneously so that interference between language schemas occurs (Hermans, Bongaerts, de Bot, & Schreuder, 1998) - which is not present to the same degree when the stimulus is already language specific as in reception tasks. As a consequence of the higher interference, also control processes can assumedly be higher (cf. Botvinick, Braver, Barch, Carter, & Cohen, 2001), which then results in higher switch costs.

Empirical evidence for different control processes when switching between languages in production vs. reception tasks is observed in ERP studies. Jackson et al. (2001) found activity over frontal and parietal areas of the cortex when participants switched between languages in a language production task. This frontal and parietal switch related activity could not be found for switching between language reception tasks (Jackson et al., 2004). In contrast, receptive language switching was associated with an early switch related activity over central brain areas. When we consider that specifically frontal and parietal activation is often associated with the resolution of interference (see Nee, Wager, & Jonides, 2007, for a meta-analysis), the differences reported by Jackson and colleagues further support the notion that more interference resolution is necessary when switching in language production than when switching in language reception tasks. As mentioned above, this could be an explanation for the higher switch costs in production than in reception tasks observed in the present study.
9.3 Inhibitory mechanisms in language switching

9.3.1 General inhibition of L1

The role of inhibitory processes in language switching (Finkbeiner, Almeida, Janssen, & Caramazza, 2006; Philipp & Koch, 2009) as well as in cognitive control in general is currently a major topic of research (see Koch, Gade, Schuch, & Philipp, 2010 for a review). However, it is important to note that there are different kinds of inhibitory mechanisms in language switching. One kind of inhibition in language switching is the general inhibition of one language. The empirical signature of the general inhibition of L1 was the slower RT for L1 responses as compared to L2 responses which was observed in all production tasks that contained direct naming (Experiment 1, 4, 6; please note that Experiment 7 also included a productive direct-naming task; however, there was no difference between L1 and L2). In contrast, L1 responses were faster than L2 responses in each reception task, in the category-production tasks of Experiments 2 and 4, and in the control experiment.

A similar effect of inhibition in naming tasks was also found by other researchers (e.g., Christoffels et al., 2007; Costa & Santesteban, 2004b; Costa, et al., 2006; Schwieter & Sunderman, 2008). Christoffels et al. (2007) argued that the context of language switching especially affects performance in L1. Bilinguals mainly control the activation level of the dominant language to compensate the imbalance between L1 and L2. This facilitates lexical output in L2 and causes longer RTs in L1 (see Costa & Santesteban, 2004b; Costa et al., 2006 for additional discussion).
However, the results of this work at hand extend these previous studies (Christoffels et al., 2007; Costa & Santesteban, 2004b) in so far as it is demonstrated that a general inhibition effect occurs only in specific language-switching tasks. That is, a general inhibition of the dominant language was observed for productive naming tasks but neither for productive digit-categorization tasks nor for any reception task. It is suggested that a general inhibition of the dominant language occurs only in situations in which premature responses in L1 are likely - as in direct naming. In contrast, a categorization task already takes some time so that a premature response in L1 is prevented. In this sense, response speed or response availability would play a role for the occurrence of general inhibition. A similar idea, albeit not in the context of general inhibition, was proposed by Finkbeiner et al. (2006). These authors suppose that participants become suspicious of a very easy response and, therefore, presumably dismiss this response. However, although the number-reception task of Experiment 5 was an easy task, participants showed no general inhibition of L1. Therefore, one can exclude the assumption that an easy task per se causes participants to increase the activation threshold of L1 which results in a general inhibition of L1. Rather, easy tasks that imply a response in either language (like in digit or picture naming) have participants re-think before giving a response in L1 too soon. Concluding, it is assumed that the occurrence of general inhibition depends on the type of task as well as on the specific type of response.

Please note that the idea of a general inhibition of the dominant language as just described differs from the inhibition proposed in Green’s (1998) ICM. The crucial difference is that the ICM does not suggest a general inhibition of one language but a reactive inhibition of a competing language that is adjusted from trial to trial.
Inhibition in the sense of the ICM is necessary for the resolution of interference between competing language schemas and can be assumed to be one cognitive control process that plays an important role for the occurrence of switch costs. In contrast to that, the idea of a general inhibition is not the one that can explain switch costs.

### 9.3.2 Asymmetrical switch costs

The inhibition suggested by Green (1998) is reactive and depends on the amount of activation the irrelevant language receives in any given trial. The higher the activation of the currently irrelevant language is, the higher the inhibition of this language will be. Therefore, the dominant and highly activated L1 receives a stronger inhibition than the non-dominant L2. As a consequence, a difference in the languages’ dominance should result in asymmetrical switch costs with higher switch costs for L1 than for L2 (cf. Meuter & Allport, 1999).

However, studies that specifically compared switch costs in L1 and L2 found a lot of different results. Some researchers found the expected asymmetrical response patterns (Meuter & Allport, 1999; Philipp et al., 2007), whereas others did not (Costa et al., 2006). Next to that, some researchers (e.g. Gollan & Ferreira, 2009; Wodniecka et al., in preparation; as cited in Kroll et al., 2008) argue that the reliance on inhibition does not necessarily cause asymmetrical switch costs in a language-switching task. In the present study results were also heterogeneous. In Experiment 1, switch costs were larger in L1 than in L2 in the reception task, whereas there was no substantial difference in the production task. In contrast, switch costs were smaller in L1 than in L2 in both tasks of Experiment 2. For
Experiment 4, asymmetrical switch costs with larger switch costs for L1 than for L2 were observed in the name-production task, whereas there was no difference found in the category-production task. Again other results were found for Experiment 5 - symmetrical switch costs for the number-reception task and asymmetrical switch costs (L1 < L2) for the category-reception task. Experiment 6 revealed symmetrical switch-cost patterns in both tasks whereas Experiment 7 showed asymmetrical switch costs (L1 > L2) in the production task and symmetrical switch costs in the reception task (see Table 14 for an overview).

Table 14. Overview of the direction of asymmetrical switch costs in each task of the experiments within this study. L1=L2 indicates that switch costs were symmetrical.

<table>
<thead>
<tr>
<th>Task</th>
<th>Production (name)</th>
<th>Reception (category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1</td>
<td>L1=L2</td>
<td>L1&gt;L2</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>L1&lt;L2</td>
<td>L1&lt;L2</td>
</tr>
<tr>
<td>Experiment 4</td>
<td>L1&gt;L2</td>
<td>L1=L2</td>
</tr>
<tr>
<td>Experiment 5</td>
<td>L1=L2</td>
<td>L1&lt;L2</td>
</tr>
<tr>
<td>Experiment 6</td>
<td>L1=L2</td>
<td>L1=L2</td>
</tr>
<tr>
<td>Experiment 7</td>
<td>L1&gt;L2</td>
<td>L1=L2</td>
</tr>
</tbody>
</table>

To go into detail, it becomes obvious that especially the reversed asymmetric pattern in Experiment 2 is unexpected and one currently can only speculate about possible explanations. When having a closer look on the data pattern in
Experiment 2, it becomes obvious that a performance difference between L1 and L2 was found for switch trials, whereas the difference in no-switch trials was pronounced less. However, participants were not slower in L1 switch trials than in L2 switch trials as it would have been expected from the ICM by Green (1998) but worse in L2 switch trials than in L1 switch trials – which resulted in the higher switch costs for L2 than for L1. Consequently, one could argue that participants of the second experiment were highly proficient in L2 and therefore inhibition of L2 was stronger than inhibition of L1. Yet, at least when looking at the self-rated competence, participants in Experiment 2 had a lower L2 proficiency than participants in other experiments (on average) so that there is no specific evidence for a high L2 proficiency in the second experiment.

However, next to language proficiency also practice effects or specific task experiences are known to influence the switch-cost asymmetry (Yeung & Monsell, 2003). Thus, another explanation could be that participants specifically biased their lexicalization process towards their weaker L2 so that L2 might have been highly activated and thus were also highly inhibited. A reason for this could be that participants needed higher cognitive activation in L2 to be able to categorize L2 digits as fast as possible because mathematical categorization usually occurs in L1, the language in which numbers are learned. As both the production and the reception task in Experiment 2 required digit categorization, this effect might have been present in Experiment 2 and not in Experiment 1. Additionally, in Experiment 2, the categorization was language-specific for both the production task and the reception task, whereas categorization was language non-specific in the reception task of Experiment 1. Thus, participants in Experiment 1 could have mentally performed each categorization in L1, resulting in a higher activation and
higher switch costs in L1 than in L2. In contrast, participants in Experiment 2 might have specifically activated L2 in order to perform the language-specific categorization, resulting in the reversed switch-cost asymmetry. Results of the category-reception task of Experiment 5 underline this hypothesis as the task was the same as in Experiment 2 and, again, switch costs were larger in L2 than in L1. In this sense, the specific task requirements might play a role for the switch-cost asymmetry. It is also interesting to note at this point that opposite asymmetric patterns of switch costs have also been found by other studies that used different tasks (see, e.g., Proverbio, Leoni, & Zani, 2004; see also Alvarez, Holcomb, & Grainger, 2003, for similar effects in an ERP study using a semantic categorization task). In detail, Proverbio et al. (2004) tested bilingual’s switching mechanism by using a semantic processing task (reception task) in which participants decided whether the final word of a sentence was semantically congruent with the rest of the sentence. The authors found faster reading and comprehension latencies when the final word was a L1 word (L2 to L1 switch) than when it was a L2 word (L1 to L2 switch). This opposite asymmetric pattern of switch costs was explained by the fact that the experimental design was blocked. That is, the participants were instructed about the type of block (mixed or unmixed) and about the direction of the switch. Possibly, participants mainly concentrated on L2 in order to be able to understand the body of the sentence. As already hypothesized for tasks used in Experiment 2 and 5 of the study presented within this work (see above), this might have resulted in higher cognitive activation of L2 than L1.

According to Abutalebi and Green (2007), it is still unclear under which circumstances asymmetrical switch costs arise. They further state that not every
language-switch situation evokes an asymmetry. For example, Costa and Santesteban (2004b) suggest that L2 proficiency influences asymmetries. Whereas unbalanced bilinguals show an asymmetrical switch-cost pattern, balanced bilinguals show a symmetrical switch-cost pattern. However, Costa and Santesteban (2004b) also demonstrated that the absolute difference in the dominance of two languages does not always predict the presence of an asymmetry. They found that bilinguals (balanced with respect to L1 and L2) showed a symmetrical switch-cost pattern even when switching between L1 and a weak L3. That is, a symmetrical switch-cost pattern was found when bilinguals were highly proficient in any two languages - irrespective of the languages used in the experiment. Nevertheless, the same study showed that highly proficient bilinguals with respect to L1 and L2 showed asymmetrical switch costs when switching between L3 and L4 or between L1 and a newly learned language. These results reject the authors’ hypothesis that L2 proficiency and symmetrical switch-cost-patterns are interconnected.

Verhoef, Roelofs, and Chwilla (2009) also furnish proof to the contrary of Costa and Santesteban’s (2004b) L2 proficiency hypothesis by demonstrating that both asymmetrical and symmetrical switch costs were found as a function of preparation interval (short versus long cue-stimulus interval (CSI)) in a single group of unbalanced bilinguals. The authors concluded that the CSI has an effect on asymmetrical switch-cost patterns.

Similarly, the present study also showed that the same participants showed different (a)symmetrical switch-cost patterns between tasks in all experiments except in Experiment 2 and 6. More clearly, in the present experiments the same
participants were tested in two different tasks in each experiment. According to Costa and Santesteban (2004b) the (a)symmetrical switch-cost pattern should have been the same between tasks in one experiment as the level of L2 proficiency was the same. However, the (a)symmetrical pattern between tasks for each experiment was diverse (except for Experiment 2 and 6). This stresses the idea that the specific task requirements also have an influence on the asymmetry. Furthermore, this allows the conclusion that the L2 proficiency alone cannot predict the occurrence of (a)symmetrical switch costs as suggested by Costa and Santesteban (2004b).

In another approach Costa et al. (2006) tried to explain the occurrence of asymmetrical switch costs in dependence on the effect of a general inhibition of L1. Results of their study showed that switch costs were symmetrical when participants generally inhibited their L1 due to the more balanced relative activation of both languages. However, this cannot be attested for all experiments within this work at hand. That is, the name-production task of Experiment 4 showed asymmetrical switch costs although a general inhibition of L1 was observed. Furthermore, there were other tasks that elicited symmetrical switch-cost patterns but no general inhibition of L1 (e.g., the category-production task of Experiment 4). Therefore, the present findings do not support this idea without exception.

Taking together all these findings, one gets the impression that there seem to be a lot of approaches that try to predict and explain the occurrence of an asymmetry. However, apparently no current model accounts transparently for the full range of behavioral data. There is a lot of evidence showing that switch-cost
asymmetries are influenced by a number of different factors. Numerous factors still seem to be unknown. The present study sheds some light on this as results suggest that the type of task (language production vs. language reception) and the specific task requirements (digit naming versus digit categorization) play a role for switch-cost asymmetries next to other factors like L2 proficiency or the specific CSI. Moreover, results of the present study provide further evidence that inhibitory processes in language-switching tasks do not automatically give rise to asymmetrical switch costs. Results concerning the asymmetry were diverse within this work. But, the switch costs per se found in the language-switching studies within this study provide compelling evidence that participants inhibited their non-target language while using the target language. The process of overcoming the inhibition took time. Therefore, participants showed longer RTs in switch trials than in no-switch trials.

9.3.3 Influence of language-switching experience on inhibitory mechanisms

The switching performance within language-switching tasks will be further discussed in the following. However, the main focus in this section is on the performance of different groups of bilingual speakers. That is, the robustness of switch costs was compared between bilinguals that were experienced in constant language switching due to working in an international company where language-switching was constantly demanded (participants of Experiment 6 = experienced participants) and bilinguals that had no experience in language switching (participants of Experiment 1 & 7 = non-experienced participants). Note that
Experiment 1 was conducted with participants at university whereas Experiment 7 was conducted with employees working at an international company where no language switching takes place. The comparison was drawn between Experiment 1 and 6 as well as between Experiment 6 and 7. The interesting question was whether a difference in the experience levels in language switching gives rise to different switch-cost patterns. In other words, the goal was to examine whether constant language switching at work still causes switch costs.

Bialystok, Craik, Klein, and Viswanathan (2004) note that a lifetime of experience as a bilingual leads to an advantage in general cognitive control processes. And, Christoffels et al. (2007) further state that language switching in everyday life should increase the ability to control languages. According to Colzato et al. (2008), bilinguals that are used to switching between languages show an advanced ability to select important from unimportant stimuli. Consequently, one might assume that bilinguals that are used to daily language switching need less inhibition than others due to their efficient top-down support of goal-relevant activities. However, there are no studies until date that tested and compared participants directly that are experienced in language switching with those that are not experienced.

According to Green (1998), an increased L2 proficiency should result in a reduced dominance difference between languages. And, this should cause less switch costs and less asymmetry due to a similar activation and inhibition level between languages. Therefore, the first interesting question was whether experienced participants had developed a better L2 proficiency due to using L2 at work frequently than non-experienced participants. The between-experiment
comparison of Experiment 1 and 6 did not reveal an advantage in L2 for experienced participants. This was underlined by the self-rated English skills of participants. That is, participants of Experiment 1 (mean score of 5.22 on a seven-point scale where 7 was very good) and those of Experiment 6 (mean score of 5.11) rated their L2 proficiency with a very similar score. It can be speculated whether participants of Experiment 1 were already quite proficient in L2 due to reading English literature, for example, and participants of Experiment 6 were skilled due to switching between L1 and L2 at work. This might be the reason for the fact that no L2 proficiency difference could be found between participants of Experiment 1 and 6. Moreover, this missing L2-proficiency difference might have caused similar switch cost patterns between experiments.

Concerning the between-experiment comparison of Experiments 6 and 7, experienced employees of Experiment 6 showed faster RTs in L2 than non-experienced employees of Experiment 7 in the reception task. Unfortunately, for the production task, the ANCOVA showed that the L2 difference between experiments was confounded by age. Therefore, the faster RTs in L2 for experienced employees than for non-experienced employees could not be attested for that task. However, when examining the self-rated English skills, it shows that participants of Experiment 6 rated their L2 proficiency with a higher mean score of 5.11 than participants of Experiment 7 (mean score of 3.51). This leads to the assumption that the experienced participants of Experiment 6 were more proficient in L2 than the non-experienced participants of Experiment 7. Consequently, the dominance difference should also be reduced between L1 and L2 for experienced participants. As said above, according to Green (1998), this should give rise to reduced switch costs. However, the present data show that
switch-cost patterns were similar between Experiment 6 and 7. Employees working in international companies showed switch costs (concerning RTs and error rates) although they have to switch languages at work constantly. Generally speaking, data suggest that switch costs occur independent of the level of experience in language-switching. Furthermore, the author of this work suggests that even proficient language switchers need to revert to inhibitory mechanisms. To give a practical example, a typical situation in an international company where language switching is a daily task is that employees write/read an E-Mail to a colleague in their L2 and afterwards continue their work by using their L1 again. Results of this work suggest that this language switch causes the RT to slow down and evokes more errors than when using the same language again.

Certainly, one might speculate whether results were influenced by other factors. For instance, it can be considered whether employees will show a better language-switching ability only when they use their ‘company language’. According to Welch, Welch, and Piekkari (2005) there are different kinds of language layers (i.e. specific forms of languages) a person uses. The company language is a formal type of language layer that contains special work-related topics and vocabularies. Possibly, the better switching ability is restricted to that language layer and, consequently, a better switching ability exists but could not be shown in this study.

Another possible explanation for similar switch-cost sizes within this work at hand might be that the kind of task had an influence on the switch-cost pattern, as already discussed in a former section. That is, the specific task requirements might determine the data pattern within language-switching tasks. This is
underlined by the fact that similar results were found for the same task that was conducted by means of different participants that represent two diverse groups of bilinguals (experienced versus non-experienced).

However, as research in this field is completely novel, conclusions drawn from these results are very speculative in nature. Yet, also considering results from other experiments within this study - for the moment and until differing results are presented it is deduced that switch costs are robust enough in nature to withstand experience in language switching. This is indirectly underlined by authors like Wang et al. (2007) who suggest that there is no specific brain area that is responsible for language-switching.

All in all, the author summarizes the recognition at this point that international corporations should deal with the problems that obviously result from language switching in language reception and language production. Concerning an employee’s work, switch costs might influence work permanently by decelerating work processes and creating errors. Certainly, further research is needed to deal with this problem that is caused by our globalized world.

9.4 Open issues and possible limitations of this work

In this last section, suggestions for further research fields as well as limitations of this study will be discussed. Certainly, the present study provides evidence for the fact that language-switch costs are a robust factor that arises in language-switching tasks. This seems to be independent of the fact whether the task is a language production or a language reception task. In addition, language-switch costs seem to occur also for participants that are experienced in constant
language switching. These results are consistent with predictions made by Green (1998). However, another factor that seems to be rather less robust and predictable is the asymmetry of switch costs. According to Green (1998), switch costs should be asymmetrical with larger switch costs for L1 than for L2. Yet, the work at hand yielded a very complicated pattern of (a)symmetrical switch costs as each task showed a unique pattern of results. The fact that different types of production and reception tasks were used might have created this heterogeneous pattern. Nevertheless, the circumstance that this diverse pattern was found highlights that the occurrence of asymmetrical switch costs might depend on many unknown factors. For example, this work certainly makes an important contribution by showing that the specific task requirements of language-switching tasks seem to play a role for the occurrence of an (a)symmetry. However, further research is certainly needed to reveal which specific task requirements and what kind of other factors influence asymmetrical switch-cost patterns.

Another aspect of this work that poses a challenge to postulations made by Green (1998) is the observation of similar switch costs between participants that were experienced and those that were not experienced in language switching. As already described, the ‘dominance-difference theory’ proposes that the more similar the two languages’ dominance is the less switch costs arise. A more similar dominance difference between L1 and L2 is expected for participants that switch between L1 and L2 constantly. Therefore, participants in Experiment 6 should have shown less switch costs compared to participants of other experiments that did not have the same experience in language switching. This could not be attested. However, this work is only the beginning of exploring the effects of language-switching experience on switching performance, and
additionally, on the situation in international companies. Further investigation is
needed to test bilinguals that constantly switch between languages to investigate
the relationship between inhibitory control and the frequency of language
switching (i.e. language-switching experience). However, there might also be
possible objections against this study and the second empirical part, in particular.
First, one critical point is that the sample size between Experiment 6 and 7
differed largely. Note that 53 participants took part in Experiment 6 whereas only
18 participated in Experiment 7. According to Keppel (1991), dissimilar sample
sizes can endanger the interne validity of the experiment and lead to a
misinterpretation of results. Furthermore, sample sizes of less than 30
participants allow only imprecise estimations, as postulated by Bortz (1999).
Therefore, the small sample size of Experiment 7 may not be able to represent
that population in an adequate way. Possibly, the small sample size as well as
the dissimilar sample sizes between experiments might have influenced results.
Consequently, increased sample sizes should be used for future research.
Besides that, a continuation of this study could be to test employees’ language-
switching ability when they switch in their company-language layer. As already
mentioned in the General Discussion, the better switching ability of employees
could possibly be restricted to the company-language layer and, therefore, the
present study was not able to show this. Certainly, more research should be
made in international companies, in general, to be able to generalize results.
Bilinguals' switching performance was studied in seven experiments in order to compare language switching performance in language production and language reception tasks. A direct comparison between production and reception tasks was not possible in former studies as different participants took part in the different experiments. The groups of bilinguals within this study differed with respect to their language-switching experience. That is, participants were either experienced in constant language switching due to work-related experience or not experienced. The testing of the switching performance of participants with work-related language-switching experience is an unexplored and novel field of research. All participants showed significant language-switch costs in all experiments and in all types of tasks independent of the switching experience of the participants. Thus, language-switch costs appear to be a very robust empirical finding. This result is interpreted in terms of a need to revert to the use of inhibitory mechanisms while switching languages. An important and novel finding of this work is that switch costs were higher in the production tasks compared to the reception tasks. Therefore, it is concluded that the size of language-switch costs depends on the type of task (production vs. reception). To account for this difference, the author of this work suggests an influence of the different input and output modalities as well as higher between-language interference when switching between languages in production as compared to reception tasks.

Furthermore, another important result is the general inhibition of L1 that was found in productive direct-naming tasks but neither in productive categorization.
tasks nor in any reception task. The finding of a general inhibition of L1 was already attested by other researchers (i.e. Christoffels et al., 2007) who suggested that bilinguals automatically adjust their L1 activation in a bilingual situation to make lexical selection in L2 easier. However, this assumption was extended and specified in the present work as bilinguals seem to automatically adjust the activation threshold of L1 only in easy production tasks (e.g. direct naming) in which a response in either language is required.
References


REFERENCES


http://www.weltsprachen.net/weltsprache-englisch.html