Lexical activation and inhibition of cognates among translation students

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1 Introduction

A central question in translation studies is why translators translate a source text in a particular way. In the beginning, this question was predominantly explored from a theoretical perspective or by investigating the work of only one translator.

With time, researchers in translation studies started to use corpus linguistics to empirically study translations. In this context, they discovered that translations differ from original texts. This discovery resulted in the formulation of different theories about why translations differ from original texts. Some of these theories, which became very influential, suggested that the naturally occurring cognitive processes during translation are responsible for the production of certain linguistic elements – instead of, for example, consciously chosen strategies.

One of these theories is the gravitational pull hypothesis by Sandra Halverson. What makes this theory more credible is that it is based on empirically driven models used in the psycholinguistics of bilingual[1] language processing. These models include information about the way words are stored in the mental lexicon and how they are accessed during translation. In addition to the claim that the structure of the mental lexicon and the naturally occurring processes during language processing lead to specific choices in terms of translation solutions, Halverson also suggested that these mechanisms change with increasing translation experience. To my knowledge, these assumptions have not yet been tested by applying well-established psycholinguistic paradigms in translation studies.

In this thesis, I thus test whether the cognitive mechanisms claimed to be responsible for translation output change with increasing translation experience. Although the mechanisms described in this thesis might be important for interpreting as well as translation, I decided to concentrate

[1] In the following, a bilingual will be defined as a person who speaks two languages. If necessary, it will be specified which type of bilingualism applies to a certain study or model (e.g. balanced vs. unbalanced, early vs. late; for a review of different types of bilingualism see for example de Groot 2011).

only on translators and the translation of written language as this was also the focus of Halverson's theory.

1.1 Current investigation

Many investigations in translation studies tend to use ecologically valid experimental setups. This means, for example, that translators translate entire texts that have only been slightly modified. The behavior of the translator is tracked by means of eye-tracking, keystroke logging or the translators are asked to verbalize their thoughts.

The experimental power of these methods, however, is limited. Especially when a translation theory is built on psycholinguistic models, paradigms and research methods from the latter field might be a better choice to investigate for example the interaction between translation experience and language processing.

In this study, I therefore applied a psycholinguistic paradigm (word translation test) combined with event-related potentials. The stimuli were cognates and non-cognates. Cognates (translation equivalents which share both meaning and form, e.g. English: *system*, German: *System*) and non-cognates (translation equivalents with no formal overlap, e.g. English: *fear*, German: *Angst*) have been investigated both in psycholinguistics and in translation studies. The main research focus in translation studies has been their frequency of use in translations. In psycholinguistics, cognates are well-studied words which are used to gain insights into models of the bilingual mind. The following chapters will show that cognates might be a good choice for the investigation of changes in language processing linked to translation experience as suggested by Halverson.

The application of this controlled methodology will also represent a suggestion for how the disciplines translation studies, psycholinguistics and neurolinguistics can be combined to gather new insights into the translation process. Especially the application of event-related potentials, which is still rare in translation studies, might provide fruitful insights into the translation process:

> “[...] ERPs are an excellent technique to provide these finer-grain measures that will allow the field to gain important information about the dynamics of language processing as it unfolds in time.” (Moldova et al.: 2016: 11)

Just as for studies on bilingual language processing, event-related potentials might, for example also uncover new opportunities in translation studies.

1.2 Outline of the thesis

This thesis will start with a discussion of psycholinguistic theories and models of language processing. The discussion includes a description of the mental lexicon (Chapter 2), lexical access during reception and production (Chapter 3) as well as the function of language control (Chapter 4).

These theories will be presented early on because the models in translation studies, especially the gravitational pull hypothesis, are based on the models used in psycholinguistics. In the aforementioned chapters, a connection will be always made not only to bilingual language processing but also to translation.

In Chapter 5, current research on frequency effects in translations will be presented. As the cognitive explanations of these effects are the motivation and starting point of the present study, the state of the art in this research field will be presented. In this context, the classification of frequency effects will be outlined as well as theories on their mental causes, research conducted on translation experience and frequency effects, and cognates as frequency effects.

An introduction to a possible methodology to investigate language processing during translation and changes linked to translation experience (Chapter 6) will follow the theoretical presentation of the state of the art. This includes the word translation paradigm as well as the use of event-related potentials. The advantages of these methods over those methods and tasks traditionally used in translation studies will also be discussed in this chapter.

In Chapter 7, a hypothesis will be formulated on the basis of the previously introduced theories. The study that was conducted to test this hypothesis will be the focus of Chapter 8, followed by the conclusion in Chapter 9.

2 Mental lexicon

The part of the long term memory where words are stored is often referred to as the mental lexicon (Aitchison 2012). Its structure influences how easy or difficult it is to access words during language reception and production.

It is not only researchers of psycholinguistics who stress the role of the mental lexicon; some theories in translation studies also attribute an important role to the structure of the mental lexicon. One of these theories is Halverson's gravitational pull hypothesis (2003, 2010, 2017), which will be presented in Chapter 5.2. Although the structure of the mental lexicon has attracted some attention in translation studies as well, research on the properties of the mental lexicon derives almost exclusively from psycholinguistics. This lack of basic research on the mental lexicon in translation studies stresses the importance of the role of interdisciplinary work and of integrating theories and models from, for example, psycholinguistics into translation studies. In the following, models on the mental lexicon from the latter field will thus be introduced.

As the following chapters will show, the mental lexicon, the mechanisms of lexical access, and language control play an important role for the reception and production of words in monolinguals and bilinguals. The structure of the mental lexicon is also important for the understanding and modeling of mechanisms of lexical access and language control. As these theories are based on the models of the mental lexicon, the description of mechanisms influencing bilingual language processing will start with a discussion on the models of the mental lexicon.

The first focus of this chapter is on discussing the question how words are mentally stored – in whole units or in chunks of information. Next, I will address the question how this information is linked in the mental lexicon as the structure plays an important role during lexical access. The theories presented in Chapter 2.1 are mainly based on the monolingual lexicon. But models of the bilingual lexicon are mostly extended versions of the monolingual theories or have been inspired by these theories. As the organization of two languages in the mind is a crucial point for understanding language processing during translation, models of the bilingual lexicon will then be introduced in Chapter 2.2, which also includes theories about the translators' mental lexicon.

2.1 The monolingual lexicon

When modeling the structure of the mental lexicon, the first question that needs to be addressed is how words are mentally stored. Are they stored as whole units or do they consist of different elements? According to several theories, words consist of different components. Evidence for this comes mainly from the investigation of speech errors in healthy speakers. Researchers recorded the speech output of healthy speakers and investigated their speech errors in order to formulate conclusions about the structure of the mental lexicon. In the following, different theories about the units that are assumed to constitute words as well as their representation in the mind will be presented.
Saussure (1971; see also Figure 1 for a model of a two component word representation) already suggested that words are stored as two parts in the mind, as concepts and word forms. This separation between meaning and form can be found in the theories of several researchers from different branches of linguistics, such as in the semiotic triangle of Odgen and Richards (1929). Here, the focus lies on the relationship between the world and the perception thereof. In psycholinguistics, the division between form and meaning has been applied as a basis for modeling the mental lexicon. The distinction between form and meaning is generally accepted and has often been used to explain speech output, and in particular speech errors: for example, the division of form and meaning explains why speech errors sometimes have a similar meaning and sometimes a similar form to the intended word (e.g. Kempen & Huijbers 1983: 186; see also Collins & Loftus 1975; Langacker 1987; Levelt 1989). Speakers sometimes, for example, choose a wrong meaning and then match it to the corresponding word form (e.g. *tomorrow* instead of *yesterday*, Kempen & Huijbers 1983: 186) or they sometimes choose a wrong but similar word form to the intended word and the corresponding

meaning (e.g. *result* instead of *resort*, Kempen & Huijbers 1983: 186). A further point to note is that it is a generally accepted fact that there is only one representation which is accessed during reception and production and not two representations – one for reception and one for production (e.g. de Bot 1992; Levelt 1989; Paradis 1984). In the following, the characteristics of word meaning and word form will be discussed in detail.

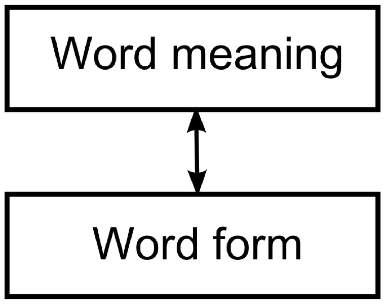

Figure 1: Representation of a word as two components, word meaning and word form according to the Saussure example

There is a huge debate whether the meaning part of words is divided into two components. Levelt (1989) suggested for example that there are semantic representations for each word as well as general knowledge concepts. This view has also been adopted by other researchers (e.g. Bierwisch & Schreuder 1992; de Bot & Schreuder 1993; Paradis 1984; Pavlenko 1999). One reason for this theory is that some conceptualized information is not part of the semantics of a word. In this context, Bierwisch and Schreuder (1992) use the example of the name *John* (ibid: 31). The semantic representation of this word would be the information that this is a proper name of a male person. The concept would contain specific information about all persons we know with the name John. The conclusion would thus be that there must be a difference between semantics and concepts. Many other models assume however only one conceptual representation and no separate semantic representation (e.g.

Caramazza 1997; Collins & Loftus 1975; Francis 1999). As very influential models of bilingual lexical processing adopted this view (see Chapter 3), it will be assumed in the following that there is no separation between semantics and concepts.

Word forms contain information about the phonological and orthographic form of the word as well as morphological information (Levelt 1989). They seem to be represented in base forms in the mental lexicon[2]. Prefixes and suffixes are added during the language production process. Only irregular forms seem to have a special representation (Poulisse & Bongaerts 1994). Word forms are often referred to as *lexemes* (Kempen & Huijbers 1983) and this label will also be used hereinafter.

Some researchers also mention a sub-lexical level. This consists of features which are, for example, part of phonemes (e.g. unvoiced, Dell 1986) or letters (Dell 1986; Snodgrass 1984). They are thus not directly a part of the words but they are a part of some influential speech production models (see Chapter 3).

Saussure's theory of concept and word form has been extended by some researchers in order to add syntactic information because the comprehension of words often depends on the syntactic context and speech errors often occur for example in the same word class. Several researchers therefore assume that syntactic information must be an important part of the mental representation of words. (e.g. Dell 1986; Levelt 1989; Levelt & Schriefers 1987; Roelofs 1992). Models including syntactic information also often assume the separation between concept and semantics described above. In these models, the syntactic information is assumed to form a representational unit that includes the semantic information of a word (e.g. Levelt 1989; see also Figure 2). According to Kempen and Huijbers (1983), this component is also referred to as a *lemma*.

[2] To avoid the problem of different representations of words with regular forms and words with irregular forms, only nouns in their base form will be used as stimuli in the present investigation.

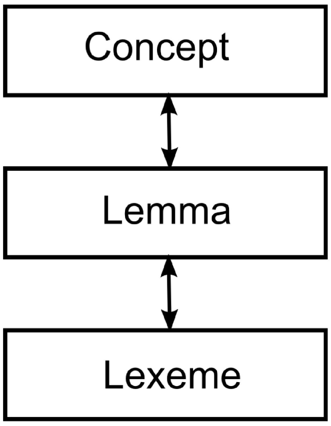

Figure 2: Representation of words as concepts, lemmata (semantics and syntactic information) and lexeme (word form) according to, for example, Levelt (1989)

But not all researchers agree on the existence of lemmata. According to Caramazza (1997) for example, there are no distinct syntactic representations (lemmata) that are activated by the conceptual representation before activation of the word form. He assumes, however, that there is a syntactic network which is activated during lexical access. Word forms can be activated and produced independently from the syntactic network. He draws this conclusion from a variety of studies on patients with brain injuries who had problems producing words of a specific grammatical class in only one production modality. One patient in a study by Caramazza and Hillis (1991) was for example able to correctly produce verbs and nouns when speaking but she was unable to produce nouns when writing. Verbs did not cause any problem during writing. Caramazza (1997) thus concluded that syntactic representations are not stored with the word form because this should not be influenced by the production modality.

Many other researchers also map concepts directly on word forms without the intermediate lemma (e.g. Collins & Loftus 1975; Snodgrass 1984). This view has also been adapted by many recent bilingual language processing models (see Chapter 3). In this thesis, it will thus be assumed that word meaning is only represented in concepts and that they are directly linked to lexemes (see Figure 1).

A second important question for the modeling of the mental lexicon is how concepts and lexemes are mentally organized. Two types of theories exist for the representation of concepts. According to decomposition views, concepts consist of smaller concept nodes. These components constitute attributes. By assembling them, they form, for example, a mental representation of a word meaning. (e.g. Bierwisch & Schreuder 1992; Dell 1986; Rips et al. 1973; Smith et al. 1974).

According to holistic models, concepts are represented as whole units (Collins & Loftus 1975; Quillian 1967). They are organized in a network and then linked according to semantic relations such as superordinate, subordinate concepts or according to synonymy (see also Levelt 1989). The more features concepts share, the more links they share. The entire meaning of a concept is, according to the holistic models, only accessed through the links in the network as they constitute the different properties of a specific concept. Collins and Loftus (1975: 408) discuss, for example, the concept of *typewriter*, which is linked to the concept of *machine*. The meaning of *typewriter* is thus only fully accessed when the connected concepts such as *machine* are also accessed.

Theories on networks and components are not that different. Where the network models assume more semantic connections between similar words, the component models assume more shared semantic features. Both theories can explain speech phenomena in monolinguals (e.g. Smith et al. 1974). Theories on a decomposition representation of concepts have, however, advantages when explaining the bilingual mind. This will be further discussed in Chapter 2.2.

Regarding the question how lexemes are represented in the mind, researchers generally agree that there is one lexeme for each word and that they are organized in a network-like structure. They are linked according to the features they share. The more features they share, the closer they are linked (Collins & Loftus 1975, see also Dell & O'Seaghdha 1992).

In conclusion, and based on the theories presented above, it can be assumed that words are mentally represented in concepts and lexemes. Two major theories exist about the representation of concepts, the decomposition view and the holistic view. Both theories can explain speech phenomena in monolinguals. Regarding bilinguals and especially translators, a question that is still to be answered is how several languages are organized in the mind. In the following chapter, theories about the representation of concepts and lexemes in the bilingual mind will thus be presented in order to answer this question.

2.2 The bilingual lexicon

Regarding conceptual representation, models of the bilingual lexicon can, in parallel to those of the monolingual lexicon, be divided into holistic and decomposition models. Within the holistic models, some researchers assumed one concept for each word in each language (e.g. Kirsner et al. 1984; Kolers 1963; Scarborough et al. 1984). Kolers (1963) argued for example that if bilinguals had only one conceptual representation for their two languages, for example for the word *butterfly* (ibid: 297), they should provide a similar explanation for these concepts in their two languages. Kolers investigated this assumption and the results showed the contrary: participants gave very different explanations to the words in their L1 and the respective translations in their L2. Kolers thus assumed that there are no shared conceptual representations in bilinguals. Another indicator for this theory comes from Scarborough and colleagues (1984). They conducted a lexical decision task[3] which included the repetition of trials. The participants were divided into two groups. Each group performed a two-part lexical decision task. One participant group performed a monolingual lexical decision task. In the second part of the task, they were presented with intralingual repetitions of trials of the first part. The second group of participants performed a bilingual lexical decision task. In the first

[3] In lexical decision tasks, participants are presented with strings of letters. Some of the trials are words, others are non-words. The participants have to decide as quickly as possible whether the stimuli are words or not (e.g. Tweedy et al. 1977).

block, they were presented with Spanish trials and in the second part with English trials. Some of the English stimuli were translations of the Spanish stimuli of the first part of the experiment. Participants were faster to respond to the within-language repetition trials. But the across-language repetition did not influence the reaction times (RTs). The authors' interpretation was that the concepts in the intralingual condition were primed[4] by the processing in the first part of the experiment. In the interlingual condition, no priming occurred. If the conceptual representations were shared across languages in bilinguals, the across-language repetition should also have influenced the reaction times. Scarborough and colleagues therefore interpreted this as separate mental lexicons for bilinguals, including separate language specific concepts. Schwanenflugel and Rey (1986) criticized, however, that semantic priming might deteriorate faster than the phonological priming effect. In the intralingual condition, semantic as well as phonological priming were present while only semantic priming occurred in the bilingual condition. Phonological priming might be strong enough to have an effect although the time between the presentation of prime and target in the two different experimental blocks was rather long. Semantic priming may no longer have an effect after this time. The authors therefore conclude that these kinds of experiments cannot prove the existence of separated, language-dependent concepts.

In other holistic models of the bilingual lexicon, there is only one language-independent concept which is shared by words of the L1 and L2 (e.g. Chen & Ng 1989; MacLeod 1976; Potter et al. 1984; Schwanenflugel & Rey 1986). For example, Schwanenflugel and Rey (1986) performed a lexical decision task, where the stimuli were preceded by semantically related or neutral primes in the target language or in the non-target language. In contrast to Scarborough's experiment, the time between the prime and the target was much shorter (300 ms instead of a separation into two experimental blocks). Schwanenflugel and Rey found semantic

4 Priming has been defined as the preparation or pre-activation of elements in the mental lexicon by certain trigger words. In monolingual contexts, the strength of pre-activation depends on the similarities of the word pairs (conceptual and/or lexical). Primed words can be retrieved faster than control words (e.g. Collins/Loftus 1975).

priming in interlingual as well as intralingual conditions and interpreted this as an indicator for shared concepts between languages.
In addition to the holistic models, decomposition models for conceptual representations have also been proposed for the bilingual mental lexicon. De Groot's distributed features model (DRM, de Groot 1992a, see also Thomas & van Heuven 2005; van Hell & de Groot 1998, and Figure 3) is an example for a decomposition model of conceptual representations in bilinguals and it is similar to the models presented in Chapter 3.1. De Groot suggested that lexemes from L1 and L2 are connected to a language independent storage of concept nodes. The lexemes are linked to all nodes required to form the meaning of the word. De Groot's model is a particularly good explanation for the representation of translation equivalents. These words often differ slightly in their meaning as shown by Kolers (1963). This is especially the case for abstract words (Taylor 1976). When assuming one common conceptual representation for translation equivalents as proposed by some of the holistic models, it is difficult to account for this fact. The distributed features model, can however explain small differences: most of the conceptual nodes are shared by words that differ slightly in meaning, but some conceptual nodes are only linked to the L1 word and others only to the L2 word.

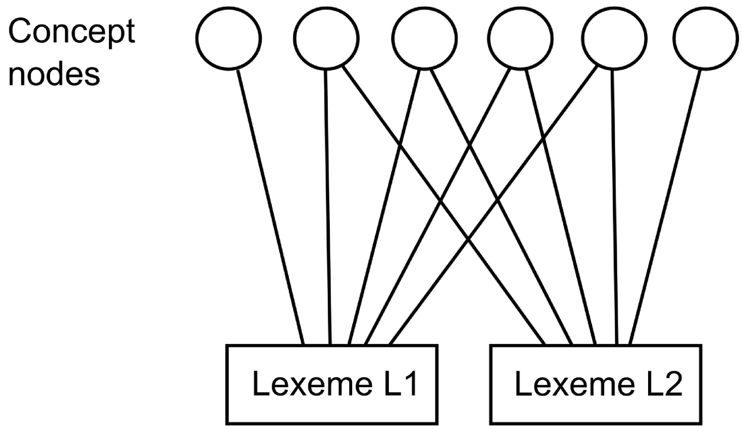

Figure 3: Conceptual and lexical representations in the bilingual mind according to de Groot's (1992a) distributed features model

Although holistic as well as decomposition models can explain the results of many bilingual word processing studies (see for example van Hell & de Groot 1998), decomposition models offer an explanation for overlapping but slightly differing meanings in the bilingual lexicon while assuming the advantage of language independent conceptual storage.

On the lexeme level, it is generally accepted, that there is one lexeme per word in each language (e.g. Colomé 2001; Costa et al. 2005; Kroll & Stewart 1994; Potter et al. 1984). There are however different theories about the integration of lexemes of two languages. How are the lexemes of two languages linked on the lexeme level and how are they linked to the conceptual level? Potter and colleagues (1984) made the distinction between the concept mediation hypothesis and the word association hypothesis (see also Figure 4). According to the concept mediation hypothesis, lexemes of two languages are only connected via the language independent concept. According to the word association hypothesis, lexemes of the L1 are linked to the conceptual level, but lexemes of the L2 which are learned after the L1 are only linked to the L1 lexeme and not to the conceptual level. This can naturally only be applied to bilinguals who acquired their L2 after their L1. Potter and colleagues also suggested that there might be changes in this structure with growing language proficiency. Lexemes of language learners might be stored according to the word association hypothesis and lexemes of more proficient bilinguals might be stored according to the concept mediation hypothesis. To test which representation of the mental lexicon is present in different types of bilinguals, Potter and colleagues compared the reaction times for picture naming (for a review of this paradigm see Glaser 1992) and word translation (see Chapter 6.1 for a detailed description of this paradigm) in fluent bilinguals and in non-fluent bilinguals. They assumed that during picture naming, participants have to access the concept of a word before they can articulate the response. During concept mediated translation, the concept would also have to be activated before articulation. During the word associated translation, this would not be the case because the translation route via the links between lexemes is shorter and thus preferably taken. Potter and colleagues assumed that word association would therefore result in shorter reaction times for word translation than picture naming. The authors however found the opposite. Picture naming was faster than word translation in both groups of bilinguals. They interpreted these results in favor of the concept mediation hypothesis (see also Chen & Ng 1989):

> “In summary, the results from the two experiments offer no support for the hypothesis that words of a second language are directly associated to corresponding words in the first language, even in nonfluent bilinguals. Rather, words in the two vocabularies are directly associated to concepts that are not linguistic, but amodal.” (Potter et al. 1984: 36)

This view, however, is controversial. According to many other researchers, there are links between lexemes in the mental lexicon (e.g. Brysbaert & Duyck 2010; de Groot 1992b; de Groot & Nas 1991; Paradis 1984). De Groot states for example:

> "Collins and Loftus (1975) already suggested that orthographically and phonologically similar words are linked in lexical memory. Although they never explicitly considered the memory structure of a bilingual, there is no reason that this type of link should be restrained to words within the same language." (de Groot 1992b: 1015)

Empirical evidence for links between lexemes in two languages comes for example from aphasics. Paradis (1984) reported the cases of aphasics who were able to translate words from one of their languages into another. They said however that they did not know the meaning of these words. This is an indicator for the existence of links between lexemes and that they can, at least in impaired speakers, provide a means of accessing lexical information during language production.

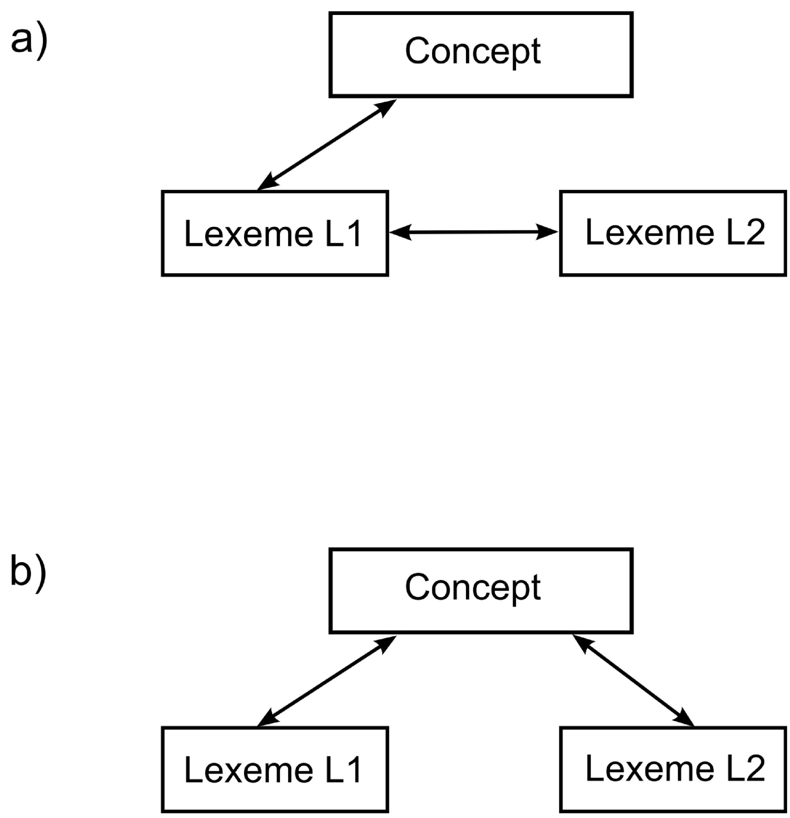

Figure 4: Representations of L1 and L2 lexemes in the mental lexicon according to the word association model (a) and the concept mediation model (b) of Potter and colleagues (1984)

Potter and colleagues' model was further challenged by several researchers (e.g. Kroll & Curley 1988; Kroll & Stewart 1994). Although Potter and colleagues found similar patterns in their experiments for fluent and non-fluent bilinguals, Kroll and Curley (1988) argued that the non-fluent participants might still have been too proficient to exhibit patterns of a word associated structure of the mental lexicon. Kroll and Curley therefore replicated these experiments. They included participants who had less knowledge of their L2 than the participants in Potter and colleagues' study. The results were in favor of the word association hypothesis and thus an indicator that the structure of the mental lexicon changes with language proficiency. Kroll and Stewart (1994) attempted to include this factor in their revised hierarchical model (RHM, see also Figure 5). As originally suggested by Potter and colleagues, they assumed that language learners first map L2 lexemes to the L1 lexemes with connections between L2 lexemes and concepts only being established with time. In unbalanced bilinguals, there are links between the lexemes as well as between the lexemes of both languages and the concept. The connections between L1 lexeme and concept are, however, stronger than between the later learned L2 lexeme and concept. The link between the lexemes remains strong. According to the authors, this leads to several processing mechanisms which are different in L1 than in L2. Forward translation (L1 to L2) is assumed to be slower than backward translation (L2 to L1) because in backward translation, the concept will not be accessed which results in shorter reaction times. This word mediated translation should also be observable in the missing effect of semantic experimental manipulation: Forward translation should be influenced by semantic blocking of the stimuli. The reaction times should be shorter in semantically blocked conditions because the concepts are primed. Backward translation should not be influenced by this manipulation because backward translation should not involve conceptual access.

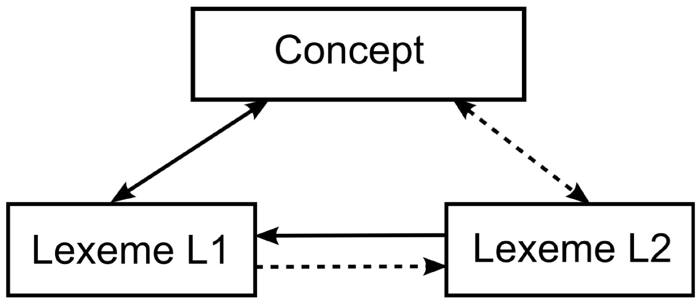

Figure 5: Revised Hierarchical Model (RHM, Kroll & Stewart 1994). In language learners, L2 lexemes are stored with L1 lexemes and access to the conceptual level takes place via the L1.

The asymmetry in reaction times between forward and backward translation which was predicted by the RHM has been identified in many studies (e.g. Francis & Gallard 2005; García et al. 2014; Ibrahim et al. 2017; Kroll & Stewart 1994).

The RHM assumes that backward translation is not influenced by the conceptual level because no conceptual access takes place. This is however not very likely. Several studies showed that the conceptual information is always activated (e.g. Altarriba & Mathis 1997, Francis & Gallard 2005, Poarch et al. 2015). Poarch and colleagues tested the predictions of the RHM, for example in children who had learned English for just eight months and who should thus behave as predicted by the RHM. The children performed a forward and backward translation and showed asymmetries in the reaction times. But in addition to the translation task, they also performed a translation recognition task (see also de Groot 1992a). In this paradigm, participants have to decide whether two words which are presented on a screen are translation equivalents. The children in that study responded slower to word pairs that were semantically related than to word pairs which were not semantically related. The interpretation of this effect is that the conceptual level is even activated in language learners who have a low proficiency in their L2. This is not in line with the RHM which predicts that there are no direct links between L2 lexemes and concepts. There might thus be asymmetries in the link strengths in the mental lexicon; but it seems that the conceptual level is always accessed.

More recently, several researchers (Brysbaert & Duyck 2010; García et al. 2014; Schoonbaert et al. 2009) thus proposed that new versions of the RHM should be based on more recent models such as the BIA+ which do not only include the presentation of words but that also focus on the activation of words. These theories will be presented in the next chapters, which deal with lexical access in monolinguals and bilinguals. In Chapter 3.3, the focus will lie on lexical access during translation with changes in the mental lexicon of translators also being presented as these changes are closely linked to the mechanisms of lexical access.

The final question to be addressed concerns the structure of the bilingual lexicon and how speakers can differentiate between L1 and L2 words in an integrated lexicon. Different solutions have been proposed in this regard. Paradis (2004), for example, suggested in his subset theory that words that belong to one language are closer linked and thus form a subset within the lexeme-network. A speaker can then decide to choose elements from one subset when producing speech.

According to a second theory, there is one language node on the conceptual level with all lexemes of L1 being linked to the language node for the L1 and all lexemes of L2 being linked to the language node of the L2 (e.g. Dijkstra & van Heuven 1998, 2002).

A third theory on the question how the mind determines to which language lexemes belong assumes that a language tag is attached to each lexeme in order to define whether it belongs to the L1 or the L2 (e.g. Durgunoglu & Roediger 1987; Green 1998). According to de Groot (2011: 126) "[...] the notion of a language tag has become widely accepted among the bilingual research community and in theories on language control by bilinguals the tag is often assigned a pivotal role." The following chapters (3 and 4) will further show which role especially language nodes and tags play for lexical activation and language control.

3 Lexical processing

In the previous chapter, the structure of the bilingual lexicon was discussed. But how are concepts and lexemes accessed in the mental lexicon? In the first part of this chapter (3.1), I will cover models of lexical processing in monolinguals as they serve as a basis for models of bilingual lexical processing, which will be presented in the second part of this chapter (3.2).

The presentation of lexical processing will be divided into the description of mechanisms occurring during language reception and language production. Both phases of language processing are important for language processing during translation. Although many researchers in translation studies have a broad perspective in their investigation of the translation process and focus, for example, on different activity phases such as drafting and revision (e.g. Carl et al. 2011), while others do not concentrate on unconscious linguistic processing but try to include different strategies the translator can use for problem solving in their models (e.g. Krings 1986), some translation scholars adapt a more fine grained view of the translation process (e.g. Kautz 2000; Mossop 2003; Steiner 2001). They concentrate on the mental processing of small linguistic units. The latter approaches to analysis of the translation process are more in line with lexical processing models in psycholinguistics (see Chapter 3.3 for a discussion of lexical processing during translation) and also distinguish between a reception and a production phase during translation (see for example Figure 6[5]).

[5] Steiner's (2001) model was chosen as an example for a translation process model that is in line with lexical processing models in psycholinguistics because it is very basic and thus shows very well the division into reception and production phase of the translation process. See also Chapter 5.2 for a more detailed description of this model.

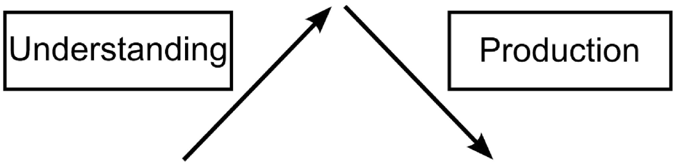

Figure 6: Basic translation process model adapted from Steiner (2001) including language reception (understanding) and production, and intended to explain the processing of small linguistic units during translation (e.g. grammatical metaphors).

This separation of reception and production will also be applied during the presentation of lexical access in bilinguals in Chapter 3.2. Mechanisms related to translation will then be discussed in Chapter 3.3.

3.1 Lexical processing in monolinguals

This chapter will start with a description of theories on lexical access in monolinguals during reception (3.1.1) followed by theories on speech production (3.1.2). As Chapter 3.2 will show, many of the theories on monolinguals presented below have been used as a basis for models on bilingual language processing.

3.1.1 Reception

Different theories have been proposed on the mechanisms and processes involved in reception, i.e. from seeing the letters of a printed word or hearing the acoustic waves of a spoken word to accessing the concept. In this chapter, the focus will be on visual word recognition as translators are presented with written words during translation and the theories to be tested in this thesis, and which will be presented in Chapter 5, are also based on the translation of written texts. However, some of the bilingual models presented in Chapter 3.2 will show that the monolingual models described below can be adapted to written as well as spoken language.

Lexical recognition models can be divided into two major groups: serial models (e.g. Becker 1976, 1980; Forster 1976) and interactive activation models (e.g. McClelland & Rumelhart 1981; for a review see also Aitchison 2012; Yap & Bolata 2015).

In serial models, initial sensory information about letters is analyzed in the mind until a complete representation of the word form is mentally activated. Once all sensory information has been activated, it is verified (Becker 1976, 1980) against mental representations of words. Word for word is checked against the sensory information. The process ends when a word matches the sensory information and is thus recognized or when all options have been checked. The possible candidates for the verification process can be narrowed down by the context. Only words which fall in the semantic field primed by the context are taken into consideration. In a matching context, words can thus be recognized faster. Becker does not distinguish between concept and lexeme in her model. Here, words are considered to be whole units which are compared against the sub-lexical information previously mentioned in Chapter 2.1.

The interactive activation model (IA) proposed by McClelland & Rumelhart (1981) belongs to another model category. In this model, it is assumed that there are three levels of representation: a visual feature level, a letter level and a word level. In this model, there is no distinction between concept and lexeme either; instead, there is an additional sub-lexical level. All elements in the IA are presented as nodes and there is one node for each element. The authors assume that processing of written words occurs in parallel: several letters are processed at the same time and the integration of information takes place at different levels at the same time. In addition, this process is interactive which means that bottom-up processes driven by the written data interact with top-down processes driven by the conceptual level. Activation spreads in the system and activates different levels. Activated letters thus activate words just as in the serial models. But in contrast to the serial models, in the IA, words also influence the activation of letters. In order to choose one element for recognition from the mental lexicon, there needs to be a mechanism to limit activation. When elements are not compatible, they therefore inhibit each other. Connections within the word level are always inhibitory. This process finally leads to one candidate which is chosen for recognition.

There are several experimental findings which indicate that the interactive activation model is better suited to explaining lexical access during speech reception than strictly serial models. Recchia and Jones (2012; see also Pexman et al. 2013 for a review of similar studies) showed for example that semantically rich, concrete words (more semantic information is associated with these words) are recognized faster in lexical decision tasks. This indicates that semantics have an influence on lexical recognition. In serial bottom-up models, this is not very likely because the lexeme is accessed before the concept. These findings are thus an indicator for interactive processing during reception (see also Yap & Bolata 2015).

The interactive activation model thus seems to be the best alternative with which to model the reception of words in monolinguals. McClelland and Rumelhart's model has also been used as the basis of very influential models of bilingual lexical access during reception (BIA, BIA+). These models will be presented in Chapter 3.2.1.

3.1.2 Production

In this chapter, models of lexical processing during production will be presented. The focus will lie on the retrieval of conceptual and lexical information. Syntactic information naturally also influences the activation of words when a speaker produces an entire sentence. As already discussed in Chapter 2.1, words can also be processed without syntactic information when they are not presented in a sentence. The study presented in this thesis will concentrate on the processing of single words in a word translation test. The role of syntax will therefore not be covered here (for further information on the processing of syntactic information during production see for example Dell & O'Seaghdha 1992).

Similar to speech recognition, there are two major classes of models in speech production as well: serial models and spreading activation models.

In modular, serial models (Levelt 1989; Levelt et al. 1999; Schriefers et al. 1990), a speaker first activates the meaning of a word and then activates the word form. The activation direction is unidirectional which means that the activation of word meaning has an influence on the phonological information but not vice versa. These models have the disadvantage that it is difficult to explain all speech errors with them. Speakers sometimes produce, for example, words which are semantically and phonologically similar to a target word they were intended to produce (*sparrow* instead of *swallow*, Aitchison 2012: 244). In serial models, wrong words with a similar meaning (*otter* instead of *beaver*, Aitchison 2012: 244) can be explained by a malfunction during the activation of concepts but a correct choice on the lexeme level. Wrong words with a similar form to the intended word (*beaker* instead of *beaver*, Aitchison 2012: 244) can be explained by a correct choice of concept but a malfunction on the lexeme level. In both cases, a neighbor node is chosen in the mental lexicon. However, when form and meaning are similar to the intended target word but both are wrong, it is difficult to assume a strictly serial processing. Schriefers and colleagues (1990) propose that this kind of errors is generated by a kind of monitoring mechanism (see also Chapter 4 on language control mechanisms). They are overlooked more easily than other errors. Dell & O'Seaghdha (1992) argue, however, that it is much more likely that these kinds of errors are an indicator for parallel and interactive processing of words (see also Aitchison 2012).

Spreading activation models assume parallel and interactive processing that could explain speech errors where form and meaning are similar to the target word (e.g. Collins & Loftus 1975; Dell 1986; Dell & O'Seaghdha 1992; Quillian 1967; see also Peterson & Savoy 1998). Quillian (1967) suggested a theory of the processing of concepts that was intended to show how to build a model of the structure of the memory which could be used in computers. This theory did not include word forms, which were only added later in revised versions of this model (e.g. Collins & Loftus 1975). Quillian suggested that activation spreads through the network starting from several points until an intersection is reached. When the activation from one starting point reaches the path the activation of another starting point has taken, an intersection is reached. The speaker then has to evaluate whether the word at the intersection is in line with the syntax and context. He also explained priming as activation spreading from the prime concept to the target concept. When spreading activation passes by a specific word, it leaves a tag and will then be pre-activated when a new automatic search process is started.

Collins and Loftus (1975) revised Quillian's theory and modified it in regard to experimental findings about word processing from the time they wrote their paper. In their version of the activation spreading model, Collins and Loftus propose for example that when the spreading activation reaches an intersection, it is added up. The activation can thus reach a certain threshold which is necessary for a concept to be chosen. In contrast to Quillian, Collins and Loftus also included a lexical level in their model. The spreading activation can have its starting point on the lexical or the conceptual level. The model is thus interactive. The links in the network have different strengths. Their strength is determined by the frequency of their use. And the stronger the links, the faster activation will be (see also Collins & Quillian 1969).[6]

Dell (Dell 1986; see also Dell & O'Seaghdha 1992) proposed a similar model of spreading activation. His model was inspired by McClelland's and Rumelhart's model for language reception. In his model, all nodes in the mental lexicon send part of their activation to connected nodes. Similar to the Collins and Loftus model, activation can spread from concepts to lexemes but also from lexemes to concepts. But Dell, similar to McClelland and Rumelhart, assume inhibitory links between lexemes. In addition to that, they also included a sub-lexical level that contains, for example, single phoneme representations. The nodes in the mental lexicon have different activation levels. When activation is sent from one node to

6 Other factors which determine the activation level of elements in the mental lexicon include for example prototypicality (e.g. Aitchison 2012).

another, the activation level of the destination node is increased because source activation is added to the destination node's activation. The candidates that reach a certain threshold after some time are then chosen for articulation. This activation level decreases over time if it is not reactivated.
Differences between the two models of Collins and Loftus, and Dell are that Dell assumes a decomposition representation of conceptual information. Dell also described words with formal similarities sharing more sub-lexical features whereas Collins and Loftus assumed stronger links between lexemes of these words. Dell assumes inhibitory links between lexemes, in Collins and Loftus' model, links are always activating.

3.2 Lexical access in the bilingual lexicon

Interactive models are very good at explaining speech phenomena in monolinguals both in terms of reception as well as of production. They have also been used to develop bilingual models of speech processing[7]. At this point, it is important to note that many translation process models still adopt a serial approach (e.g. Steiner 2001; Tirkkonen-Condit 2005; Carl & Dragsted 2012). As the empirical studies presented in the previous chapter showed, interactive models are better suited to explaining language processing. The fact that most translation process models from translation studies are serial is another reason to explore recent models of bilingual language processing from psycholinguistics instead of only using existing models from translation studies to explain translation phenomena.
In the following chapters, I will describe adaptations of the monolingual interactive activation and spreading activation models for bilingual production. As in the previous part, lexical recognition will be covered first, followed by lexical access in production.

[7] Modular serial models have also been adapted for speech production (e.g. de Bot 1992; Bierwisch & Schreuder 1992). But as these models are not very likely to explain speech phenomena in monolinguals, they will not be covered for bilingual speakers.

3.2.1 Reception

When considering the reception of words in bilinguals, a very important question is whether the lexemes of both languages or only the ones of the intended language are activated. In the relevant literature, language selective theories assume that only one language is activated and language non-selective theories state that both languages are activated (for a review see for example de Groot 2011).

Many recent studies can be interpreted in favor of the language non-selective theory; they lead to the conclusion that bilinguals activate both languages during reception (e.g. Dijkstra et al. 1998, 1999; Thierry & Wu 2007; van Heuven et al. 2008; Wu et al. 2013; Wu & Thierry 2012).

One indicator for language non-selective access comes from studies with interlingual homographs. These are words that share their form in two languages but not their meaning (e.g. the word *angel* exists in English and in Dutch but in Dutch it means *sting*, Dijkstra & van Heuven 1998: 191). When assuming language selective access, the processing of interlingual homographs should not differ from the processing of other words because the homograph in the non-intended language should not influence the respective word in the intended language. To test this theory, Dijkstra and colleagues (1998) performed, for example, a lexical decision task with Dutch speakers who were presented with English stimuli. In addition to non-words, English control words, English-Dutch interlingual homographs as well as Dutch filler words were presented. The participants' reaction times were significantly longer for the interlingual homographs, which Dijkstra and colleagues interpreted as an indicator for language non-selective access during reception.

A shortcoming of this kind of study is however, that both languages were included in the experimental setting. It therefore does not explain the mechanisms of lexical access in bilinguals in all situations. In this experiment, the participants were in a bilingual situation where both languages were required. Bilinguals can, however, also communicate in predominantly monolingual settings (e.g. Grosjean 2001). The study conducted by Dijkstra and colleagues cannot answer the question whether both languages are also active in monolingual settings. But in more recent studies which attempted to answer this question, indicators for language non-selective access during reception were also found when the participants engaged in a purely monolingual task. Wu and Thierry (2012) conducted a classic go/no-go task. In these paradigms, participants have to respond to one kind of stimulus but they have to withhold their answer when they see a second kind of stimulus. In this study, Wu and Thierry tested participants who were English-Chinese bilinguals as well as a monolingual English control group. The participants saw circles and squares on a black screen in the go-condition of the task and had to press a left or right button depending on the stimulus. In the no-go-condition, the participants were presented with English words which they had to ignore. Some of the English words, however, had a Chinese translation with formal similarities to the Chinese words for circle and square. If lexical access were also non-selective in purely monolingual settings, the bilingual participants should have shown a different reaction to the critical English-Chinese translations compared to the English control words. The authors did not observe any behavioral differences. But Wu and Thierry also measured electrophysiological responses to the stimuli (see also Chapter 6.2 on the use of these techniques). The results showed that, in the bilingual participants, a brain reaction which has been linked to control mechanisms was stronger for the words which had a Chinese translation similar to circle and square than for the controls. The monolingual group did not show any differences. Thierry and Wu interpreted the results in favor of the non-selective lexical access hypothesis.

It can thus be concluded that bilinguals always activate lexemes in both languages. This language non-selective access has been implemented in models of speech reception which are based on the interactive activation model (IA, McClelland & Rumelhart 1981).

Dijkstra and van Heuven (1998) developed the BIA (bilingual interactive activation model; see also Figure 7) on the basis of the IA. According to the BIA, words are represented on four levels (letter features, letters, words and a language node). The major difference between the BIA and the IA are the language nodes. As already described in Chapter 2.2, Dijkstra and van Heuven assume one language node per language. All words in a language are connected to the respective language node. When bilingual readers are presented with a word, they activate letter features, then letters, then words. The words send activation back to the letter level and activate the respective language node which inhibits other language nodes. A spreading activation is thus initiated which subsequently leads to a higher activation level of the best matching word compared to other words. It is thus chosen for recognition.

The activation and inhibition processes determine the speed of recognition. Frequent words are recognized faster for example because they have a higher resting level of activation. When a reader activates a word frequently, the activation level does not completely drop before it is activated and thus raised again. This is not the case for rarely used words. Several mechanisms influence the speed of recognition of interlingual homographs that, as shown earlier, have been used to investigate language non-selective access. The shared form increases activation and leads to stronger activation. The word nodes however inhibit each other. And the fact that both language nodes are activated (especially in a mixed language setting), leads to more inhibition. This increases the time it takes for one word to reach the critical threshold necessary for reception.

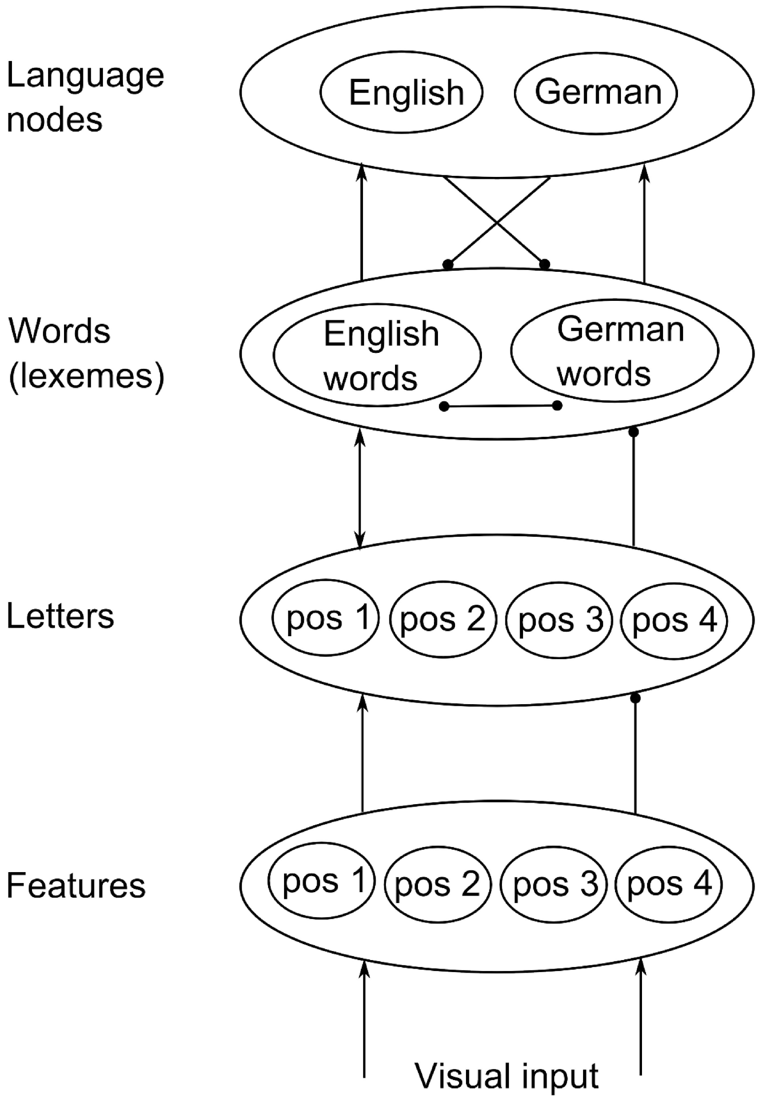

Figure 7: BIA model according to Dijkstra & van Heuven (1998). Arrows indicate activation processes and dots indicate inhibition processes. The model was designed for four letter words (four positions for features and letters) but according to the authors it can be applied to shorter and longer words as well.

Although the BIA explains many experimental findings, it has several shortcomings. It does for example not contain phonological representations and semantics. The role of linguistic and non-linguistic context for the recognition of words is not explained in detail either (Dijkstra & van Heuven 2002).

The BIA was thus modified. Dijkstra and van Heuven (2002) proposed a revised version of the model which they called the BIA+. In addition to orthographic information, phonological and semantic information of words is also activated in a language non-selective manner in the BIA+ and can thus also influence the recognition process in bilinguals. Dijkstra and van Heuven also implemented a task decision system in their model.
The authors propose that the BIA+ can not only explain reception of written words but also of spoken language and to a certain extent also speech production mechanisms (see also Kroll & Dijkstra 2002). Further models on lexical access during production in bilinguals as well as empirical evidence for these models will be presented in the next chapter.

3.2.2 Production

Similar to analyses of word reception, many studies on word production showed that both languages are activated in bilinguals. This has been shown for lexical activation in single word production studies (e.g. Acheson et al. 2012; Colomé 2001; Colomé & Miozzo 2010; Costa et al. 1999, 2000; Hermans et al. 1998; Hoshino & Thierry 2011; Poulisse & Bongaerts 1994; Rodriguez-Fornells et al. 2005; Spalek et al. 2014) but also for syntactic information in studies that involve sentence production (e.g. Hartsuiker et al. 2004).
Evidence comes, for example, from the investigation of speech errors in bilinguals. Poulisse and Bongaerts (1994) compiled a corpus of unintended language switches in language learners in which they found blends between languages. These are non-words, composed of two existing words of a speaker's two languages (e.g. *elchother* from the Dutch word *elkaar* and the English word *each other*, ibid. 42). These speech errors have been interpreted as an indicator for the parallel activation of words in both languages.
In addition to the observation of spontaneous speech production in bilinguals, controlled experiments also lead to the conclusion that lexical access during production is non-selective. One type of experiment that is

used in this context is the picture word interference task (for a review of this paradigm see Costa et al. 1999). In these paradigms, pictures are presented together with words and participants have to name the pictures. The words can be either the same as the object shown on the picture, similar in their form or their meaning, or completely different. The different degrees of similarity influence the naming latencies of the pictures in monolingual settings (Glaser 1992). If the words are the same as the pictures or if their form is similar, pictures are named faster. If the meaning is similar but not the same, participants need more time. Naming latencies are not affected by the words if neither meaning nor form share similarities with the name of the depiction.

The picture word interference task has also been used in bilingual settings. Here, the bilingual participants have to name the pictures in their L1 but the words presented as distractors are in the participants' L2. If language selection was language specific, the picture and word being the same would facilitate the process. If lexical selection was language non-specific, the reaction times would be slower in this case because the lexemes would be in competition (e.g. Costa et al. 1999).

Models of lexical access in bilingual speech production therefore have to include the activation of words in both languages in parallel. The model of Collins and Loftus (1975) for lexical access in monolingual speech production was adapted by Potter and colleagues (1984). They assume a spreading activation. But they reject the possibility that, for example, lexemes in the L1 activate lexemes in the L2 and assume instead that activation only passes via the conceptual system (concept mediation, see also Chapter 2.2). Kroll and Stewart (1994) also developed their revised hierarchical model (RHM), which was introduced in Chapter 2.2, on the basis of the models by Collins and Loftus, and Potter and colleagues. In contrast to Potter and colleagues, they assume that word mediation is possible but that especially balanced bilinguals also pass by the conceptual level when accessing lexemes in the other language. One shortcoming of this model is that it does not always assume activation of conceptual information in language learners. Recent studies showed, however, that even language learners access the conceptual level (see

Chapter 2.2). This model should thus be adapted and include conceptual access for all kinds of proficiency levels.
Dell's (1986) model has also been used to describe bilingual lexical access during production. Some researchers used the model to describe language non-selective access without postulating a new type of model (e.g. Costa & Santesteban 2004).
Although many studies showed activation of both languages during production, it is still possible to produce speech in only one language. According to Poulisse and Bongaerts (1994), for example, intrusions between languages are rather infrequent. And also de Groot states:

> “Generally, if a bilingual has selected a language for current use, his or her speech contains few intrusions of the non-selected language, and misunderstandings arising from mistaking an input for a word in the other language are rare.” (de Groot 2011: 279)

A major question is therefore how bilinguals can assure production in only one language. This question will be dealt with in Chapter 4 on language control. But first, the specific mechanisms of lexical access during translation will be discussed.

3.3 Lexical access in translation

As already mentioned in the chapter on the structure of the bilingual lexicon (Chapter 2.2), different hypotheses exist in psycholinguistics about lexical access during translation (see also Figure 8 for different models of lexical access during translation).
According to the word association hypothesis, a translator activates a source language lexeme and then the target language lexeme via a direct link without accessing the conceptual representations (Potter et al. 1984). This mechanism is sometimes also referred to as transcoding (e.g. de Groot 2011). According to the concept mediation hypothesis (Potter et al. 1984), the translator first accesses the source language lexeme and

passes by the conceptual level in order to activate the target language lexemes.

Potter and colleagues (1984), who originally proposed these two theories, conducted a number of experiments in order to investigate which mechanism applies to translation. They compared the translation of single words from L1 to L2 with the naming of words and pictures in L1 and L2. They hypothesized that the naming of pictures requires the speaker to access conceptual information and that word naming does not. The comparison with the reaction times of word translation should thus reflect whether the conceptual level is accessed during translation. Participants named words faster than they named pictures, as predicted by the authors. Word translation turned out to be slower than picture naming in L2. The results of this study were thus interpreted in favor of the concept mediation hypothesis.

Indications for the word mediation hypothesis come for example from the case reports of Paradis (1984), which was also already mentioned in Chapter 2.2. The author describes a case of an aphasic who was able to translate names of objects which were present in the room he was in, but was unable to explain or show what the words meant. In this case, the patient was thus apparently able to translate without accessing the conceptual level.

Also some translation scholars assume that facilitating links between lexemes exist that directly activate target language lexemes (e.g. Carl & Dragsted 2012; Halverson 2017; Mossop 2003).

In their revised hierarchical model, Kroll and Stewart (1994; see also Chapter 2.2 for a more detailed description of the RHM) finally proposed that both mechanisms exist but that they depend on translation directions. Unbalanced bilinguals use word associated lexical access when translating from L1 to L2 and concept mediated lexical access when translating from L2 to L1.

More recent studies however, lead to the conclusion that the conceptual level is always accessed during translation (e.g. Altarriba & Mathis 1997; Francis & Gallard 2005; Poarch et al. 2015). This is also in line with the interactive activation models (e.g. Dijkstra & van Heuven 1998, 2002), which assume that activation cannot be restricted to one level of lexical processing.

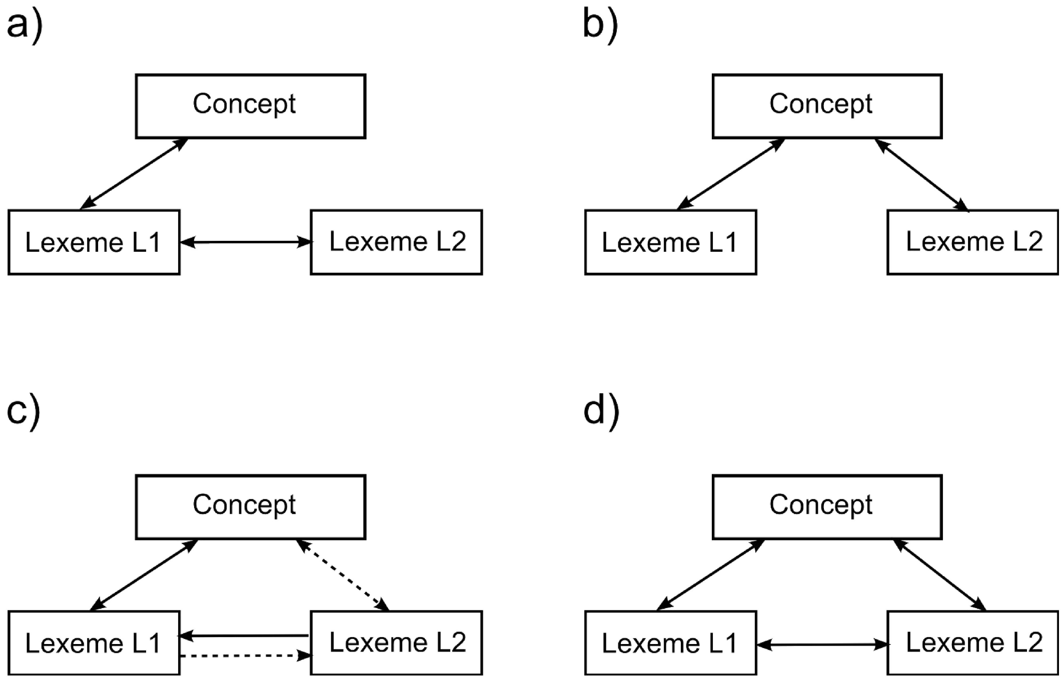

Figure 8: Models of lexical access during translation: a) word mediated translation and b) concept mediated translation adapted from Potter et al. 1984, c) differences in forward and backward translation according to the RHM, adapted from Kroll & Stewart (1994), and d) an interactive activation model where activation is not limited to one route (link strengths in the mental lexicon are not taken into account in this figure).

The frequent use of lexemes in a translation context seems to have an impact on representations in the mental lexicon. Several authors assume that the links between lexemes of translation equivalents, which are often used in translation, become stronger which then facilitates translation[8] (e.g. de Groot 1992b; García 2014; Paradis 1984):

> “Translating a word will strengthen the memory connection (whether direct or indirect by means of conceptual representation) between the translations, and the stronger this connection, the more skilled translating between these words will be.” (de Groot 1992b: 1002)

[8] We can of course only assume increased facilitating links between lexemes if we adopt a model of lexical access according to Collins and Loftus' (1975) who proposed only activating links in contrast to Dell (1986) who suggested inhibitory links between lexemes.

García and colleagues (2014) suggested that not all links between lexemes become stronger but that it depends on the frequency of use. This is especially important if translators often use special L1 words to translate an L2 word even if there are several options:

> "In particular, during the first months of formal translation education prospective translators establish and analyze interlinguistic associations more frequently and intensely than they did before enrolment. We speculate that continual reflection about similarities and differences between equivalents leads beginner students to recognize and reinforce novel inter-linguistic associations while inhibiting cross-language connections to representations which they wrongly believed to be shared between equivalents. This possibility, however, remains to be empirically assessed." (García et al. 2014: 10)

The increasing link strength in the mental lexicon between translation equivalents is thus a first hint of mental processes that might change among translation students. In the following chapter, the special role cognates play in these theories will be presented. They have been repeatedly used in psycholinguistics to investigate the structure of the mental lexicon as well as the mechanisms of lexical access in bilinguals and might therefore also be a good option to test the predictions made in the gravitational pull hypothesis on changes in experienced translators.

3.4 Cognate facilitation effect

So far, the processing of cognates has not been linked to the models of the mental lexicon and bilingual lexical access in this thesis. Cognates however play an important role in the investigation of these structures and mechanisms.

Cognates are recognized and produced faster than non-cognates. This effect has been referred to as the cognate facilitation effect (CFE; Sherkina 2003) or cognate effect (Kroll et al. 2002). In the following, I will refer to this phenomenon as cognate facilitation effect or CFE.

The CFE has been observed in visual bilingual word recognition tasks. Cognates are recognized faster than non-cognates (e.g. Cristoffanini et al. 1986; de Groot & Nas, 1991; Dijkstra et al. 1999; Lemhöfer et al. 2008) and they are also read faster than non-cognates in a sentence context (Ibáñez et al. 2010). The size of the CFE depends on the size of the formal overlap of the cognates – the more features they share, the stronger the observed facilitation (Cristoffanini et al. 1986). The cognate facilitation effect is not only limited to stimuli of the same scripts. It is also present when the two languages used in an experiment have different scripts such as English-Hebrew (Gollan et al. 1997), English-Korean (Kim & Davis 2003) and English-Japanese (Hoshino & Kroll 2008).

Cognates are also processed faster in tasks which involve overt production and no reading. The cognate facilitation effect was, for example, also present in picture naming tasks (e.g. Costa et al. 2000, 2005; Christoffels et al. 2006; Kroll & Stewart 1994). For example, Costa and colleagues (2000) performed a picture naming task in the language pair Spanish-Catalan. The participants were presented with pictures showing either objects which had cognate names in the two languages (such as the name for *cat*: *gat* in Catalan and *gato* in Spanish; ibid: 1285) or which had non-cognate names in the two languages (such as the name for *table*: *taula* in Catalan and *mesa* in Spanish; ibid: 1285). The participants named objects with cognate names faster than those with non-cognate names.

Not only healthy participants in controlled experiments exhibit facilitated processing of cognates. It has also been observed that cognates can recover faster than non-cognates in bilingual aphasics (Kohnert 2004).

And finally, what is of special interest for the present study, several researchers observed that cognates are translated faster than non-cognates. This effect was a feature in the translation of single words without context (Christoffels et al. 2006; de Groot 1992b; García et al. 2014; Kroll et al. 2002; Kroll & Stewart 1994).

But at least one study also showed a cognate facilitation effect when participants were presented with a context before they translated the single cognates and non-cognate words (van Hell & de Groot 2008).

It is not clear whether the cognate facilitation effect depends on language proficiency. In a study by Kroll and colleagues (2002), the difference in the reaction times for cognates and non-cognates (they called the difference *cognate effect*, ibid: 152) was lower for highly proficient bilinguals than for less proficient bilinguals. Christoffels and colleagues (2006) could, however, not replicate this effect.

In conclusion, cognates are processed faster and with more ease in different populations and in different language processing tasks. But what are the underlying mechanisms of the cognate facilitation effect and how can the effect be explained with the models of bilingual lexical access described in the previous chapters?

The first question to be answered is whether cognates have a special representation in the mental lexicon. Some authors who assume a decomposition view of conceptual representations argue that the cognate facilitation effect is due to a larger semantic overlap (e.g. van Hell & de Groot 1998).

Costa and colleagues (2005) argue that the semantic overlap is no reason for cognates to be produced faster than non-cognates since formal similarities are the only difference between these word pairs. There is, for example, not a greater semantic similarity between the Spanish-English cognates *cat-gato* and the Spanish-English non-cognates *dog-perro* (ibid: 97).

Some researchers (e.g. Cristoffanini et al. 1986; Kirsner et al. 1993) assume that the CFE is caused by a shared morphological representation of the cognates. According to this account, bilinguals activate the same morphological structure when using their two languages, which would lead to easier access.

There are, however, also shortcomings in this model. In terms of common morphological representation, the similarities might not always be greater between cognates than between non-cognates either. For example, common morphological stem is not always present in cognates (*carrer* in Spanish and *calle* in Catalan, Costa et al. 2005: 98).

As stated previously, cognates are defined as translation equivalents with similar forms. This is precisely where Costa and colleagues (2005) see the explanation for the CFE: If a bilingual wants to produce a cognate, two word forms (L1 and L2) are activated in the mental lexicon due to spreading activation. The target word form thus receives activation from two sources, the concept and the sub-lexical level. A non-cognate would not receive as much activation as there is no similar word form in the other language to return activation. Due to the increased activation, cognates can thus be produced faster, with fewer mistakes and with even aphasics profiting from this effect (Costa et al. 2000, 2005).

The amount of activation also depends on when the word in the other language was last used. If it was used recently, it might still have a higher level of resting activation. And it might thus activate the intended cognate more strongly than if it had not been used for some time. The activation might also flow in both directions and not only facilitate retrieval of the word form but also send activation to the word meaning and thus increase activation of this specific word (Costa et al. 2005).

The neighborhood effect shows similar results as the CFE. Words with a dense neighborhood (words which have a similar form to many other words) are produced with fewer mistakes and less frequently reach a tip of the tongue state (TOT, participants cannot utter a word they are looking for but can name words which have a similar meaning or form to the intended word; see Brown & McNeil 1966) than words in a less dense neighborhood. This gives reason to believe that cognates do not have a special representation but that their facilitated production is due to the mechanisms of lexical access, namely interactive activation (Costa et al. 2005).

This view is also shared by other researchers. Dijkstra and colleagues (2010, see also Dijkstra & van Heuven 2002) also assume that cognates profit from their shared features during lexical activation but that they do not have a special representation. Dijkstra and colleagues therefore also assume that the cognate facilitation effect is due to interactive activation, which is stronger for words that share features:

> “In localist connectionist models (position 4), a processing consequence of an increase in cross-linguistic similarity of the cognate (e.g., tomato) is that its counterpart in the other language (e.g., tomaat) becomes more activated. Because both readings of the cognate converge at the semantic level, there is relatively more semantic activation in the lexicon than for non-cognates. The largest co-activation would be expected to arise for identical cognates.” (Dijkstra et al. 2010: 299)

The cognate facilitation effect has thus often been interpreted as an indicator for language non-selective access because words in both languages of a bilingual are activated and therefore lead to a higher level of activation as well as faster and easier retrieval (e.g. Costa et al. 1999; Dijkstra et al. 2010).

In models which are based on the model by Collins and Loftus, in which facilitating links exist between lexemes and a sub-lexical level is not explicitly described, cognates share stronger links between their lexemes, which facilitates lexical access (e.g. de Groot 1992b, see also Figure 9). This is especially the case for translation, where the source word's lexeme activates the target word's lexeme more strongly when they share more features: “One plausible way that the representation of cognates and non-cognates differs is that the T1 links could be stronger in the case of cognates.“ (de Groot 1992b: 1015)

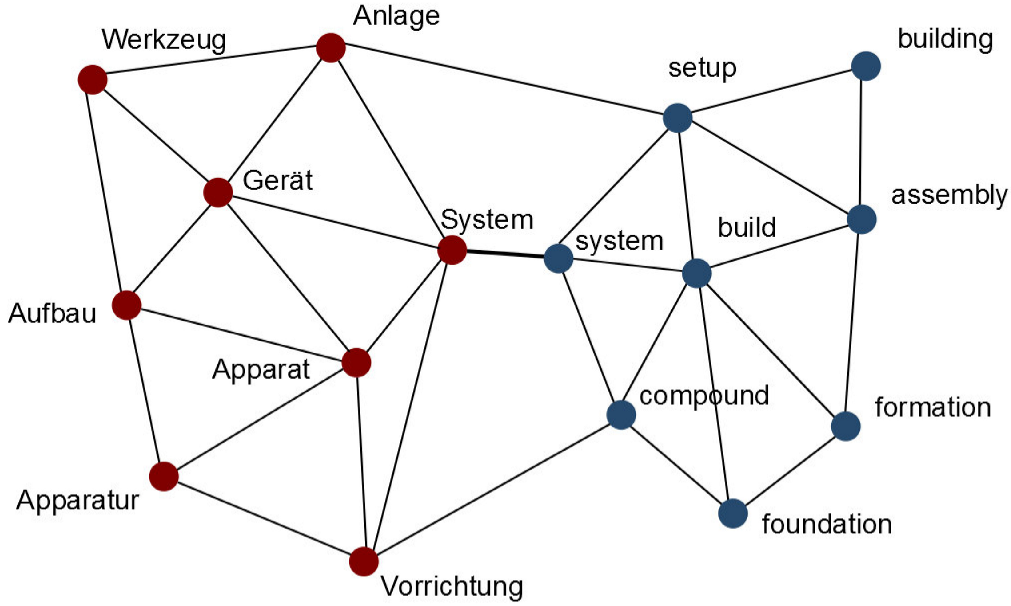

Figure 9: Model of the network-like organization of the lexeme level in bilinguals. The red dots represent L1 lexemes (here German) and the blue dots represent L2 lexemes (here English). The lexemes of the cognates System (GE) and system (EN) are, according to de Groot 1992a, closely linked which could be an explanation for faster production times during translation.

In addition to the mental lexicon and lexical activation, another mechanism is important for successful language processing, especially in bilinguals, namely mental control processes. They might be just as important as the activation processes described in the previous chapters. In Chapter 4, theories on language control will therefore be discussed.

4 Language control mechanisms

Speakers, no matter whether they are monolingual or bilingual have to control their speech processing in order to avoid errors. In this chapter, I will introduce the different mechanisms linked to the broader term language control. Their implication in monolingual speech processing models will be briefly discussed before concentrating on theories of language control in bilinguals and in translators.

Language control has been divided into several sub processes (see for example Dong & Zhong 2017; Green & Abutalebi 2013). Concentrating on internal self-control, two of the most extensively studied mechanisms are monitoring and inhibition.

Monitoring has been defined as the supervision of processes in the brain. According to Levelt (1983), speakers monitor their speech production internally and externally and evaluate whether a mismatch occurs between the speaker's intentions and the actual processes. In Levelt's model, the speaker only monitors speech production internally at the level of inner speech, if all linguistic information has been accessed but articulation has not yet taken place. Through a perceptual loop, inner speech can be evaluated by the monitor:

> “The monitor, finally, performs two functions. The first one is a matching function: it compares parsed aspects of inner and outer speech with (i) the intentions, and the message sent to the formulator, and (ii) criteria or standards of production.” (Levelt 1983: 49-50)

According to more recent accounts, monitoring has been defined as the supervision of the conflict arising from competing processes taking place in the mind (conflict monitoring; e.g. Acheson 2012; Botvinick et al. 2001; Donkers & van Boxtel 2004; Follstein & van Petten 2008; Ganushchak & Schiller 2008; Kerns et al. 2004). In models of conflict monitoring, a speaker constantly monitors all ongoing processes. Conflict can for example arise from two words which are both activated and compete for production (e.g. Acheson et al. 2012). When an error is likely to occur, a great deal of conflict between two possible words is present in the brain which can then be detected (Ganushchak & Schiller 2008).

Inhibition is the active suppression of processes in the mind (e.g. Green 1998; Green & Abutalebi 2013; Kok 1999; Shao et al. 2014).

Monitoring and inhibition work in unison in order to avoid errors. In the perceptual loop theory as well as in the conflict monitoring theory, the monitor sends information to a control system so that speakers can adjust their behavior. Levelt (1983) states for example:

> "If some mismatch is detected which surpasses certain criteria, the monitor makes the speaker aware of this, or in other words: an alarm signal is sent to working memory. The speaker can then take action on the information received." (ibid: 50)

According to Green (1998), the automatic control system is constantly adapted by the monitoring of action planning. This view is also in line with other researchers (e.g. Botvinick et al. 2001; Kerns et al. 2004). Botvinick and colleagues state for example:

> "The conflict monitoring system first evaluates current levels of conflict, then passes this information on to centers responsible for control, triggering them to adjust the strength of their influence on processing." (ibid: 625)

Monitoring and inhibition are thus closely linked and work cooperatively in order to adjust speech production.

Both processes have been included in monolingual speech production models. But despite the interlinked functions described above, only one of the two mechanisms is involved in most models. Monitoring has, for example, been included in many serial speech production models (e.g. Kempen & Huijbers 1983; Levelt 1983, 1989; Levelt et al. 1999; Schriefers et al. 1990).

Furthermore, inhibition has been included in monolingual speech processing models. McClelland and Rumelhart (1981, see also Chapter 3.1.1) for example, assumed inhibitory links between word nodes in their interactive activation model for speech recognition. While reading, word nodes inhibit each other to assure that one word survives this competition process and is then recognized.

Inhibition has also been considered in bilingual language control. These mechanisms, which allow a bilingual speaker to use only one language for production, will be presented in the next chapter.

4.1 Bilingual language control

How are languages controlled in bilinguals? As Verhoef (2009) states, bilinguals rarely unintentionally mix their languages. There thus seems to be a strong mechanism which keeps the languages separate:

> "Although bilinguals can choose from at least two response alternatives for any given concept, they are able to restrict their speech to one language only, rarely making cross-language intrusion errors [...]." (Verhoef et al. 2009: 84)

Several models include inhibition processes to account for the separation of languages in the mind. For language reception, Dijkstra and van Heuven (1998, 2002) proposed two sources of inhibition in both their BIA and BIA+ model. On the one hand, the language nodes that are linked to all lexemes of the respective language, can inhibit a whole language on a global scale. This process depends on the linguistic and extralinguistic context of the bilingual reader. On a local scale, lexemes from different languages inhibit each other during the interactive activation process of word recognition.

For language production, a very influential model has been proposed by Green (1998, see also Green 1986 for a former version of the model). In his inhibitory control model (IC), he proposes mechanisms which are similar to those integrated in the BIA+ (see Dijkstra & van Heuven 2002 for a comparison of the models).

According to Green, languages can have different activation levels in the brain. And when one of the languages is to be used for production, its activation level has to be higher than the activation level of the other languages (see also Paradis 2004 for a theory of different activation levels). In a former version of the model, Green (1986) proposes different activation levels: selected (current language of production), active (is important for the current process) and dormant (not used and not active). To choose a language for production, its activation level thus has to be modified. In Green's IC model (1998), speakers create schemas for actions they are performing. Schemas are a series of processes necessary to perform a certain task (e.g. *word production*, ibid: 69). Speakers can retrieve schemas from memory if they have previously used them or create new schemas. Schemas compete with each other. During a Stroop task for example (Stroop 1935), in which color words are displayed in a matching or non-matching color and participants are asked to name the color and not to read the word, the schema for color naming competes with the schema for word reading. Speakers can inhibit unwanted schemas in order to achieve their goal. The schemas on the other hand are one source of adaptation of a language's activation levels:

> "A language task schema regulates the outputs from the lexico-semantic system by altering the activation levels of representations within that system and by inhibiting outputs from the system." (Green 1998: 69)

A speaker can thus not directly inhibit or activate a language system but only via task schemas.

In order to choose words of the right language for production, Green assumes that each word is represented as a lemma node which contains a tag indicating language membership (see also Chapter 2.1 on a discussion of the representation of words and especially the existence of lemmata). When only one language is chosen for production, inhibition of elements with the wrong language tag is launched as soon as initial activation has taken place. The task schemas activate the wrong language tags which then inhibit elements of the unwanted language.

Evidence for the IC comes from language switching paradigms. In these tasks, participants are presented with language neutral stimuli such as colors or digits. The language in which the participants have to name these stimuli is alternated (e.g. Macnamara 1968).

According to the IC, unbalanced bilinguals should need less time to switch from their L1 to L2 than to switch from L2 to L1. The L2 does not need to be inhibited as much as the L1 in unbalanced bilinguals. When switching from L1 to L2, it takes less time to reactivate the only mildly inhibited L2 than to reactivate the strongly inhibited L1 when switching from L2 to L1:

> “Since both languages are potentially active and competing to control output, successful selection requires the inhibition of active lemmas with non-target tags. Also because inhibition is reactive more active lemmas will be more inhibited. Because overcoming prior inhibition will be a function of the prior amount of suppression, it can be predicted that the cost of switching will be asymmetric. It will take longer to switch into a language which was more suppressed – for unbalanced bilinguals this will be L1, their dominant language.” (Green 1998: 74)

Meuter and Allport (1999) tested this assumption of language switching asymmetries based on reaction times. In their study, unbalanced bilinguals had to name digits either in their L1 or in their L2. The digits were presented with colored rectangles (either blue or yellow) which were cues for the language the participants had to answer in. The results confirmed the assumptions of the IC. Switching costs were higher from L2 to L1 than from L1 to L2.

Green's IC model was also supported by the findings of several other more recent studies (e.g. Abutalebi et al. 2008; Hernandez et al. 2001; Philipp & Koch 2009).

Although there is strong evidence for inhibitory processes in bilingual language production, another account also exists which assumes that languages are separated without inhibition.

According to the language specific selection hypothesis, only words of the intended language are taken into consideration for lexical selection (e.g. Costa et al. 1999, 2006; Costa & Santestebastan 2004; see also Roelofs 1998). All other elements (activated or not) are ignored.

In a picture word interference study, Costa and colleagues (1999) investigated whether lexemes of two languages in a bilingual's mind compete for selection during production as predicted by the IC for example (also referred to language non-specific selection), or whether only lexemes of the target language are considered for production (language specific selection). As already described in Chapter 3.2.2, in this paradigm participants are presented with pictures accompanied by words on a screen. They have to name the pictures and ignore the words. Naming latencies depend on the relationship between picture and word. Participants need more time to name the pictures when picture and word are semantically similar (e.g. *table* and *chair*, Costa et al. 1999: 366) compared to unrelated meanings (e.g. *table* and *house*, ibid: 366). Pictures are named faster when picture and word are the same or when they have a similar form (e.g. *table* and *tailor*, ibid: 366). The longer reaction times for semantically similar pictures and words have been explained by competition in the mental lexicon. Due to spreading activation, the picture *table* for example activates its corresponding concept. Activation spreads on the conceptual level which results in the activation of several words linked to *table*, for example also *chair*. The word *chair* however also receives activation from the word-stimulus. It is thus activated twice. When the picture and word are not semantically related, the words that are co-activated due to spreading activation do not receive extra activation from the written stimulus. In the case of semantically related words, it thus takes more time to inhibit the wrong word *chair* which is activated by two sources, than to inhibit the wrong word in the unrelated condition. Reaction times are shorter for cases in which picture and word are the same because in these cases the correct word receives activation not only from the conceptual level but also by the word distractor. It is thus highly activated and other activated words do not need to be inhibited as much as in the other conditions. Costa and colleagues used this mechanism to investigate whether words of two languages also compete for production. In their study, participants had to name pictures in their L1. The pictures were paired with L2 translations of the pictures' names. Costa and colleagues hypothesized that when words are selected language specifically, the translations should facilitate naming of the pictures because the translations activate the same concept as the picture but no interference takes place on the lexeme level. The results of the study supported the authors' hypothesis and they therefore assumed that only words of the target language are taken into consideration for production.

The language specific selection hypothesis does not necessarily exclude language non-specific selection mechanisms. In a more recent article, Costa and Santesteban (2004, see also Costa et al. 2006 for similar and Verhoef et al. 2009 for contrasting results) argue that both mechanisms exist and that their application depends on language proficiency. In a language switching paradigm, the authors found asymmetric switching costs in low-proficient bilinguals but not in highly proficient bilinguals. This is in line with the IC model, which states that it takes more time to switch into a dominant language because it takes more time to overcome the strong inhibition. In balanced bilinguals, no asymmetries should be present because both languages have to be equally inhibited. Costa and colleagues also found, however, that the highly proficient bilinguals did not show asymmetries when they switched from and into a third weaker language either. Switching costs were still present. But Costa and Santesteban argued that these results suggest that the highly proficient bilinguals had learned a language specific selection mechanism which they could also apply to weaker languages. They also assumed that switching costs could also reflect switching between two schemas and that they were not necessarily caused by inhibition.

This study is thus an indicator that language proficiency might have an influence on the control mechanisms in bilinguals. In the following chapter, language control during translation will be presented.

4.2 Translation and language control

Translation requires an efficient control mechanism to assure rapid changes between source and target language (e.g. Ibáñez et al. 2010) as well as a high quality target text which contains no interferences from the source language.

In translation studies, several translation process models include a monitoring component (e.g. Carl & Dragsted 2012; Tirkkonen-Condit 2005; Toury 1995).

Tirkkonen-Condit proposes, for example, that monitoring is a capacity which translators learn with increasing experience. They observe their behavior in order to temporarily stop automatic processing whenever they encounter a problem:

> "It looks as if literal translation is a default rendering procedure, which goes on until it is interrupted by a monitor that alerts about a problem in the outcome. The monitor's function is to trigger off conscious decision-making to solve the problem." (Tirkkonen-Condit 2005: 408)

This view of monitoring speech production is similar to Levelt's (1983, see also Chapter 4) definition in which monitoring only takes place after the first activation of words. However, for Tirkkonen-Condit, monitoring is a much more conscious process that can be applied voluntarily by the translators whereas Levelt assumed a highly automated process.

Tirkkonen-Condit reports empirical evidence for this mechanism from think aloud protocols (e.g. Ericsson & Simon 1980, see also Chapter 6). In these experiments, translators are asked to verbalize all thoughts that come into their minds while translating. Tirkkonen-Condit uses cases where translators first utter words that they then directly replace with other expressions they consider are better suited as hints for a monitoring mechanism. Tirkkonen-Condit assumes that monitoring mechanisms are influenced by experience but she does not report experimental findings to support this theory.

Carl and Dragsted (2012) tested Tirkkonen-Condit's monitoring model on the basis of key-logging and eye-tracking data. The authors assumed that automated language processing during translation could be observed as eye-fixations on the source text which indicate comprehension processes occurring in parallel to target text production. When monitoring leads to adaptation of behavior, the translator focuses either on reading the source text or on producing and focusing the target text. Carl and Dragsted specify that they assume the translation process to be literal until problems occur. There definition of the literal translation process is similar to the word mediated translation described in Chapter 3.3. When a problem occurs, monitoring leads the translator to engage in deep understanding, which is defined in a similar way as concept mediated translation. Carl and Dragsted investigated this hypothesis with the help of eye-tracking and key-logging data during natural translation of texts. They did not report any data related to translation experience levels. They showed that translation of a text was very smooth and only stopped at points that might be semantically difficult to translate. The authors argue that in this case, the monitor halts production of the target text and leads to more reading of the source text. In some cases, the translators started writing a target sentence before having read the entire source sentence and then had to delete and correct the first part of the sentence when they came to a semantically difficult part of the sentence. Carl and Dragsted assume that the literal translation (or word mediated translation) is stopped in these cases by monitoring of speech production. As was shown in Chapter 3.3, it is however not very likely that translators engage in either concept mediation or word mediation but that translation occurs via an interactive activation mechanism. It is thus not very likely that monitoring is responsible for the application of concept or word mediation. Schaeffer and Carl (2015) revised this view of the monitor model and suggested that concept mediated and word mediated processes occur at the same time but that, similar to the model of Carl and Dragsted, word mediated processes are responsible for translation production. Concept mediated processes constitute monitoring of the translation process. This assumption is closer to the interactive activation account but it does not take into consideration that monitoring is part of the executive functions and thus not equal to linguistic processing in the same way that concept mediated translation is.

The investigation of monitoring in translation studies is thus not based on recent, generally accepted psycholinguistic findings and models.

Inhibition, which is a very important factor in models of language control in psycholinguistics, has also been included by translation scholars in theories on the translation process. Shreve and colleagues (Diamond &

Shreve 2017; Shreve & Lacruz 2017) assume for example, in line with Green's IC model, that inhibition is necessary to control the different languages involved in translation.

In psycholinguistics, several accounts have been made in terms of how languages are controlled by means of inhibition during translation. Green (1998) also addressed the question of language control in translation in his IC model:

> “A critical control issue is apparent: how does a person avoid naming the target word in L1 when translating from L1 → L2 or avoid naming the target word in L2 when translating from L2 → L1?” (Green 1998: 73)

According to the IC, translators actively inhibit lexical items from the source language during word translation. The stronger the activation of the words and thus the stronger the competition the more the unwanted elements need to be inhibited.

This assumption was tested by Price and colleagues (1999). In a PET study, they investigated whether control mechanisms are more involved in translation compared to reading. The authors conducted a test with highly proficient English-German bilinguals. They did not report any translation experience on behalf of the participants or whether they were balanced bilinguals. During the experiment, the participants had to silently read or to translate written words in either their L1, their L2 or in a mixed condition with both L1 and L2 words. The participants were asked to mouth their answer which was supervised by the researchers. Price and colleagues found stronger activation of areas linked to inhibition during translation compared to reading (the anterior cingulate cortex and subcortical structures). They interpreted these results in favor of the IC model.

Another interesting study related to translation and language control was performed by Ibáñez and colleagues (2010). They did not investigate the process of translation but tested whether translation experience leads to language specific lexical selection as suggested for language expertise by Costa and Santesteban (2004). Ibáñez and colleagues performed a self-paced reading task that involved language switching. Participants were presented with sentences which were shown word for word on a screen with participants moving on to the next word at their own pace. The participants had to repeat the sentences in the presentation language once they had finished reading a sentence. The experiment contained switch trials (two consecutive sentences were in different languages) and non-switch trials (two consecutive sentences were in the same language). The authors hypothesized that when language was controlled by means of inhibition, there would be an asymmetry in reading times for L1 and L2 switch-trials just as in the study by Meuter and Allport (1999). Two groups of participants were tested. Translators with at least two years of professional experience and a matched group of very proficient bilinguals were contrasted. The bilingual control group showed asymmetric switching costs, whereas the translators did not. Ibáñez and colleagues interpreted these results in favor of Costa's language specific selection hypothesis:

> “The results of the present study suggest that translators do not use inhibitory processes to control for the concurrent activation of their two languages.” (Ibáñez et al. 2010: 265)

Thus, translators might, just as highly proficient bilinguals, develop the capacity to control their languages by concentrating only on the elements of the relevant language and not through inhibition.

It becomes clear at this point, that there are several research gaps. Monitoring has been considered in translation process models and it has been suggested that translation experience influences monitoring processes. There is however, to my knowledge, no empirical data which supports this assumption. Inhibition has been investigated slightly more systematically. Price and colleagues showed that inhibition plays a role when bilinguals translate. But they did not test professional translators. Ibáñez and colleagues showed that translation experience has an influence on control mechanisms. But they only investigated reading and repetition processes and not translation. So far, there seem to be no studies investigating monitoring or inhibition processes during translation with carefully controlled experimental methods, including the factor of translation experience.

As mental control mechanisms are responsible for controlling language contact and avoiding interferences, and as it has been suggested that they change with language proficiency and translation experience, they might be an important factor to consider when investigating changes in language processing related to translation experience. As especially inhibition has been suggested to be influenced by language proficiency and translation experience, I will focus on this component of mental control in the following. It has to be underlined at this point, however, that there seems to be a strong relationship between the different components of mental control – especially inhibition and monitoring – and it might be difficult to distinguish between the two in an empirical study.

As the most important factors for language processing during translation, namely the mental lexicon, lexical activation and language control, have now been introduced from a psycholinguistic perspective, the next chapter will discuss frequency effects in translations and their mental causes that were the inspiration of the present investigation.

5 Frequency effects in translations

In the previous chapters, mechanisms of language processing in bilinguals and translators were introduced. The theories discussed served as a basis for influential theories (the gravitational pull hypothesis) related to the question why translators translate the source text in a certain way. They thus constitute an important basis to understand important theories in translation studies. So far, however, the motivation for the gravitational pull hypothesis, that is the nature of translations and how they differ from original texts in a certain language, has not yet been discussed in detail.

In this chapter, the state of the art of translation studies will thus be presented. As already mentioned in the introduction, a central question in translation studies is why translators translate a source text in a given way. First reports on the nature of translated texts were based predominantly on anecdotal evidence and case studies. Later studies were more systematic and investigated the nature of translations by means of corpus linguistics. The state of the art in this research field will be presented in Chapter 5.1. Only more recently have researchers from translation studies attempted to find cognitive explanations for frequency effects in translations, such as the gravitational pull hypothesis by Halverson. These cognitive explanations will be presented in Chapter 5.2.

In this thesis, I will test one of the assumptions postulated by the gravitational pull hypothesis, which is linked to translation experience. This will be tested on the translation of cognates. Previous research on translation experience and cognates in relation to frequency effects in translation (Chapters 5.3 and 5.4) and in relation to each other (Chapter 5.5), will therefore also be discussed in the following.

5.1 Classifications of frequency effects in translations

Translations differ from other written texts. The frequencies of linguistic properties such as grammatical features or lexical choices are found to be different between these two types of text. This effect has been investigated for several decades and the research conducted in this field will be briefly introduced in the following.

Different labels have been assigned to the language in translations, which differs from the language in target texts. Santos (1995) and Tirkkonen-Condit (2002) for example used the term *translationese*, Frawley (1984) talked about *third code* and Schäffner and Adab (2001) about *hybrid text*. Many first reports on the special nature of translations were, however, only anecdotal evidence (e.g. Catford 1965). Later studies investigated these characteristics by corpus linguistic means and led to general theories about the nature of translated texts such as the classification of frequency effects into different categories. Some of these categories have been suggested to be translation universals (Baker 1996), or the presence of specific structures in translations which are different from non-translated text. What is important in this context, however, is that they are not due to the structure of the source text. The absence of the influence of the source text as well as the question whether these frequency effects are really universal and can always be found has been widely debated (see for example Mauranen & Kujamäki 2004). In this study I will thus use the term frequency effects instead of translation universals. A large number of categories has been proposed in the literature, including the following:

- explicitation
- simplification
- normalization
- anti-normalization
- shining-through
- law of growing standardization
- law of interference
- unique item hypothesis

Some of the labels presented above refer to the same categories. In order to allow a more structured approach of these frequency effects, especially in regard to the question of their causes, Hansen-Schirra (2017) divided these classifications into two broader categories. The first category comprises frequency effects that can be linked to comprehensibility, including explicitation and simplification. Both frequency effects can on the one hand lead to an easier understanding of the target text but on the other hand might be due to cognitive understanding processes. Detailed definitions and examples of these frequency effects will be provided below:

Explicitation

Explicitation (e.g. Baker 1996; Becher 2011; Blum-Kulka 1986; Hansen-Schirra & Steiner 2012; Klaudy 1998; Steiner 2001) describes the phenomenon that translations are more explicit than originals in a language. Baker defined explicitation for example as “the tendency to spell things out in translation, including, in its simplest form, the practice of adding background information” (Baker 1996: 176). Becher defines this phenomenon as “[...] the verbalization of information that the addressee might be able to infer if it were not verbalized“ (Becher 2011: 18). And according to Steiner, a definition of explicitation would be the following:

> “We assume explicitation if a translation (or language-internally one text in a pair of register-related texts) realizes meanings (not only idea-tional, but including interpersonal and textual) more explicitly than its source text – more precisely, meanings not realized in the less explicit source variant but implicitly present in a theoretically-motivated sense. The resulting text is more explicit than its counterpart.” (Steiner 2012: 60)

In corpora, explicitation can for example be observed on the lexical level. In English translations, the word *that* is much more frequent than in English originals (Baker 1996). According to Baker, this is a way to make the texts more explicit than texts which were produced from scratch.

Simplification

Simplification has been defined as “the idea that translators subconsciously simplify the language or message or both” (Baker 1996: 176). This can be observed in the usage of shorter sentences in translations compared to originals and in a lower number of content words compared to original texts (for a review see Hansen-Schirra 2017). Laviosa investigated these features for example in a corpus of newspaper articles (Laviosa-Braithwaite 1996) and in a corpus of narrative prose in English (Laviosa 1998). In both corpora, she found a lower percentage of content words in the translations compared to the originals. In the corpus of newspaper articles, Laviosa also found shorter sentences for translations compared to originals.

The second category suggested by Hansen-Schirra (2017) describes frequency effects in translations which can be linked to preserving norms of the target culture versus introducing interferences from the source language. This category thus includes normalization, anti-normalization, shining-through and the unique item hypothesis. Causes of these categories might be the way translators deal with language contact. As Hansen-Schirra suggests, the translator either tries to avoid interference from the source language (e.g. normalization) or allows interference from the source language (e.g. shining-through, unique item hypothesis). A detailed description and examples of the frequency effects which fall into this second category proposed by Hansen-Schirra will be presented below.

Normalization

Normalization is, according to Baker, the tendency to follow the norms of the target culture to a larger extent in the translations than in originals:

> "'Normalisation' (or 'conservatism') is a tendency to exaggerate features of the target language and to conform to its typical patterns. […] Normalisation is most evident in the use of typical grammatical structures, punctuation and collocational patterns or clichés." (Baker 1996: 183)

Teich (2003) investigated normalization, for example, on the basis of a corpus of English and German popular scientific originals and German translations from English. The results showed that passive constructions are used more frequently in English texts. In regard to the frequency effects in translations, Teich found that the German translations contained more alternatives for passive constructions than the German originals. This was therefore interpreted as a case of exaggerating the norms of the target culture or normalization.

Anti-normization

Hansen (2003) investigated normalization. But she also uses the term anti-normalization for instances where less features are found than expected by the norms of the target language or "when the opposite of target language norms can be found in translation" (Hansen-Schirra 2017: 237).

Law of growing standardization and interference

Toury (1995) also investigated the special role of language in translations. He suggested that translations are located between two poles, the law of growing standardization (ibid: 268) and the law of interference (ibid: 275). The concept of the law of growing standardization is similar to Baker's concept of normalization – the translator strictly respects the norms of the target language. Toury's concept of the law of interference cannot be found in Baker's categories. This concept describes the fact that some features of the source language are transferred to the target text – that the interaction between the two languages involved in the translation becomes visible in the target text.

Shining-through

Teich (2003) adapts the categories of Baker and Toury, but renames the laws of interference as shining-through because the source text shines through in the target text:

> "[One] of the factors that makes translations different from comparable texts in the same language as the TL is that the source language – to a greater or lesser extent – shines through in translations." (Teich 2003: 22)

In the study on popular scientific texts already outlined above, Teich found not only instances of normalization, but also of shining-through. She did not only find more cases of passive alternatives in the German translations, which was interpreted as a case of normalization. But the German translations also contained more passive constructions than the German originals. As English texts of this genre typically contain more passive constructions than German originals, the phenomenon in the German translations was interpreted as shining-through: the source language shines through in the target texts.
This example of Teich's study shows that translations do not necessarily only exhibit one category of frequency effects. They can, for example, contain over- as well as under-representations of linguistic structures and thus show characteristics of normalization, anti-normalization and shining-through at the same time. This mixture of characteristics has been labeled as hybridization by Hansen-Schirra (2011).

Unique item hypothesis

According to the unique item hypothesis (Tirkkonen-Condit 2003; 2004), elements which are unique to a specific language will be more frequent in originals than in translations. The author tested this hypothesis on a corpus of Finish originals and translations with the results being in line with Tirkkonen-Condit's assumptions. Another example of unique items was provided by Capelle and Loock (2017). The authors investigated the use of phrasal verbs in English translations from a Romance language to their use in original English texts. They found a higher number of phrasal verbs in the originals than in the translations. Capelle and Loock argued that this can be interpreted as shining-through. Phrasal verbs are not used in Romance languages and the translators were therefore influenced by the source texts and used fewer phrasal verbs in the target texts than could be found in comparable originals.

In the classifications by Hansen-Schirra listed above, I already briefly mentioned possible causes for the frequency effects. But the question has not been answered fully yet: What exactly causes these frequency effects?

Three main causes have been suggested for frequency effects in translations (e.g. Becher 2011; Hansen-Schirra et al. 2012): structural difference between languages, voluntary choices and strategies of the translator as well as more or less unconscious cognitive processes.

Structural differences can, according to Klaudy (1998, see also Becher 2011), for example explain instances of explicitation. In these cases, the translator is forced to make something explicit in the target text which was implicit in the source text. This is due to structural differences between the languages; that which be expressed implicitly in the source language has to be expressed explicitly in the target language because there are no means to remain implicit in the target language.

Strategies of the translator lead, for example, to explicitation when the translator tries to avoid risks and to be very precise (e.g. Pym 2005).

These two possible causes of frequency effects will not be further discussed in this thesis. Instead, I will concentrate on cognitive causes for frequency effects in translations which have already briefly been mentioned above. They will be presented in the following chapter.

5.2 Cognitive explanations for frequency effects in translations

In translation studies, there have been several attempts to find cognitive explanations for the frequency effects introduced in the previous chapter. Steiner and Hansen-Schirra (Steiner 2001; Hansen 2003; Hansen-Schirra & Steiner 2012; see also Hansen-Schirra 2017) suggested, for example, that instances of explicitation and simplification can be explained by an incomplete repackaging of information. According to their theory, a translator analyses the information in the source text during reception and transforms them into a linguistic form in the target language during production (see also Figure 10). This production phase involves, according to the authors, different degrees of complexity, starting with a very simple linguistic structure and culminating in a very complex structure on a kind of continuum which the translator follows up to a certain point. If a translator stops repackaging at an early point on this continuum, less complex structures are used for production. This then leads to simplification or explicitation.

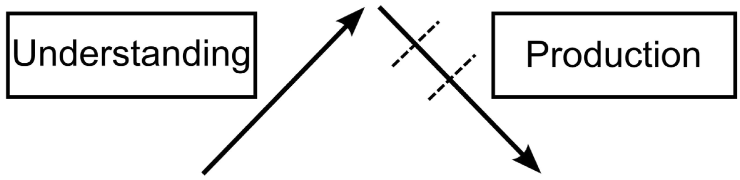

Figure 10: A simple model of the translation process explaining explicitation and simplification (adapted from Steiner 2001; see also Figure 6). The dashed lines indicate an incomplete production phase during translation which leads to less complex linguistic structures in the target text.

Another very influential theory which aims to explain frequency effects is the gravitational pull hypothesis by Halverson (2003, 2010, 2017). On the one hand, Halverson bases her theory on Langacker (1987) and on the other hand on models of the mental lexicon and of lexical access, which were described in the previous chapters (e.g. de Groot 1992a, b; Kroll & Stewart 1994; Pavlenko 1999).

Halverson assumes a decomposition representation of concepts. According to her, words are further divided into concept, lemma and lexeme and organized in a network-like structure. Lexical access takes place by spreading activation. She further assumes that structures in the mental lexicon become stronger when they are repeatedly activated. She calls this mechanism entrenchment.

> “Indeed, the links between translation pairs across languages are also strengthened through frequent activation of one member of the pair, given an assumption of joint activation at some representational level.” (Halverson 2017:14)

As reported earlier, this is also in line with other researchers from the fields of translation studies and psycholinguistics (see Chapter 3.3).

Apart from that, according to Halveson (2003), higher activation levels of elements in the mental lexicon are due to prototypicality[9] – prototypical expressions have a higher activation level than synonyms. And the relative frequency of use in a monolingual context also influences the activation level of elements in the mental lexicon.

The strength of representation within the mental lexicon is referred to as salience by Halverson. She distinguishes between three important kinds of representations and links within the mental lexicon:

- the strength of representations of the source language (also referred to as *gravitational pull*, Halverson 2017: 15)
- the strength of representations in the target language (also referred to as *magnetism*, Halverson 2017: 14)
- the strength of links between elements of the two languages (also referred to as *connectivity*, Halverson 2017: 14).

The salience of representations and the strength between links in the mental lexicon can account for frequency effects in translations. Translators tend to produce highly activated elements more frequently than less activated elements. This can then be found in frequency effects in text corpora:

> "However, the likelihood of a particular translational outcome (e.g., over- or underrepresentation) will depend on the specific structure of the bilingual semantic network activated in any given instance." (Halverson 2010: 352)

> "Thus the more established (entrenched) a link is, the more likely it will be activated and used in translation, and vice versa." (Halverson 2017)

This is in line with models from the field of psycholinguistics. Dell (1986) stated, for example, in his article in which he defined spreading activation in the mental lexicon, that speech errors are an outcome of the natural processing of the speech production system:

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9 See also Chapter 3.1.1 and 3.1.2 on different word activation mechanisms.

> “Errors are the natural consequences of the theory's assumptions. It just so happens that, on occasion, incorrect items have higher activation levels than correct ones and are selected. A large part of this potential for error comes from the spreading of activation and the construction of multiple representations.” (Dell 1986: 289-290)

The natural workings of the system could thus also explain word choices in translations. And if there are important changes in word choices among translators, this should also be reflected in the natural workings of the system.

Halverson (2017) suggested that the links between elements of the two languages involved might for example lead to effects such as those described by the unique item hypothesis. These links might, however, also play a role for the other phenomena included in Hansen-Schirra's (2017) second category.

Halverson further assumed that the mechanisms which lead to frequency phenomena are influenced by translation experience:

> “In a linguistic event, e.g. encountering a word or expression, certain cognitive routines are activated. The more frequently the event-type is repeated, the more “permanent” its activation pattern becomes. We might conjecture that this same process will pertain to translation events. In other words, translation (sub)routines will also become entrenched with increasing repetition.” (Halverson 2003: 199-200)

This is also in line with researchers from the field of psycholinguistics (de Groot 1992b; García et al. 2014; Paradis 1984, see also Chapter 3.3). García and colleagues (2014) also suggest, for example that the links between elements of the translator's two languages might be altered due to translation experience:

> “We speculate that continual reflection about similarities and differences between equivalents leads beginner students to recognize and reinforce novel inter-linguistic associations while inhibiting cross-language connections to representations which they wrongly believed to be shared between equivalents.” (García et al. 2014: 10)

Other researchers in translation studies also assume that the activation of elements in the mental lexicon determines which elements are chosen for a translation. Carl and Schaeffer (2017) compared, for example, translation from scratch and post-editing. The variety of translation solutions (translation entropy) was higher in translations from scratch than in post-editing. The authors argued that in post-editing, a translation solution is already primed by the output of the machine translation and thus easier to access and thus chosen for the final version of the target text.

Carl and Schaeffer did not link their findings to categories of frequency effects in translations. Neither did they consider changes in the mechanisms which might correlate with translation experience.

In this thesis, I will investigate the connection between the mental processes, of which it has been suggested that they lead to frequency effects in translations, and whether they change with translation experience. An advantage of Halverson's theory is that it is based on psycholinguistic models of the mental lexicon and language processing. Many studies exist in this field, and in the study presented in this thesis, I will use them to investigate the relationship between translation experience and the structure of the mental lexicon. But there is also a disadvantage to Halverson's theory. As was shown in Chapter 4, mental control mechanisms such as inhibition play an important role in bilingual language processing and during translation. I will thus not only investigate the structures of the mental lexicon, but also inhibition. Before addressing the question of how the structure of the mental lexicon and inhibition can be empirically investigated, I will first present existing research in translation studies on the relationship between translation experience and frequency effects in translations. I will also present the role of cognates for the investigation of frequency effects and finally, a prestudy will be presented which shows that the use of cognates in translations correlates with translation experience.

5.3 Frequency effects and translation experience

Before introducing studies that investigated the relationship between translation experience and frequency effects in translations, the concepts of translation experience, expertise and competence will be briefly introduced.

An expert in any kind of profession or activity has to gain expertise in order to achieve a high level of performance. Many scholars assume that acquiring expertise is a continuous development from novice to experts which takes place by gathering experience in the respective field (for a review and controversial discussion see Ericsson 2006). Hurtado (2017) adapts this view of expertise to the field of translation. Ericsson criticizes, however, that "[extensive] experience in a domain does not, however, invariably lead to expert levels of achievement" (Ericsson 2006: 6). We can therefore not be sure to measure increasing levels of expertise when investigating translation students with different amounts of translation experience. Due to this debate, I will use the term translation experience instead of translation expertise in this thesis.

During the above mentioned development from novice to expert, translators have to acquire translation competence (e.g. Hurtado 2017; PACTE 2000). Translation competence[10] has been defined as the "knowledge and abilities translators need to translate correctly, and what enables them to be able to perform the cognitive operations necessary to develop the translation process and the tasks required in the professional setting [..]. This competence identifies the translator and distinguishes her/him from the non-translator." (Hurtado 2017: 12)

It is important to note at this point that translation competence is different from L2-competence. This view is generally accepted in translation studies (PACTE 2017) as well as in psycholinguistics (Obler 1983; Vildomec 1963; García 2014):

[10] Different sub-components have been suggested which might be part of the broader term translation competence. These sub-components will not be further explored here. For a review see, for example, Esfandiari and colleagues (2015).

> “However we have been able to corroborate the fact that TC is different from bilingual competence and is a competence acquired either through personal experience as a translator (self-taught) or as a result of a learning process.” (PACTE 2017: 281)

In the present study, the L2 competence of the participants will therefore also have to be taken into consideration. Especially since the structure of the mental lexicon as well as language control mechanisms have been assumed to change with language proficiency in psycholinguistics (see Chapters 2, 3 and 4).

Getting back to the main question of this chapter – whether frequency effects depend on translation experience – the first fact to note is that in translation studies, several corpora were created which contain translations by translators with different levels of translation experience. But only some of these corpora were investigated for frequency effects (for reviews see Rodriguez-Ines 2017a, b).

The CORDIALL (Corpus of Discourse for the Analysis of Language and Literature) contains different sub-corpora of originals and translations as well as a sub-corpus (CORPRAT) with product and process data collected on novice and expert translators (e.g. Pagano et al. 2004). This corpus includes key-logging information, audio files of retrospective interviews as well as the translation product. To my knowledge, no data on frequency effects in the translations in relation to translation experience have been published.

Another database with product as well as process data is the CRITT tpr-database (e.g. Carl 2012). The principal aim of this database was to gather process data of many translators for the same source texts. With the help of several research institutes, the CRITT team at the Copenhagen Business School, gathered product data and process data for translations, post-editing and monolingual editing (the source text was not presented in this editing mode) for six different English texts that were translated into a variety of target languages. These target languages include among others Danish, Spanish, German and Chinese. The database contains information on student translators as well as professionals. The tpr-database does not only contain key-logging data like the CORPRAT but also eye-tracking data. Although the tpr-database contains product data, it was mainly built to investigate translation behavior. The analysis of translation experience in the CRITT tpr-database therefore concentrates on process data (e.g. Balling & Carl 2014; Martinez-Gómez et al. 2014) while there seem to be no studies on frequency effects related to translation experience.

In the TransComp project, 12 student translators' product and process data were gathered in a longitudinal study over three years (e.g. Bayer-Hohenwarter 2010; Göpferich 2009). The data of these student translators was compared to the behavior and target texts of 10 professional translators. The researchers investigated, for example, the number of mistakes, linguistic shifts and unique translation solutions in the corpus among translation trainees and experts.

PACTE (Rodriguez-Ines 2017) constructed a corpus of translations from 35 translators and 24 foreign language-teachers. The participants translated texts from their L1 Spanish or Catalan into their L2 English, French or German and from their L2 into their L1. Rodriguez-Ines reports on a number of analyses in the corpus. This includes the use of loanwords, the length of sentences and the type/token ratio. One result of this study was that translators used more loanwords in their target texts than the foreign language teachers.

The findings, especially those of the TransComp project and the PACTE research group, suggest that there are indeed differences in the frequency effects of student and professional translations. This supports Halverson's assumptions of changes due to translation experience from a corpus linguistic view. In the following chapter, the use of cognates in translation studies will be presented as this will also further outline the motivation for the use of this group of words for the present study.

5.4 Frequency effects and cognates

Cognates have not only been used in psycholinguistics in order to test the models of the mental lexicon and lexical access. In translation studies, they are also considered very useful in reflecting how translators process their languages during translation:

> "Cognates provide a reliable and easily quantifiable tool for future research. How translation students and professional translators choose to translate cognates can be seen as a reflection not of only their attitude towards cognates but of their attitude towards the entire enterprise of translation." (Malkiel 2009: 321)

Several studies have investigated the use of cognates in translations (e.g. Gieshoff 2017; Hansen-Schirra et al. 2017; Kußmaul 1989; Kußmaul & Tirkkonen-Condit 1995; Malkiel 2009; Oster 2017; Tercedor 2011; Vandepitte et al. 2015; Vintar & Hansen-Schirra 2005).

Vintar and Hansen-Schirra (2005) conducted, for example, a corpus based study in the language pairs Slovenian-English and German-English. They found a connection between the use of cognates and the status of the foreign language English in Slovenian and in German. In German, English words were, at least at the time the corpus data for this study were collected, more accepted during translation than in Slovenian. Vintar and Hansen-Schirra found that the German translations contained more cognates than German originals and the Slovenian translations contained fewer cognates than original Slovenian texts. This led to the conclusion that the language pair English-German shows more shining-through on the lexical level and the language pair Slovenian-German more normalization.

The number of cognates in translations has not only been investigated in large corpora. In one recent study for example, the influence of production modes on the use of cognates in translations was studied (Oster 2017). Translation students were divided into two groups. One group produced a written translation of a text with a high cognate density while the other group spoke the translation of this text. The number of cognates in the source text which were translated by target language cognates was compared for the two groups. In addition to that, the spoken translation was further divided into first spontaneous production and final production after self-correction. The results showed that the percentage of source language cognates translated by target language cognates was highest for the first oral production phase, followed by the final oral production phase. The lowest percentage of cognate-cognate-translations was found in the written production mode (see also Figure 11). It was suggested that the different production modes and phases differ mainly in the amount of time the participants have to formulate their translation and that this leads to different strengths for monitoring of production. This interpretation was however very speculative and will need to be tested in further studies.

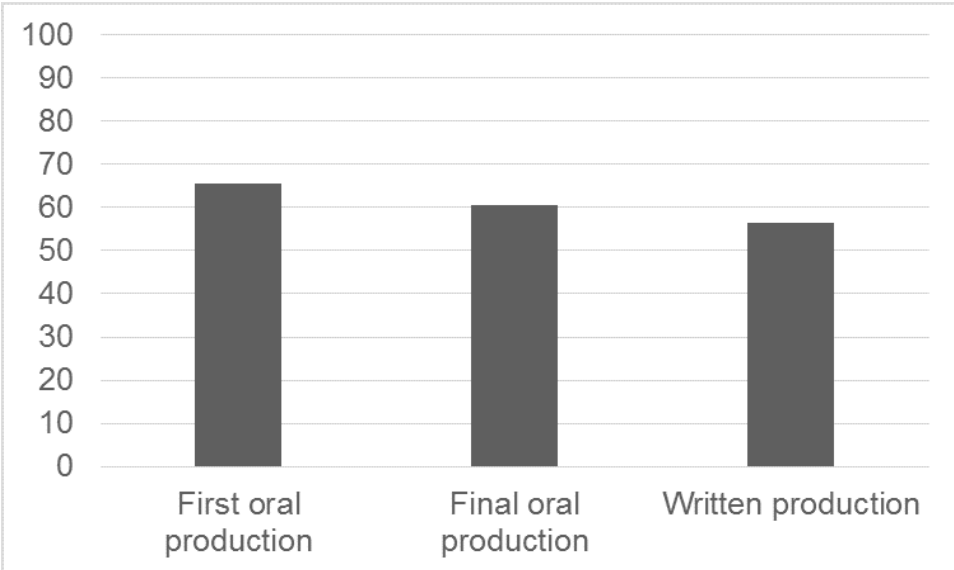

Figure 11: Number of cognates in translations according to different production phases and modes (spontaneous first oral production, oral production after self correction and written production)

Gieshoff (2017) investigated the use of cognates during simultaneous interpreting. She manipulated the participants' visual input and the noise level of the stimuli. The participants in Gieshoff's study were eight interpreting students from the University of Mainz. They were presented with videos containing speeches in American English. In the control condition, the participants saw a man who was clearly articulating a speech in the video while his lip movements were visible. The participants were asked to interpret the speech they were listening to. In one experimental condition, the lip movements were manipulated. The participants saw only a fixed image of the speaker. In the second experimental condition, white noise was added to the speech. The participants were presented with all possible combinations of conditions (lip-movements without noise, lip-movements with noise, no lip-movements without noise, no lip-movement with noise). The analysis of the translation of cognates in the target text was similar to Oster (2017). In a first step, source text words which had a similar form in the target language were identified. In a second step, the translation of these words was investigated in the target text and instances of cognate-cognate translations were counted. The results of this study showed that the participants used more cognate-cognate translations in the condition without lip-movements. The manipulation of the noise level had no effect on the number of cognates in the target text. Gieshoff suggests that lip-movements have an impact on the comprehension of a spoken text and that this leads to more available resources for the control of cognate-production.

Hansen-Schirra and colleagues (2017) report on several studies on the predictors of cognate frequency in translations. The predictors investigated include sociological and technological developments over longer periods of time, different text types, the impact of machine translation and post editing versus human translation, translation experience (see Chapter 5.5 on a detailed description of this study) and linguistic context. For the investigation of the influence of linguistic context, the authors presented for example lists of single words and texts to translation students. Both, lists and texts contained the same cognate stimuli. The participants had to translate the lists of words and the texts from English into German. The results showed that the participants produced a cognate-cognate translation in the single word list condition more often than in the text condition (see Table 1 for the results).

Condition	Cognate-cognate translation	Cognate-non-cognate translation	No translation
Single word list	57.39	32.24	10.37
Text	37.27	54.91	7.82

Table 1: Number of cognate translations in single word translation and text translation

Several studies showed that translation students try to avoid cognate-cognate translations (e.g. Kußmaul 1989; Kußmaul & Tirkkonen-Condit 1995; Malkiel 2009; Tercedor 2011).

Kußmaul (1989; see also Kußmaul & Tirkkonen-Condit 1995) conducted a study with think aloud protocols where participants were asked to verbalize every thought that came into their mind while translating (Ericsson & Simon 1980; see also Chapter 6 for a more extensive discussion of this method). This study was conducted with translation students. Kußmaul reports that the students feared interferences. They tried to avoid cognate translations. When a cognate word came into their mind, they searched for alternatives. However, Kußmaul reported no statistics on these cases and did not investigate whether this phenomenon was influenced by translation experience.

Tercedor (2011) investigated the translation of cognates in cases where the target text had to meet special spatial constraints such as, for example, forms. Two experiments were conducted. In the first experiment, translation students translated a web contact form which contained cognates. They were allowed to independently choose their preferred software to produce their translations and had one whole week in which to translate the experimental text at home. There was thus very little experimental control. The reported results concentrate only on single cognates and give no clear picture of the overall use of cognates in this context. In the second experiment Tercedor tested foreign language students. They translated sentences which contained the same cognates as the texts in experiment 1. Here, the students were presented with a more controlled setting, where for example the time of stimulus presentation was controlled. This is a major shortcoming of the study. Tercedor's aim was to compare foreign language students and semi-professional translators, but the experimental conditions were not comparable.

Malkiel (2009) had 15 translation students translate a short text containing cognates. As in Tercedor's study, the participants translated the text at home and could use as many resources as they wanted. They had two weeks to finish the translation. After the first translation of the text, the participants were asked to delete this first version and to translate the text again from scratch. These two versions were then compared by Malkiel. The results showed that the participants chose more non-cognate translations in the second version of the target text. The author interprets these results in favor of Kußmaul's theory of the fear of interferences.

The studies introduced above thus showed that frequency effects have also been investigated on the use of cognates. The use of cognates can be a good starting point for a cognitive study. Single words can be controlled more easily, which is important for the investigation of speech processing mechanisms in bilinguals. In addition, cognates have also been extensively studied in psycholinguistics in order to shed light on bilingual language processing.

As the studies on cognates and experience reported above were not sufficiently controlled for confounding variables, a prestudy was conducted for this thesis. This prestudy will be presented in the following chapter.

5.5 The number of cognates in translations and translation experience

Hansen-Schirra and colleagues (2017) investigated the influence of several factors and translation modalities other than language status on the number of cognates in target texts. Besides the factors already mentioned in Chapter 5.4, the interaction between the use of cognates and translation experience was also investigated by the authors.

For this study, 43 students of the FTSK in Germersheim participated in the experiment. They all studied English and their mother tongue was German. The participants translated a text on home affairs in the United States which was taken from the news platform www.foxnews.com. The original text was shortened in order to obtain a higher cognate density. The final text was 187 words long and contained 49 English-German cognates which were analyzed in the target texts. The students translated the text in a lecture at the FTSK. In contrast to, for example Malkiel and Tercedor, we chose this procedure for several reasons although it constituted a less natural working environment for the students. First of all, the conditions should be as comparable as possible for all participants. This could vary if the participants choose the place and time and even computer and software by themselves. In addition to that, we were interested in the influence of the mental processes on the translation product, which change with experience. If the participants were able to use external resources such as dictionaries at home, we could not ensure that differences are not due to different use of these resources. Since the experiment was part of the students' course, they did not receive any further credit for participation. The participants were informed that the target texts would be treated anonymously and the results used for scientific purposes only. They were further informed that their results had no influence on their grades and that they could withdraw from the experiment at any time.

For the analysis of the translations, the number of cases in which participants decided to translate a source language cognate with a target language cognate was counted (e.g. *system* was translated by *System* and not by *Anlage*). The number of cognates in the translations correlated significantly with the semester of the participants (see also Figure 12): $r(41) = -.42$, $p = .005$.

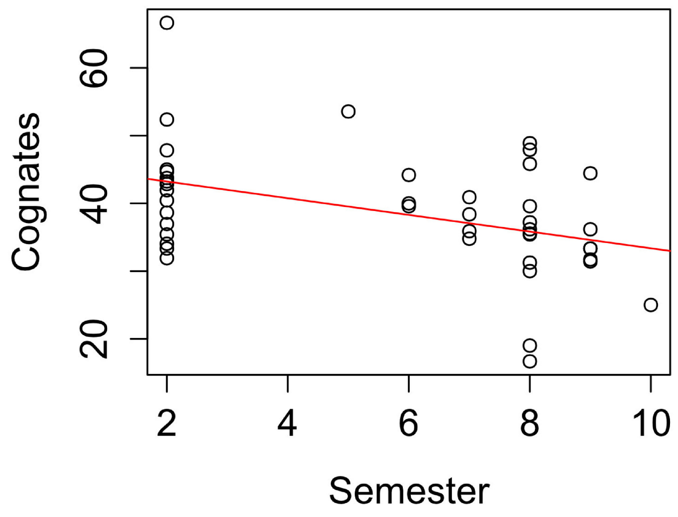

Figure 12: Correlation of semester and cognates.

These results support Halverson's assumption that there are changes in the mechanisms linked to frequency effects in translations and that they are related to translation experience. The results are also a motivation to investigate these mechanisms on the processing of cognates. Cognates are thus not only a way to investigate mechanisms of language processing with psycholinguistic methods, but their use in translations also seems to be linked to translation experience. In this thesis, they will therefore be used to investigate whether the structure of the mental lexicon and inhibition change in relation to translation experience. Before discussing the hypotheses which will be tested in this study in detail, possible measurements for the structure of the mental lexicon and for inhibition will be introduced in the following chapter.

6 Measurements for structures in the mental lexicon and for inhibition

This chapter will start with a discussion of measurements which have traditionally been used in translation process research. I will argue why these methods are not a good choice for the purpose of the present study. In Chapters 6.1 and 6.2, alternative approaches will be presented.

The question why translators use certain expressions in the target language has always been a central point of interest in translation studies. In early stages of this discipline, the translation process was modeled by investigating only the product. But as this information was not detailed enough to draw sufficient conclusions about the ongoing processes, empirical methods were introduced (e.g. Kußmaul & Tirkkonen-Condit 1995; see for example Göpferich 2008 for a discussion of traditionally used research methods).

One of the first methods used were think aloud protocols (TAP; Ericsson & Simon 1980, Kußmaul & Tirkkonen-Condit 1995; for a review see Jakobsen 2017). In this method, participants are asked to verbalize all thoughts that come into their mind while translating. The speech output is recorded and transcribed. The TAPs are then analyzed for different aspects. One major drawback of think aloud protocols is that it is generally assumed that many mental processes during translation occur automatically (e.g. Jääskeläinen & Tirkkonen-Condit 1991). This is in line with the psycholinguistic models presented in the previous chapters. Lexical access as well as control mechanisms occur unconsciously and can often not even be detected with the help of behavioral methods but only using electrophysiological methods (e.g. Wu & Thierry 2012). Participants can thus not report on these processes in think aloud protocols (e.g. Jakobsen 2017). Kußmaul & Tirkkonen-Condit (1995) already stated in regard to different applications of think aloud protocols:

> “The validity of all these methods has been questioned, basically for the reason that, in spite of their seeming closeness to the translation process, they nevertheless do not get close enough and still leave out too much.” (Kußmaul & Tirkkonen-Condit 1995: 183)

In addition, the think aloud method might slow down and even alter the participant's production because it constitutes extra effort (Jakobsen 2003).

To overcome some of these shortcomings, keystroke logging was introduced (e.g. Jakobsen 1999; for a review of studies performed with keystroke logging see also Jakobsen 2017). In this method, participants perform a written translation and a software registers all keystrokes. The software then provides the insertions as well as deletions with exact time stamps to the researcher.

With keystroke logging, no information is gathered about mental processes occurring when the participant is just reading the source or target text. Eye-tracking was thus introduced to translation studies. With this method, the eye-movements of the participants are tracked while they read or translate. Some studies used eye-tracking alone and compared, for example, reading for comprehension and reading for translation (Jakobsen & Jensen 2008). But in many recent studies, eye-tracking has been combined with keystroke logging in order to uncover patterns of translation behavior (e.g. Balling & Carl 2014; Carl 2012; Dragsted & Carl 2013; Jakobsen 2011).

All of the above mentioned methods have in common that the participants translate entire texts. And one goal of many studies is to create a very natural setting where the translators can use external resources and feel as much like in their real work-life as possible (e.g. Kußmaul & Tirkkonen-Condit 1995; Malkiel 2009; Tercedor 2011; Whyatt 2010). This is, however, also a shortcoming of these studies. As shown in the previous chapters (Chapters 2, 3 and 4), cognitive processes during bilingual word processing and translation have been extensively studied in psycholinguistics. Many models and theories have been suggested for this field of research. In translation studies, these theories are not often considered for translation process models (one example of their application is the gravitational pull hypothesis by Halverson 2003, 2010, 2017). But most importantly, although there are some attempts to use these theories, the methodologies which are well established in psycholinguistics to test the theories and models on language processing and mental control have to my knowledge not been applied in translation studies.

In the present study, I will thus use psycholinguistic methods that are well established and have been previously used to measure the representation of words and inhibition. In the following chapters, word translation tests as well as event-related potentials will be presented. Word translation tests have been used in psycholinguistics to shed light on the structure of the mental lexicon. Event-related potentials can reveal a variety of mental processes which cannot easily be investigated by behavioral methods, including inhibition.

6.1 Word translation tests

The word translation test is a paradigm which is widely used in psycholinguistics but is not common in translation studies. In word translation tests, single words are presented on a computer screen and the participants are asked to orally translate these words as quickly and precisely as possible.

These tests have been used to investigate a variety of topics. In many word translation studies, the directionality effects predicted by the RHM were investigated (e.g. de Groot et al. 1994; Francis & Gallard 2005; García et al. 2014; Ibrahim et al. 2017; Kroll & Stewart 1994; Poarch et al. 2015; Sholl et al. 1995; see also Chapters 2.2 and 3.3 for a discussion of the RHM). For this purpose, reaction times of forward translation (L1 to L2) are compared to reaction times of backward translation (L2 to L1). Asymmetries in the reaction times were predicted by the RHM because forward translation should be conceptually mediated and backward translation word mediated. Recently, control mechanisms involved in word translation compared to a within language word generation task were also investigated (Jost et al. 2018, see also Chapter 6.2.3 for a more detailed description of this study).

Other studies tested which linguistic factors influence the reaction times during word translation. De Groot (1992b) tested a variety of these factors and found that words with a high frequency were translated faster than those with a low frequency, concrete words were translated faster than abstract words, short words were translated faster than longer words and cognate were translated faster than non-cognates. Faster reaction times for cognates were interpreted by stronger links between the lexemes in the two languages compared to non-cognates (see also Chapter 3.4). Tokowicz and Kroll (2007) also investigated whether the fact that some words have more than one translation in another language has an influence on the production speed in a word translation test. Their results showed that words with several possible translations were translated slower than words with only one translation.

Word translation tests have thus been proven to be a good approach to measuring lexical access and language control during translation while limiting confounding variables that might be induced by the context in larger textual units. And the effects measured during word translation might still have an influence during natural translation of texts. Halverson states for example:

> “While translators translate words in context, they still translate words. It is not impossible that some of the characteristics of semantic organization at this level should percolate up to the surface of translated texts.” (Halverson 2017: 40)

Empirical studies also show that the cognate facilitation effect, which was originally observed in word translation tests is also present when a linguistic context is presented before the source word that has to be translated by the participants (e.g. van Hell & de Groot 2008, see also Chapter 3.4).

For the purpose of investigating changes in the links between lexemes in the translator's lexicon, I will therefore use word translation tests. The confounding variables stated by de Groot (1992a, word frequency, concreteness and word length) will be controlled for. The mental control mechanisms involved in the translation of cognates and non-cognates will be investigated by combining reaction time measurements during the word translation test with event-related potentials. The use of event-related potentials and the way they can be used to investigate inhibition will be presented in the next chapter.

6.2 Event-related potentials

Event-related potentials (ERPs) are averaged EEG-signals to a stimulus or a response. They have been used to investigate processes in the brain since the 1930s. Hans Berger (1929) first observed electric brain activity by placing an electrode on a participant's scalp. Only some years later, Davis and colleagues (1939) recorded the first ERP as a response to an acoustic stimulus. Since then, the ERP-technique has become more and more popular because new technologies such as computers made it easier and cheaper to conduct experiments (for a review see Luck 2005).
ERPs do not offer a high spacial resolution like hemoglobic methods (such as fMRI) but they provide very precise timing. The waveforms that can be observed as a brain response to a stimulus or a response are also referred to as components. Most of them are labeled according to their polarity (negative = N, positive = P) and either in which temporal order they peak (P1, N1, P2, N2 are typically the first/second positive or negative peak in the ERP) or at which point in time their peak usually occurs (N400 typically peaks at about 400 ms). Other components, such as the ERN (error related negativity), are labeled according to the condition at which they are usually larger. And some components are named according to their localization such as the ELAN (early left anterior negativity), which can be observed at anterior electrodes on the left side of the head (for a review see Luck 2005; Luck & Kappenman 2012).
In language studies, several stimulus locked ERP-components have been used to investigate for example lexical processes (P2, Sereno et al 1998;

Strijkers et al. 2010), semantic processes (N400, Holcomp 1993; Koester & Schiller 2008; Kutas & Hillyard 1980), syntactic processes (P600, Coulson et al. 1998) and inhibition (N2, Folstein & van Petten 2008). And more recently, a response locked ERP linked to monitoring has been investigated in speech production (ERN/Ne, Acheson et al. 2012; Ganushchak & Schiller 2008; Masaki et al. 2001).

In the following, I will present the N2-component that can be used to investigate mental control processes in translators. This component was used to measure inhibition during translation in the present study. The difficulties which arise when investigating ERPs in overt speech will be discussed and solutions for these difficulties will be presented. And finally, I will review the literature on ERP studies of cognate processing and single word translation.

6.2.1 The N2 component as an indicator of inhibition

The N2 was first thought to be part of the P300 component and both were modulated in the Oddball paradigm (e.g. Squires et al. 1975). These tasks are typically go/no-go tasks in which participants have to respond to one stimulus group but not to the other. In addition, one stimulus group is presented frequently and one with a low probability (80/20 for example). The N2 and P3 are typically larger in the rare condition and had thus been linked to the detection of probability (for a review see Folstein & van Petten 2008).

Pfefferbaum and colleagues (1985) discovered however, that the N2 on frontal electrode sites was not only larger on rare stimuli but also on no-go-trials in go/no-go tasks when the probability of the stimuli was not modulated (see also Kok 1986). Due to this experimental effect on this component, the N2 has been linked to inhibition processes (Jodo & Kayama 1992; Pfefferbaum et al. 1985; Thorpe et al. 1996).

The location of the N2 and the experimental conditions are important in this context. Apparently, three sub-components of the N2 exist: One fronto-central (anterior) sub-component is sensitive to novelty of stimuli and thus for example modulated by probability in the Oddball paradigm, another fronto-central sub-component has been related to inhibition and monitoring processes (e.g. Pfefferbaum et al. 1985), and a third posterior sub-component has been linked to visual attention (for a review see Folstein & van Petten 2008).

In the present study, I am interested in mental control mechanisms. The design of the word translation test should already exclude differences in the novelty of the stimuli between conditions. And by focusing on frontal electrode sites reported in studies on mental control, I should be able to investigate only the N2-sub-component linked to inhibition and monitoring. But which control mechanisms does the N2 reflect?

Some studies suggested that the N2 was rather linked to pure conflict monitoring and that it did not reflect the active inhibition of actions (cf. Nieuwenhuis et al. 2003; Yeung et al. 2004, see also Donkers & van Boxtel 2004). But it has been shown that the size of the N2 correlates negatively with the number of errors made (Falkenstein et al. 1999) and many researchers concluded that the N2 reflects inhibition processes and not (only) monitoring mechanisms (e.g. Bruin et al. 2001; Carriero et al. 2007; Dong et al. 2009; Eimer 1993; Falkenstein et al. 1999; Falkenstein 2006; Kok 1986). But as stated previously (see Chapter 4), inhibition and monitoring of language processing are inter-dependent. It is thus very likely that the N2 can be linked to both mechanisms.

The N2 has been observed in many tasks involving mental control. The effect Pfefferbaum and colleagues (1985) observed on the N2 in no-go-trials has been replicated in several studies (e.g. Bruin & Wijers 2002; Falkenstein et al. 1999; Jackson et al. 1999).

In Eriksen flanker tasks (Eriksen & Eriksen 1974), participants have to respond to a letter which is flanked by other letters which might be of the same kind as the critical letter (congruent condition) or of another kind (incongruent condition). The incongruent condition involves more mental control in order to ignore the letters next to the target stimulus (for a review see Folstein & van Petten 2008). The N2 has been shown to be larger for the incongruent than for the congruent condition (Bartholow et al. 2005; Dong & Zhong 2017; Heil et al. 2000; Kopp et al. 1996; Yeung et al. 2004).

Dong and Zhong (2017) performed an Eriksen flanker task on students with interpreting training and students without interpreting training. They found a larger N2 for the first group. They concluded that interpreting involves a lot of inhibition which strengthens the general capacity to inhibit actions.

In the stop signal task (e.g. Logan et al. 1984), participants respond to trials and have to withhold their response when they are presented with a stop signal. The N2 has been shown to be larger in trials with successful inhibition than in trials with failed inhibition (Pliszka et al. 2000; Schmajuk et al. 2006).

The N2 has also been observed in linguistic tasks. In the Stroop task (Stroop 1935), participants are presented with color words. In the congruent condition, the color words are presented in the respective font color (e.g. the word *blue* is presented in *blue*) in the incongruent condition, the color words are presented in a non-matching font color (e.g. the word *blue* is presented in *red*). The N2 has been shown to be larger in incongruent trials than in congruent trials (e.g. Holmes & Pizzagalli 2008; Silton et al. 2010).

The N2 has been observed in language switching tasks as well. Jackson and colleagues (2001) conducted a digit naming task in which participants had to switch between their languages. The N2 was larger in switch-trials than in non-switch trials (see also Schmitt et al. 2000, 2001).

Several studies have been conducted combining language switching with picture naming (Christoffels et al. 2007; Verhoef et al. 2009). Participants had to name some pictures in their L1 and other pictures in their L2. The N2 was larger in switch trials than in non-switch trials in these studies, too.

Independent component analysis led to the conclusion that the N2 in switch paradigms reflects the same mechanism as the N2 in go/no-go tasks and can thus be linked to inhibition (Jackson et al. 2001; Kopp et al. 1996; Schmitt et al. 2000).

For the present study, it is not only important to understand the processes which are reflected by the N2 but also at which electrodes[11] the N2 related

[11] See for example Luck (2005) for an introduction to EEG electrode labels and placements.

to inhibition has been reported to be largest. In the early non-linguistic studies, the N2 was largest at the Fz-electrode (e.g. Pfefferbaum et al. 1985; Falkenstein et al. 1999; Heil et al. 2000). These studies included only midline-electrodes, but the N2 has also been reported to be largest at fronto-central electrodes in studies using more electrodes (e.g. Bartholow et al. 2005; Bruin & Wijers 2002; Yeung et al. 2004). In some studies, the N2 has however been reported to be largest on right-frontal electrodes (e.g. Bokura et al. 2001; Pliszka et al. 2000; Schmajuk et al. 2006).

In linguistic tasks, the N2 was largest at central mid-line electrodes (Holmes & Pizzagalli 2008), Fz (Christoffels et al. 2007, Jackson et al. 2001) and FC4 (Verhoef et al. 2009).

Besides the localization of the N2, the time window plays an important role for the data analysis of the present investigation as well. The time window of the N2 differs in different studies. Some authors suggested that the N2 peaks later in bilingual tasks (for a review see Christoffels et al. 2007). Table 2 presents an analysis of the different time windows in studies investigating the frontal N2 linked to inhibition in manual tasks and Table 3 presents an analysis of such studies on monolingual and bilingual tasks.

Time window reported	**Peak reported**	**Task**	**Reference**
200-400 ms	275 ms	go/no-go	Pfefferbaum et al. 1985
200-400 ms	300 ms	go/no-go	Falkenstein et al. 1999
–	283 ms	go/no-go	Jackson et al. 1999
200-250	–	go/no-go	Bruin & Wijers 2002
155-370 ms	–	Eriksen flanker	Heil et al. 2000
250-350 ms	–	Eriksen flanker	Bartholow et al. 2005
300-400	344 ms	Eriksen flanker	Yeung et al. 2004
190-230	210 ms	stop-signal	Pliszka et al. 2000
200-220	200 ms	stop-signal	Schmajuk et al. 2006

Table 2: N2-time window and peak latency in motor tasks

Time window reported	Peak reported	Task	Reference
136-240 ms	212 ms	Stroop	Holmes & Pizzagalli 2008
275-374 ms	–	language switching in picture naming + cognate status	Christoffels et al. 2007
300-360 ms	330 ms	language switching in picture naming + cognate status	Verhoef et al. 2009
300-350 ms	320 ms	language switching in digit naming	Jackson et al. 2000
300-600 ms	–	tacit picture naming-task, go/no-go response (monolinguals vs. bilinguals)	Rodriguez-Fornells et al. 2005
300-700 ms	450 ms	go/no-go on semantic category and grammatical gender decision	Müller & Hagoort 2006

Table 3: N2-time window and peak latency in linguistic tasks

In the next chapter, an important question for the use of the event-related potential technique will be discussed: is it possible to use overt speech when combining a word translation test with EEG. It is usually advisable to reduce noise in the EEG in order to produce clean data. And this question has therefore to be considered before designing an experiment.

6.2.2 ERPs in overt speech

Unfortunately, when investigating overt speech, motor artifacts occur and can hide ERP-components of interest. This is why many studies use tasks where the participants have to press buttons instead of using overt speech (for a review see Costa et al. 2009).

Recently, new artifact reduction methods have been developed (e.g. de Vos et al. 2010) which make it possible to reduce muscle artifacts resulting from overt speech and even to investigate response-locked ERPs such as the ERN and the CRN during overt speech (e.g. Acheson et al. 2012; Ganushchak & Schiller 2008).

Apart from that, several studies showed that ERPs are free from muscle artifacts up to 400 ms after stimulus onset in studies which involve overt speech (e.g. Eulitz et al. 2000; see also Costa et al. 2009). According to the literature presented in the previous chapter, the N2 peaks well before 400 ms. In word translation tests using overt speech production, the N2 should thus be free from speech related muscle artifacts. From a technical perspective, the event-related potential technique can therefore be taken into consideration for the investigation of inhibition during word translation including overt speech production. In the following, existing studies on word translation and cognate processing using ERPs, where the present investigation can be based on, will be presented.

6.2.3 ERPs in word translation tests and cognate studies

Several ERP studies have been conducted using the word translation test as a paradigm (Christoffels et al. 2013; Janyan et al. 2009; Jost et al. 2018) or cognates as stimuli (Acheson et al. 2012; Christoffels et al. 2007; Midgley et al. 2011; Peeters et al. 2013; Strijkers et al. 2010).

As far as I know, only very few ERP studies on word translation tests exist. Christoffels and colleagues (2013) compared backward and forward translation while including interlingual homographs as markers of language conflict. They focused on the P2 and the N400 components and found that translation direction had an impact on both components. The N400 was larger for interlingual homographs. The authors concluded that this is an indicator that the conceptual level is accessed no matter the translation direction.

Janyan and colleagues (2009) investigated whether concreteness and cognate-status of words lead to the activation of different brain regions during word translation. The authors investigated a time window of 300-500 ms without naming specific ERP components. They found topographical effects of the concreteness effect in cognates but not in non-cognates. Janyan and colleagues argue that this could be an indicator for concept mediated translation in cognates and word mediated translation in non-cognates (but see Chapters 2.2 and 3.3 on these theories and especially on a discussion of the involvement of the conceptual level during translation).

Jost and colleagues (2018) compared a word translation test to a within language word production test in order to compare neural activity linked to lexical access mechanisms. The authors did not concentrate on classic ERP components but investigated several time windows. They found higher activation in a time window of 424-630 ms after stimulus onset in the word production test compared to translation. Based on the literature, Jost and colleagues suggested that this effect reflects that more words are activated during a word generation task than during translation.

Among the studies which are based on cognate stimuli in paradigms other than translation, different ERP components have been investigated. Acheson and colleagues (2012) performed a picture naming task in L1 and L2 and investigated the response-locked ERN component that reflects monitoring. The authors observed a small difference in the ERN which was, however, not significant.

Strijkers and colleagues (2010) also investigated brain reaction in a picture naming task in L1 and L2 to cognate and non-cognate stimuli. They concentrated, however, on stimulus locked ERPs and not on a specific component but on the general time course linked to cognates and non-cognates. The authors found diverging brain responses for the two stimulus types from 200 ms after stimulus onset. Cognates showed lower amplitudes than non-cognates and Strijkers and colleagues interpreted this as a reflection of the CFE in ERPs.

Midgley and colleagues (2011) compared ERPs for cognates and non-cognates in a semantic categorization experiment. The participants read lists of words and had to press a button when they read words that fell into a specific semantic category. Half of the critical words were cognates and half non-cognates. The authors found a larger N400 for non-cognates than for cognates. The authors interpreted this as a facilitated mapping of lexemes to concepts for cognates.

In the study by Peeters and colleagues (2013), the participants had to perform a lexical decision task in their L2. Similar to the study of Midgley and colleagues, the authors found a larger N400 for non-cognates than for cognates. In addition to the previously reported studies, Peeters and colleagues found a larger P600 for cognates which they associated with the difficulty of deciding which language cognates belonged to in their paradigm.

To my knowledge, Christoffels and colleagues (2007) reported the only study so far which investigated the N2 component in ERPs that are locked to cognate and non-cognate stimuli. In their study, participants performed a language switching task while naming pictures with either cognate or non-cognate names. Besides switch and non-switch trials, the authors also investigated ERPs linked to cognates and non-cognates. They found a larger N2 in cognate compared to non-cognate trials. Although the authors argue that it is difficult to assume inhibition mechanisms while strong facilitation can be observed for cognates, these results are in line with Green's (1998) IC model. If language control involves inhibition, elements in the mental lexicon which have stronger activation have to be inhibited accordingly. In the case of cognates, there is more activation and thus there should be also more inhibition than for non-cognates. As the N2 has been shown to reflect inhibition in a variety of studies, it can be used in the present study to investigate inhibition processes during translation. In the following chapter, I will further discuss which effects we should expect to find during cognate and non-cognate translation among students with different experience levels.

7 Hypotheses

So far, the research on the mental lexicon, lexical access and mental control in psycholinguistics was reviewed (Chapters 2, 3 and 4). Many researchers agree that words are stored as concepts and lexemes in the mental lexicon. In bilinguals and thus also in translators, there is only one mental lexicon. Bilinguals have shared conceptual representations for their two languages, but one representation for each lexeme in each language. Facilitating links exist between the lexemes of two languages. When bilinguals activate entries in the mental lexicon during reception or production, activation spreads in the whole lexicon, not excluding the languages that are not involved. The same mechanism is present during translation; activation spreads in the whole lexicon and does not exclude the conceptual level.

The frequent activation of certain translation equivalents leads to changes in the mental lexicon. The strength of frequently used links between lexemes of L1 and L2 is strengthened (e.g. de Groot 1992b; García et al. 2014; Paradis 1984).

Besides the mental lexicon, control mechanisms also play an important role in speech processing of bilinguals and translators (Chapter 4). As both languages are activated during lexical access some kind of mechanism has to assure that only one language is used for production. Mental control mechanisms consist of several sub-processes. Two extensively studied sub-processes are monitoring and inhibition. These processes are tightly linked and inter-dependent. But only inhibition has been shown to differ significantly depending on the experience of participants in language switching paradigms. This was shown for language proficiency as well as for translation experience. Low proficient bilinguals used inhibition to control languages, proficient bilinguals used language specific selection mechanisms, which means that they did not inhibit the uninvolved language but simply ignored it. Similar results were shown for translation experience. Participants with no translation experience used inhibition to control their languages and participants with translation experience used language specific selection mechanisms.

The review of the state of the art in translation studies (Chapter 5) showed that major research questions in this field are how translations differ from original texts in a certain language and why they differ. Many corpus linguistic studies tried to answer the first of these questions and more recently, very influential suggestions have been made on the mental causes for frequency effects in translations (e.g. Halverson 2003, 2010, 2017; Hansen 2003; Hansen-Schirra & Steiner 2012; Steiner 2001). One of these theories is the gravitational pull hypothesis by Halverson. This theory is based on the psycholinguistic research presented in the first part of this thesis and it suggests that representation and link strengths in the mental lexicon influence the translators' translation solutions. Another assumption of the gravitational pull hypothesis is that translation experience modifies the mechanisms which are responsible for frequency effects, namely the links between elements in the mental lexicon. This has also been suggested in psycholinguistics but to my knowledge, it has not yet been empirically investigated. In this thesis, I will test this assumption.

In a prestudy (Chapter 5.5), I tested whether experience related differences in the frequency of cognate use in translations could be observed in the language pair English-German. Cognates have been well studied in translation studies as well as in psycholinguistics. In the latter field, they have been used by many researchers to investigate the structure of the bilingual mental lexicon as well as lexical activation. And as the prestudy showed a relationship between cognate use and translation experience, this gave me another motivation to use this type of stimulus for the present study.

A shortcoming of Halverson's gravitational pull hypothesis is that it does not contain mental control mechanisms. Influential models in psycholinguistics such as the BIA+ (Dijkstra & van Heuven 2002) or the IC (Green 1998) suggest, however, that mental control plays an important role during language processing. Different sub-components of mental control have been suggested and they probably interact quite strongly. In most relevant studies, inhibition in particular was chosen and investigated (Chapter 4). In the present study, I will thus not only investigate changes in the links in the mental lexicon as suggested by Halverson, but also inhibition. I will investigate how inhibition is linked to lexical processing during translation and whether it changes with translation experience.

A review of several empirical methodologies showed that methods traditionally used in translation studies such as eye-tracking, keystroke logging or TAPs, might not be useful when investigating the mental lexicon and inhibition during translation (Chapter 6). A better option might be to investigate the processing of cognates in word translation tests while measuring reaction times and event-related potentials.

Cognates have been shown to be translated faster than non-cognates in word translation tests (Chapters 3.4 and 6.1). The faster reaction time for cognates has been explained by stronger links between cognate lexemes (e.g. de Groot 1992b). As these translation equivalents share more formal features, they are more closely linked than non-cognates. This results in a higher activation level and thus faster reception and production times.

Also in ERP studies (Chapter 6.2.3), participants showed a different response to cognates than to non-cognates (Christoffels et al. 2007). In a picture-naming test, the N2 component, which has been linked to inhibition in previous studies, was larger for cognates than for non-cognates. The explanation for this was that cognates receive more activation due to their shared form and meaning. In accordance with Green's IC model, cognates should thus be inhibited more strongly than non-cognates in order to avoid interferences. So far, no N2 component for cognates and non-cognates has been reported for word translation tests. But as the IC model does not only apply to speech production during picture naming but also during translation, we could expect similar results in word translation tests.

So what could we expect to find in an empirical study contrasting cognates and non-cognates in a word translation test with participants of different experience levels? If the links between lexemes in a translator's mind change with translation experience, which links would that be and how can this be reflected in behavioral and electrophysiological data?

For the link strength between lexemes, several reports and theories of other researchers and the finding of the prestudy could lead to the assumption that, above all, the links between non-cognates become stronger with translation experience. García and colleagues (2014) suggested that translation students might create stronger links between translation equivalents which are considered to be a good translation. For the language pair English-German, this could affect cognates and non-cognates. Kußmaul (1989, see also Kußmaul & Tirkkonen-Condit 1995) reported a think aloud study which showed that translation students tried to avoid translating English cognate words caused by the German cognate equivalent. They tried to find non-cognate synonyms. The prestudy could also be interpreted in this direction. Advanced students used more non-cognate translation solutions for source language cognates. If link strength between lexemes changes if translators correct themselves and avoid certain translation solutions (e.g. García et al. 2014), cognates and non-cognates could be a good candidate to test this. At least in the language pair English-German, the studies presented above lead to the conclusion that translation students try to avoid cognates. It could thus be assumed that avoiding cognates reduces the link strength between these words in the mental lexicon of translation students and for the language pair English-German, whereas the links between non-cognate-words chosen as an alternative translation solution are strengthened (see also Figure 13 on the possible changes in link strength).

The altered link strength should be reflected in the reaction times for cognates and non-cognates in a word translation test. If the links between non-cognate translation equivalents are reinforced over time because they are used preferably, the cognate advantage should decrease in the word translation test.

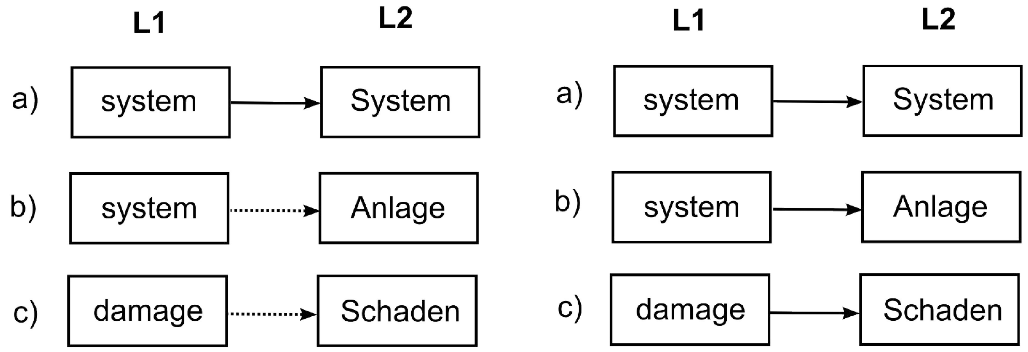

Figure 13: Left: Links between lexemes in bilinguals without translation experience. The cognate pair system and System (a) are closely linked due to formal similarities. The cognate-non-cognate pair system/Anlage (b) as well as the non-cognate pair damage/Schaden (c) have weaker links. Right: Links between lexemes in bilinguals with translation experience. Due to repeated use of cognate-non-cognate translations and non-cognate translations and avoidance of cognate-cognate translations, the advantage of link strength of cognate pairs (a) decreases and links in cognate-non-cognate pairs (b) and non-cognate pairs (c) are strengthened.

Besides the links between lexemes, the inhibition mechanism might play an important role during translation. According to the literature, the inhibition processes should depend on the level of activation in order to avoid interferences (Chapter 4.1). This can also be investigated in a word translation test contrasting cognates and non-cognates. The N2 component should be larger for cognates than for non-cognates just as Christoffels and colleagues (2007) showed for picture naming. As cognates also receive more activation during lexical access in a word translation test, they need to be inhibited more strongly than non-cognates in accordance with the IC model (Green 1998). If links between cognate and non-cognate lexemes change as described above, the difference in the activation level will change and thus the difference in the need for inhibition. The N2 modulation will decrease just as the difference in reaction times will decrease.

We also have to take another possibility into consideration however. It has been suggested that inhibition processes during language processing change with language proficiency (Costa & Santesteban 2004) as well as translation experience (Ibáñez et al. 2010). According to these assumptions, highly proficient bilinguals as well as highly proficient translators use language specific lexical selection processes and do not use inhibition in order to control their languages. If more experienced translators engage in more language specific lexical selection processes, there should be no need to inhibit cognates more strongly than non-cognates, because they can just be ignored during lexical selection no matter how high the activation level is. The hypothesis on language specific lexical selection was primarily based on language switching paradigms and it is thus not likely that this also applies to translation. If the results of the present study show however, that there is no difference in the N2 for cognates and non-cognates or that the modulation of the N2 decreases while the difference in reaction times does not, this might be an indicator contradicting the IC of Green and a sign for language specific lexical selection processes instead. This is however only speculative and at the moment, I formulate only the following hypotheses which will be tested in this study:

a) cognates are translated faster than non-cognates
b) CFE decreases with translation experience
c) N2 is larger for cognates than for non-cognates
d) modulation of the N2 decreases with translation experience

The investigation of these hypotheses will not only help to fill research gaps in translation studies, but in psycholinguistics it might also help to advance the understanding of language processing in bilinguals and translators:

> “Finally, it would be interesting to examine how excitatory and inhibitory mechanisms are affected by translation expertise in both word reading and word translation [...].” (García et al. 2014)

The four hypotheses stated above will be investigated in an empirical study which will be presented in the next chapters.

8 Study

In the present study, the cognate facilitation effect and the N2 were measured in a word translation test. These two measurements and several factors of experience were then included in a statistical model. The aim of the present study was to investigate the interaction between translation experience and links between L1 and L2 lexemes on the one hand and the amount of inhibition during translation on the other hand

8.1 Method

In the following, the method which was used in the present study will be described in detail. This section will thus cover information on the participants, the measurements to gather information on their experience level as well as on the stimuli used in the word translation test. The experimental procedure will be explained as well as the recording and analysis of the EEG data.

8.1.1 Participants

Forty students from the translation department (FTSK Germersheim) of the University of Mainz participated in the experiment (36 female, mean age = 22.07, sd age = 5.24). All participants were German native speakers and studying English[12], all had normal or corrected-to-normal vision and no history of brain injury or illness. The participants were in different semesters of their studies, in order to investigate students with different levels of experience (mean = 3.52, range = 2-11). Six participants were excluded from the final analysis due to outlier data based on the questionnaire and language test (3 participants) and on the behavioral data (3 participants, see also Chapter 8.2.1 for a detailed report on the statistics).

[12] All participants were late English-German bilinguals.

The participants gave written consent according to the Helsinki-rules (see Appendix for the consent form). They were informed that they could withdraw from the experiment at any moment and without giving any reason for their withdrawal.
The participants received course credit for their participation in the experiment.

8.1.2 Material

To evaluate the experience of the participants, a questionnaire was designed for the purpose of this study (see Appendix I for the questionnaire). It is based on an instrument used by García and colleagues (2014) and was adapted for the purpose of the present study. The questionnaire included questions about history of language acquisition and formal education. It contained a self rating part where the participants had to evaluate their language level in German and English as well as their level of experience in forward and backward translation by using a score between 100 (very good) and 0 (very poor). I also included questions about the time the participants spend consuming German and English media per week and how much time they spend on forward and backward translation and interpretation. A scale with seven possible answers was provided for this part of the questionnaire (0-3, 3-6, 6-9, 9-12, 12-15, 15-18, 18+ hours per week).
The language level of English was not only assessed through self rating in the questionnaire but also with the help of an online language test (Dialang, https://dialangweb.lancaster.ac.uk/ see also Elmer et al. 2010; Jost et al. 2018; Zhang & Thompson 2004). In this language test, different aspects of language competence can be tested. As the participants had to deal with single written words in English during this study, they only took the test on English vocabulary knowledge. The test consisted of a placement test and the main language test. The results of the placement tests were used by the software to choose appropriate tasks in the main test. The output of the placement test was a number of points ranging from

0 to 1000. The output of the main language test was a level of proficiency divided into six groups according to the Common European Reference Framework for Languages (A1, A2, B1, B2, C1, C2). Studies using Dialang to measure language competence reported either the results of the placement test (e.g. Jost et al. 2018) or the results of the main language test (e.g. Elmer et al. 2010). For the present study, results of both placement test and main test were used for the statistical analysis as this might reveal differences between the participants that might not be detected otherwise.

A total of 88 abstract English nouns was chosen for the word translation test. Half of the stimuli (44) were English-German cognates and the other half were English-German non-cognates (see Appendix II for the stimuli lists).

The stimuli were abstract nouns. There are often several possible ways to translate abstract nouns and if we assume that links between translation equivalents change in relation to translation choices, this effect should be strongest for abstract words. The word class of nouns was chosen because many studies investigating the cognate facilitation effect in word translation tests used nouns (e.g. de Groot 1992b; García et al. 2014). In addition to that, nouns can be translated most easily without context.

To evaluate the cognate status of the possible stimuli, a group of 31 translation students was asked to rate the similarity of the experimental stimuli and their possible translation in German on a scale from 1 (no similarity) to 7 (high similarity). Cognates were rated significantly more similar to their translations than non-cognates (see Table 4). To control for other variables, the words were matched for their frequency in the source language according to the BNC (British National Corpus – http://www.natcorp.ox.ac.uk/), word length in letters and possible translations in the target language German according to a corpus based online dictionary (www.linguee.de). Concreteness rankings were taken from Brysbaert and colleagues (2014; see Table 4 for the statistics).

Cognate -status	Frequency	Word length	Trans-lations	Concrete-ness rating	Similarity rating
Cognates	M = 7104.89, SD = 6499.05	M = 8.05, SD = 2.09	M = 9.95, SD = 4.58	M = 2.55, SD = .68	M = 5.01 SD = 1.89
Non-cognates	M = 7515.02, SD = 7091.38	M = 7.86, SD = 1.94	M = 10, SD = 5.06	M = 2.63, SD = .54	M = 2.20 SD = 1.68
P-values	W = 992; p = .84	W = 938; p = .80	W = 948.5; p = .87	W = 854, p = .34	W = 1593, p < .0001

Table 4: Statistics of the stimuli of the word translation test. Wilcoxon tests were performed for the frequencies, word lengths, possible translations, concreteness ratings and similarity ratings for cognates and non-cognates. The differences of the frequencies, word lengths, possible translations and concreteness ratings were not significant. The only significant difference was observed in the similarity ratings. The stimuli groups thus only differed in their cognate-status.

8.1.3 Procedure and design

The participants were tested individually at the TRA&CO center at the FTSK in Germersheim. They sat in an electrically shielded and acoustically attenuated room in front of a computer screen. The participants were instructed to fixate the screen, to avoid movements, especially blinking, and to speak the translation of the words as quickly and correctly as possible.

The experiment was divided into a training phase and an experimental phase. During the training phase, the participants were familiarized with the task. It consisted of one block of stimuli and the experimental phase consisted of 10 blocks of stimuli. Each block consisted of four cognates and four non-cognates which were repeated four times each. The stimuli were randomly assigned to the blocks and presented in a pseudo-random order within the blocks. Each stimulus was preceded by a fixation cross for 500-800 ms. A jitter was included in order to avoid the participants developing a systematic expectancy of the next stimulus which could result in a contingent negative variation in the ERPs (CNV, Walter 1964, see also Christoffels et al. 2007). The fixation cross was followed by a black screen for 500 ms. The words stayed on the screen for 500 ms, followed by a black screen for 2500 ms. The next trial started automatically (see Figure 14 for the experimental routine). The participants were asked to answer before they saw the fixation cross of the next trial. In all, every block thus contained 16 trials per condition and 32 trials in total. The training phase contained 32 trials and the experimental phase consisted of 320 trials.

The stimuli were presented with the software PsychoPy (Peirce 2007). The vocal responses of the participants were registered with Audacity® (https://audacityteam.org/). Trigger-recording of the stimuli and the vocal responses was done with the Cedrus® stimtracker which includes a voice key. For the trigger-recording of the stimuli, a little white square was placed on the screen for each stimulus. The optical sensor of the stimtracker then detected the presentation of the stimulus. The information of the stimtracker were directly sent to the EEG and matched to the raw EEG data.

Including the time for preparation, the questionnaire and the language test, the experiment lasted for about two hours.

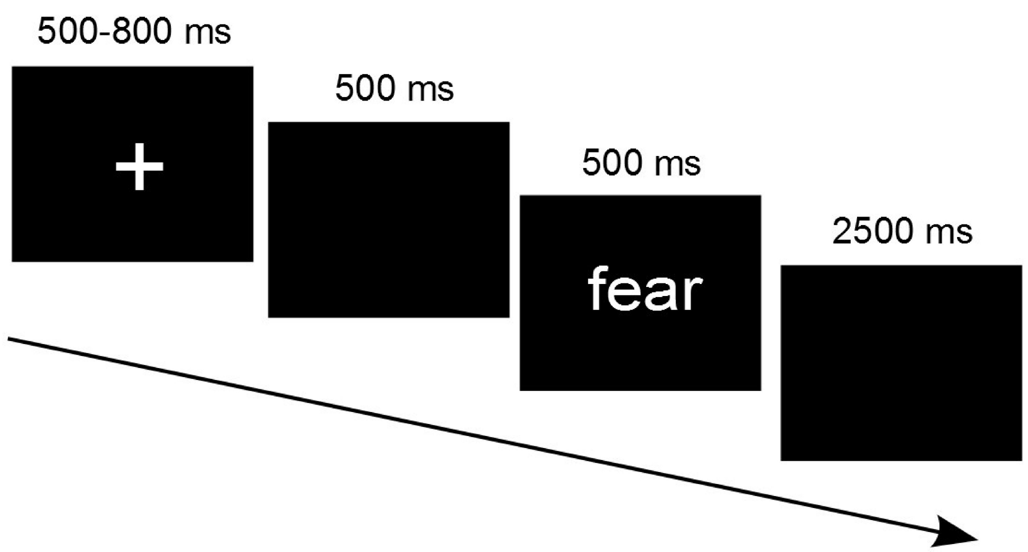

Figure 14: Experimental routine of the word translation test

8.1.4 EEG-recording and apparatus

The EEG was recorded from 64 electrode sites with the SynAmps 2 system of Neuroscan (Compumedics, El Paso, TX, USA) at a sampling rate of 1000 Hz. Electrode caps with Ag/Ag+ electrodes were used. The impedance was kept below 5 kΩ. The online reference was a reference electrode located between Cz and Cpz.

Off-line processing was performed with EEGLAB (Delorme & Makeig 2004). During off-line processing, the data were down-sampled to 250 Hz for faster data processing. The signal was filtered with a high-pass-filter at 0.5 and a low-pass filter at 40 Hz. Bad channels were manually rejected and independent components (ICA) were computed. Artifacts were then reduced by manually rejecting ICA-components resulting from noise. The rejected bad channels were replaced with interpolation.

For the ERP-analysis, epochs of 250 before stimulus onset and 1000 ms after stimulus onset were defined. The baseline was corrected in a window from -250 to 0 ms to the stimulus onset. Bad epochs were manually rejected.

8.1.5 Exclusion of data

Trials were rejected from the ERP as well as from the RT analysis when participants did not answer correctly. This included if the translation of a word was not found in the dictionary linguee (www.linguee.de), if the answer consisted of several words (*plan* was translated with *ein Plan*) or if the participants did not use a noun but a word of another word class to translate the stimulus (*plan* was not translated with the noun *Plan* but with the verb *planen*). The trials were also rejected when the participants did not answer, when the voice key was triggered by a false alarm (for example when a participant produced sounds of hesitation) and when a cognate was translated by a non-cognate. One non-cognate stimulus (*meaning*) was excluded from the analysis because it was translated as *Meinung* (engl. *opinion*) in two cases. Despite the similarity ratings, it was thus retrospectively considered to be a false friend and therefore completely excluded from the analysis. And finally, all trials in which the response time was beyond three standard deviations were rejected.

8.2 Results

In the following, the results of the study will be presented. Questionnaire data and the results of the language test will be presented in the first part, followed by behavioral data in the second part and ERP data in the third part.

8.2.1 Biographical data and language history

As already introduced in the previous chapter, the following experience related information was gathered in the questionnaire and in the language test in order to measure the competence level of the participants (see also Table 5 for a summary of the biographical, questionnaire and language data):

Factors linked to biographical information:

- age
- years of formal education (years_of_edu[13])
- highest degree

[13] The abbreviations given in parentheses are used for display reasons in the figures of this chapter.

Factors linked to language proficiency in L1 and L2:

- age when starting to learn English (age_aqu_E)
- years learning English (years_E)
- points received in the language placement test (L_Points)
- language level (L_Level)
- self rating of English competence (SR_German)
- self rating of German competence (SR_English)
- hours spent weekly reading in German (hours_reading_G)
- hours spent weekly reading in English (hours_reading_E)
- hours of weekly exposure to TV/radio in German (hours_TV_G)
- hours of weekly exposure to TV/radio in English (hours_TV_E)

Factors linked to translation experience:

- semester
- self rating of forward translation competence (SR_FT)
- self rating of backward translation competence (SR_BT)
- hours spent weekly performing forward translation (hours_FT)
- hours spent weekly performing backward translation (hours_BT)
- hours spent weekly performing forward interpretation (hours_FI)
- hours spent weekly performing backward interpretation (hours_BI)

In a first step, the mean and standard deviations of each category were calculated in order to remove participants who were outliers, which could influence the statistical analysis in a negative way. Outliers were defined as values that lie more than three standard deviations above or below the mean. One participant was removed because the points he received in the language placement test were more than three standard deviations below the mean ($M = 748.68$, $SD = 155.70$, removed participant = 220). One participant was removed because his age was more than three standard deviations above the mean ($M = 22.08$, $SD = 5.24$, removed participant = 53). One participant was removed because his self rating of German was more than three standard deviations below the mean ($M = 98.47$, $SD = 3.97$, removed participant = 80). Three of forty participants were thus considered outliers on the basis of the questionnaire and language data and removed from the data set before further statistical analysis (see also Chapter 8.1.1 for a more detailed description of the participants).

Parti-cipant	Semester	Age	Years of English training	Language Level English	Self rating English	Self rating Forward Translation	Self rating Backward translation
1	2	20	10	B2	80	80	75
4	2	20	14	B2	80	70	80
5	5	23	12	B2	80	70	90
6	6	21	12	B2	70	60	80
7	2	21	8	C1	75	70	75
8	4	21	12	C1	85	70	85
10	2	21	11	C1	90	85	80
11	2	20	11	C1	70	70	90
12	2	23	12	B2	72	60	75
13	2	19	9	B1	75	60	80
14	2	21	11	C1	88	75	70
15	4	20	14	B2	75	70	85
16	2	20	11	C2	80	80	85
17	2	22	13	B2	85	85	85
18	2	20	10	C1	60	90	95
19	2	19	13	B2	75	40	80
20	4	21	11	B2	75	75	95
22	2	20	14	B2	65	60	75
23	2	20	10	B2	70	65	70
25	6	23	10	C1	85	80	95
27	4	22	13	C1	85	80	90
28	2	21	10	B2	60	60	70
29	2	19	12	B2	75	70	75
30	5	21	13	C1	85	85	90
31	2	19	10	C1	80	60	80
32	5	24	14	B2	80	80	90
33	11	23	17	-	85	85	90
34	5	22	11	C1	90	80	85
35	9	23	9	B2	90	95	100
36	7	21	11	C1	85	50	60
37	3	53	8	B2	80	80	95
38	3	25	13	C2	80	70	70
39	6	21	11	C1	80	70	90
40	5	21	10	B2	70	85	70

Table 5: Summary of the biographical, language and questionnaire data

Figure 15 shows a first correlation analysis of the questionnaire and language test data.

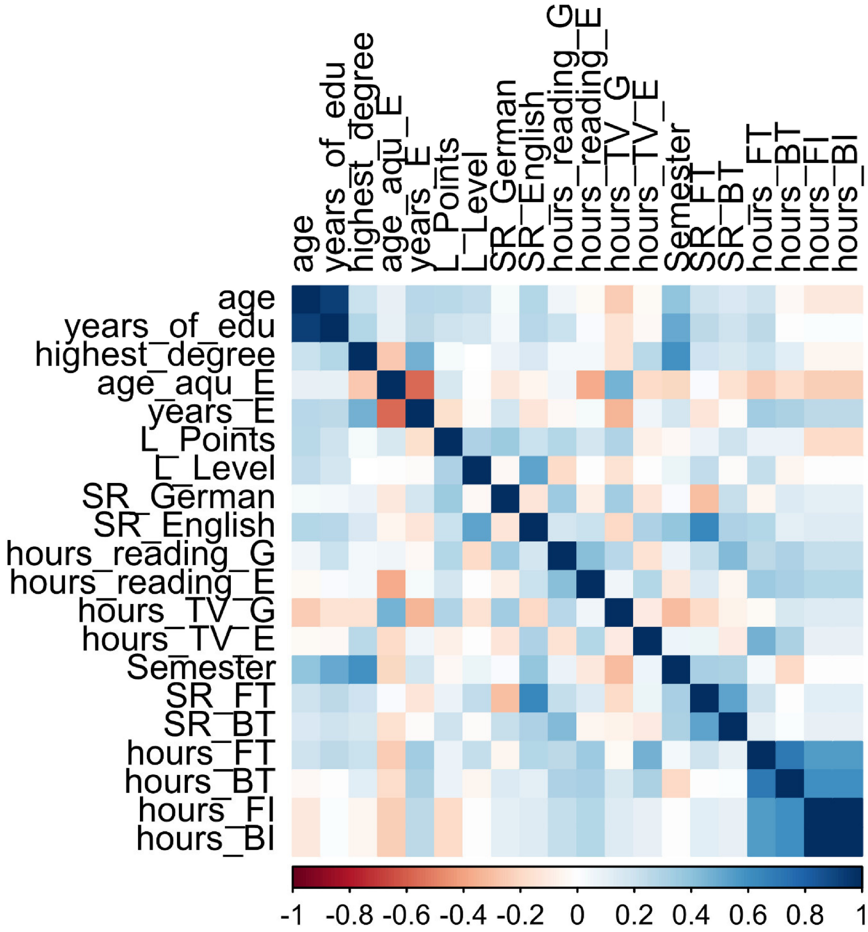

Figure 15: Correlation matrix of questionnaire and language test data with uncorrected p-values. Each variable has been correlated with all other variables. The darker the shade of the color field, the stronger the correlation. Blue indicates positive correlations, red negative correlations. The mid line is the correlation of the variables with themselves and thus a perfect positive correlation.

There was a significant, positive correlation between self ratings of language level and the results of the language test (language level, see also Figure 16): $r(28) = .53$, $p = .006$[14]. This indicates that the students were rather good at judging their language competence.

[14] For multiple comparisons, p-values were adjusted according to the Bonferroni correction procedure.

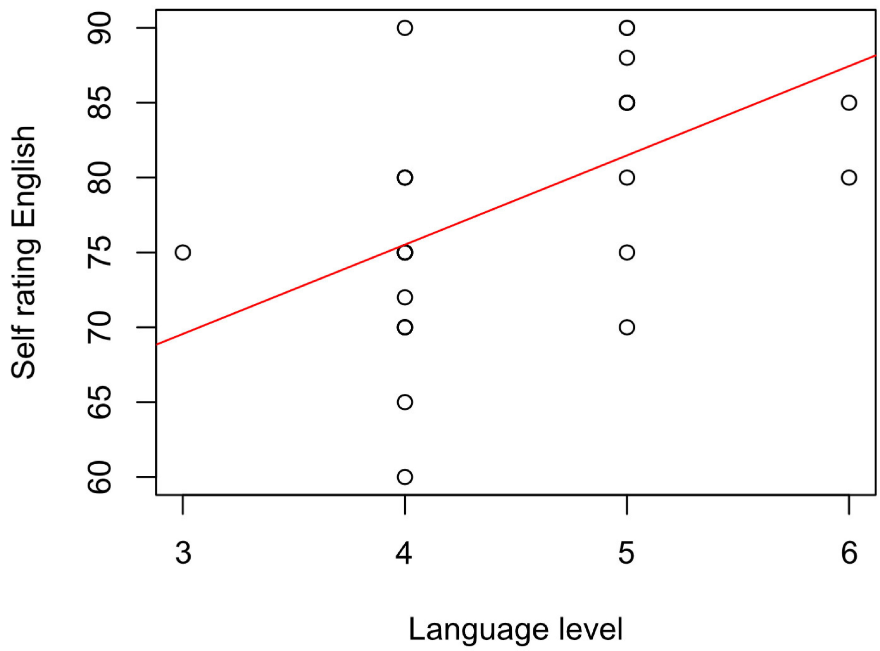

Figure 16: Correlation of language level (1 = A1, 2 = A2, 3 = B1, 4 = B2, 5 = C1, 6 = C2) and self rating of English level

The age of the participants and the years they spent in formal education also correlated positively: $r(30) = .93$, $p < .0001$. And the age the participants started learning English correlated negatively with the years they have been learning English: $r(30) = -.57$, $p = .0007$. The semester correlated positively with the years spent in formal education: $r(30) = .51$, $p = .01$. The semester also correlated positively with the highest degree obtained $r(32) = .59$, $p = .0006$. The language level did not correlate with the semester (see Figure 17 for a more detailed view): $r(30) = .07$, $p = .68$. In the following chapters, statistical models will be used in order to investigate if and which of the questionnaires and language test data has an influence on the CFE as a measurement of lexical representations in the mind and the modulation of the N2 as a measurement of inhibition. Although I will test the hypothesis that the CFE as well as the modulation of the N2 by the cognate status of stimuli decreases with translation experience, the literature shows that language proficiency might also influence these factors. The correlations computed in this chapter will help to avoid collision problems when fitting the statistical models.

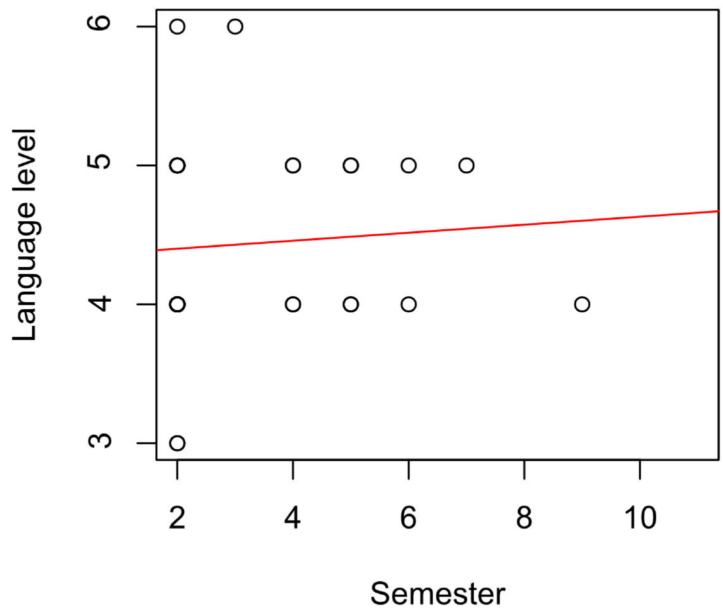

Figure 17: Correlation of semester with language level

8.2.2 Behavioral data

For the analysis of the behavioral data of the word translation test, the following variables were measured:

- number of trials which were not translated
- number of wrong answers
- number of cognates which were translated with non-cognates
- number of RT-outliers

As for the questionnaire data, participants were removed from the dataset if their behavioral data was more than three standard deviations above or below the mean and was thus considered as outlier data. One participant was removed because the number of cognate stimuli which were not translated was more than three standard deviations above the mean ($M = 4.70$, $SD = 5.79$, removed participant = 28). One participant was removed because the number of trials where no voice key trigger could be recorded or where a false alarm triggered the voice key was more than three standard deviations above the mean ($M = 19.08$, $SD = 15.09$, removed participant = 66). And one participant was removed because his mean reaction time for cognates was more than three standard deviations above the mean of the whole sample ($M = 789.87$, $SD = 111.64$, removed participant = 1218.77).

Before calculating the statistics on the reaction times, several trials were rejected from the data set (see also Chapter 8.1.5). In 5.60 % of the trials, the voice key did not send a trigger or sent a false alarm due to non-vocal noise. In total, 8.87 % of the trials were removed because the participant did not answer, 4.37 % were excluded due to wrong answers and 1.39 % were removed because the reaction time for the answers was beyond three standard deviations from the mean and thus classified as outliers. And finally, 6.12 % of the cognate-trials were removed from the analysis as they had been translated with non-cognates[15].

Figure 18 shows the distribution of mean reaction times per participant for cognate and non-cognate stimuli. According to visual inspection and according to the Shapiro-test, the data were normally distributed. A paired t-test was thus computed on the sample. The reaction time for cognates ($M = 769.91$, $SD = 84.88$) was significantly shorter than for non-cognates ($M = 911.70$, $SD = 98.90$): $t(33) = -15.11$, $p < .0001$.

[15] This does not mean that the non-cognate answers were not correct. This chapter also contains statistics on reaction times including these stimuli. But in order to control as much as possible for the conditions (NC-translations vs. C-translations), these trials were removed for the first measurement of reaction times.

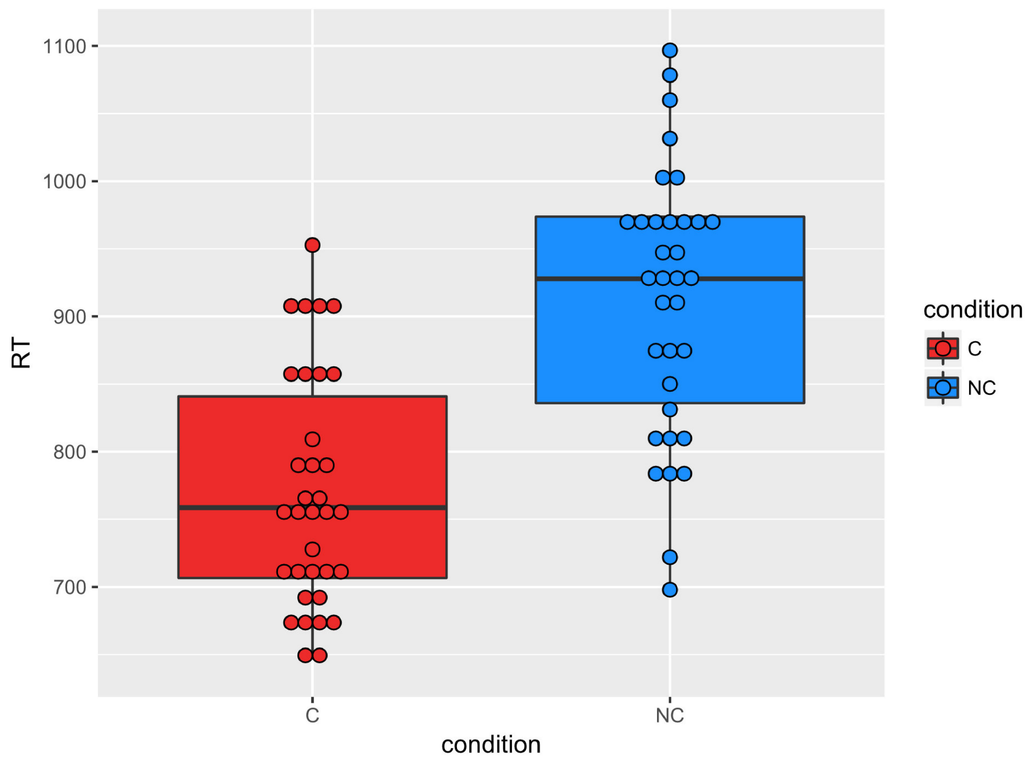

Figure 18: Mean reaction time per participant for cognates and non-cognates. Reaction times for cognates are presented in red, reaction times for non-cognates in blue. Each dot represents the mean reaction time of one participant. The boxes represent the middle 50 % of the data. The black horizontal lines represent the medians of the samples.

The CFE was calculated by subtracting the mean reaction time for cognate stimuli from the mean reaction time for non-cognate stimuli per participant (see Kroll et al. 2002 for a similar approach). Before investigating the impact of experience on the CFE, I explored the interaction between the other behavioral measures and the CFE. Figure 19[16] shows a correlation matrix on the behavioral measures. There were, however, no significant correlations between the CFE and the other behavioral variables.

[16] The abbreviations used in the figure refer to the following measurements: Not = Stimulus was not translated, Wrong = the translation was wrong, dif = a cognate was translated by a non-cognate, No_Trigger = No Trigger was recorded by the stimtracker or a background noise send a trigger, Outl = reaction times were not within three standard deviation above or below the mean, RT = reaction times, C indicates numbers for cognate-stimuli and NC indicates numbers for non-cognate stimuli.

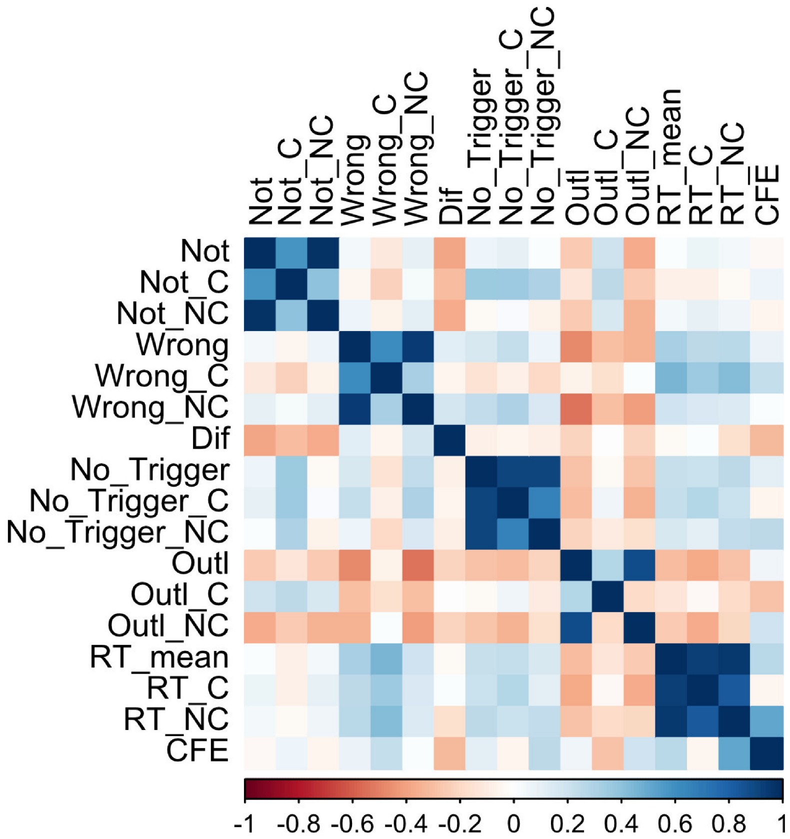

Figure 19: Corrplot of behavioral measurements

In a next step, the interaction between CFE and experience was calculated. Although the features of the stimuli (e.g. word length, frequency, concreteness) were controlled in the experimental setting used, they will be included in the statistical analysis later on in order to avoid any possible confounds.

Many measurements of experience were gathered during the language test and in the questionnaire the participants had to fill in (see Chapter 8.1.2). A multiple regression was thus calculated in R in order to investigate if there were one or several factors that affect the CFE. As there were a lot of factors, their number was reduced in a first step. The factor *semester* was included in the model as it showed to influence translation behavior in the prestudy. To further fit the statistical model, two approaches were used. In a first step, the backward approach was applied by creating a full linear model and rejecting factors with the highest p-value over .05[17] one by one. The following factors were included into the full linear model:

- semester
- age
- points received in the language placement test
- language level
- years learning English
- hours spent weakly reading in German
- hours spent weakly reading in English
- hours of exposure to German media per week
- hours of exposure to English media per week
- hours spent weakly performing forward translation
- hours spent weakly performing backward translation
- hours spent weakly performing forward interpreting
- hours spent weakly performing backward interpreting

In order to avoid the collision problem, factors which might express the same aspect of experience were not included (see also Chapter 8.2.1 for a first analysis): the self ratings (they seemed to reflect the experience measured for example in the language test quite well), years of education (correlated with the semester), the highest degree obtained (correlated with the semester) and the age the participants started to learn English (correlated strongly with the years the participants have been learning English).

The final model obtained by the backward approach contained only the semester and the time the participants spend with German media as predictors, although the last factor was only marginally significant. No deviations from linearity, normality and homoscedasticity were discovered by visual inspection of the residual plots. The final linear model which was computed to predict the influence of the semester of the students and their time spent consuming German media was not significant ($F(2, 29) = 2.2$,

[17] The factor semester was not removed no matter what p-value it had.

p = .13, with an R^2 of .13. The predicted CFE of the participants is 177.13 ± 29.47(standard errors) - 10.49 (hours spent consuming German media) ± 5.28 (standard errors) .05 (Semester) ± 4.43 (standard errors). According to this model, the CFE decreased by 10.49 ms for each hour spent on German media and by .05 ms for each semester. These changes are however not significant for the semester (p = .99) and only marginally significant for the time spent consuming German media (p = .056).[18]

As the choice of factors for the linear model is rather controversial, another approach was chosen to limit the number of variables included in the model. The function *regsubsets* from the package *leaps* (Miller 2017) in R was used to calculate the four best fitting variables from all biographical and language test data. The same variables indicated above for the backward approach were included in the function. The variable *semester* was forced in which means that it had to be considered for all possible models. The following variables were indicated by the function to be the best choice for fitting a model of up to four variables:

- semester (forced in)
- hours of weakly exposure to German media
- language level
- hours engaged in backward translation

No deviations from linearity, normality and homoscedasticity were discovered by visual inspection of the residual plots of the final linear model. The model which was computed to predict the influence of the above listed independent variables on the CFE was marginally significant ($F(4, 24) = 2.57$, p = .06, with an R^2 of .30. The predicted CFE of the participants is 346.62 ± 90.52(standard errors) - 12.22 (hours of weakly exposure to German media) ± 5.36 (standard errors) - 1.46 (Semester) ± 6.15 (standard errors) - 24.93 (language level) ± 14.80 (standard errors) - 30.41 (hours spent on backward translation) ± 19.51 (standard errors). According to this model, the CFE decreased by 12.22 ms for each hour of weakly exposure to German media, by 1.46 ms for each semester, by

[18] See Winter (2013) for the notation of the statistics.

24.93 ms for each language level and by 30.41 ms for each hour spent on backward translation. Only the exposure to German media was significant: semester (p = .81), exposure to German media (p = .03), language level (p = .10), hours spent on backward translation (p = .13).

As the responses to the stimuli varied among the participants (not all words were translated by all participants and some trials were excluded due to wrong translations), the two models which were created in the last steps were further explored. To account for factors linked to differences in the remaining stimuli, linear models which included the mean frequency of remaining cognate and non-cognate stimuli as well as mean length of remaining cognate and non-cognate stimuli for each participant were included in two full linear models including a) the variables obtained by the backward approach and b) the variables obtained by the automatic approach. These full models were then compared to the models without the information of the remaining stimuli by computing an ANOVA. The full models did not differ significantly from the previously reported models: a) F(4) = .16, p = .96; b) F(4) = .21, p = .93.

The remaining stimuli thus seem to have no influence on the statistical model presented before. To conclude, the only variable which seems to have an influence on the CFE is the time the participants are exposed to German media. This result will further be discussed in Chapter 8.3.

8.2.3 ERP data

For the ERP-analysis, the same trials were rejected for the ERP analysis as for the behavioral analysis (wrong responses, false triggers, no answers, RT outliers, translation of cognates by non-cognates, see also Chapter 8.1.5 on the data analysis) but in addition to this, another 10.49 % of the trials were removed due to noisy EEG trials.

After visual inspection of the ERP plots, a time window of 225-330 ms after stimulus onset was chosen for the analysis of the N2 (see Figure 20). This time window is based on the N2 literature (e.g. Pfefferbaum et al. 1985; Falkenstein et al. 1999; Heil et al. 2000; Bokura et al. 2001; Bartholow et al. 2005; Christoffels et al. 2007; see also Chapter 6.2). For the statistical analysis, ROIs consisting of three electrodes each were computed for the following sites: fronto-central-midline (FpZ-Fz-FCz), frontal-right (F2-F4-F6), frontal-left (F1-F3-F5), central-right (C2-C4-C6), central-left (C1-C3-C5), central-parietal-midline (CZ-CpZ-Pz), (for similar ROIs for the frontal N2 see for example Pliszka et al. 2000). In addition to the ROI choice of Pliszka and colleagues, not only lateralized ROIs were used but also central ROIs as the N2 has often been reported to be largest over fronto-central electrode sites (e.g. Pfefferbaum et al. 1985; Bruin & Wijers 2002; Bartholow et al. 2005; Christoffels et al. 2007, see also Figure 21 of a topographical distribution of the voltage in the N2-time window).

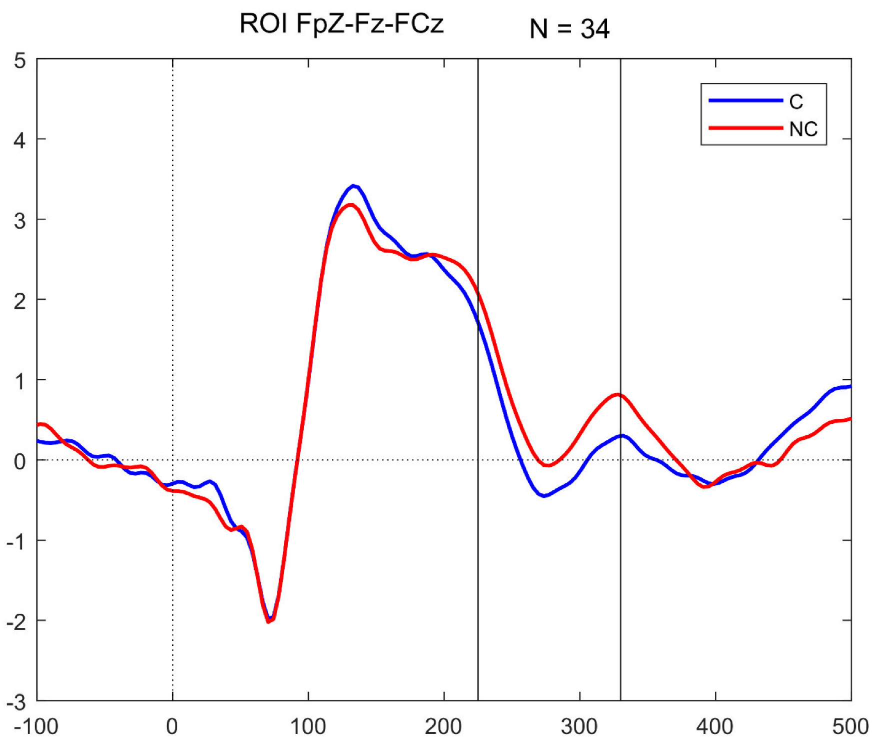

Figure 20: Stimulus locked event-related potential at Fz for cognates (blue line) and non-cognates (red line). Black vertical line indicates the time window of the N2 which was manually chosen.

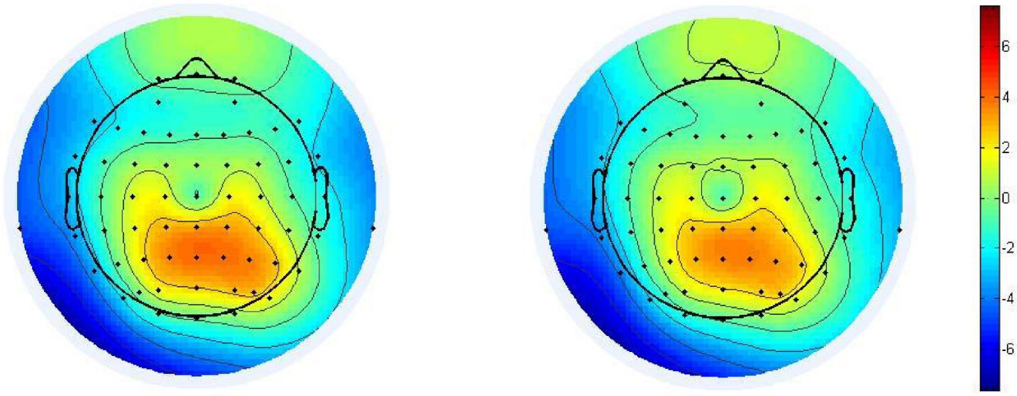

Figure 21: Topoplot of the two conditions (left cognates, right non-cognates). The figure shows the distribution on the scalp of the averaged voltage at the time window of 225-330 ms after stimulus onset.

As the data were normally distributed, a paired t-test and the effect size (Cohen 1988) were computed for each ROI (see Table 6).

ROI	**Cognates**	**Non-cognates**	**P-values**	**Effect-size**
FpZ-Fz-FCz	M = -.23, SD = 2.59	M = .25, SD = 2.61	t(33) = -4.01, p = .0003	d = -.19
F2-F4-F6	M = -.93, SD = 2.48	M = -.47, SD = 2.27	t(33) = -3.67, p = .0009	d = -.19
F1-F3-F5	M = -1.43, SD = 2.49	M = -1.03, SD = 2.48	t(33) = -2.82, p = .008	d = -.16
C2-C4-C6	M = .61, SD = 1.65	M = .82, SD = 1.61	t(33) = -2.82, p = .008	d = -.13
C1-C3-C5	M = .61, SD = 1.88	M = .43, SD = 1.91	t(33) = 2.44, p = .02	d = .09
CZ-CpZ-Pz	M = 2.56, SD = 2.45	M = 2.63, SD = 2.43	T(33) = -.82, p = .42	d = -.03

Table 6: Results of the paired t-tests and the effect size for the mean amplitude in the time window of 225-330 ms after stimulus onset at the defined ROIs

In a next step, the modulation of the N2 was computed by subtracting the mean amplitude of the cognate condition from the mean amplitude of the non-cognate condition. The ROI with the lowest p-value and the highest effect size (FpZ-Fz-FCz) was chosen for these calculations. A correlation was computed in R to investigate the relationship between CFE and the modulation of the N2. The CFE did not correlate with the modulation of the N2: $r(32) = -.09$, $p = .63$.

In order to investigate the influence of experience on the N2, a linear model was computed. As for the behavioral data, the model was fitted and the number of variables was reduced by using the backward approach and the automatic approach with the package leaps in R. The same factors were considered for model fitting as for the statistical analysis of the CFE. The factor *semester* was included in both models.

The final model obtained by the backward approach contained only the semester and the hours spent weakly reading in German. No deviations from linearity, normality and homoscedasticity were discovered by visual inspection of the residual plots. The final linear model which was computed to predict the influence of the semester of the students was significant ($F(2, 29) = 4.70$, $p = .02$, with an R^2 of .24. The predicted modulation of the N2 is .50 ± .35 (standard errors) - .03 (semester) ± .05 (standard errors) and - .23 (hours spent weakly reading in German) ± .08 (standard errors). These changes were only significant for the time spent reading in German ($p = .006$) but not for the semester ($p = .54$).

As for the statistical analysis of the CFE, another approach was chosen to limit the number of variables included in the model. The function *regsubsets* from the package *leaps* in R was used to calculate the four best fitting variables from all biographical and language test data. The same variables indicated above for the backward approach were included in the function. The variable *semester* was forced in. The following variables were indicated by the function to be the best choice for fitting a model of up to four variables:

- semester (forced in)
- hours spent weakly reading in German
- hours of weakly exposure to English media
- hours spent performing backward interpretation per week

No deviations from linearity, normality and homoscedasticity were discovered by visual inspection of the residual plots of the final linear model. The model which was computed to predict the influence of the above listed independent variables on the modulation of the Fz was marginally significant ($F(4, 27) = 2.80$, $p = .05$, with an R^2 of .29. The predicted modulation of the Fz of the participants is .44 ± 0.64 (standard errors) - .04 (semester) ± .05 (standard errors) - .20 (hours spent weakly reading in German) ± .08 (standard errors) + .11 (hours of weakly exposure to English media) ± .09 (standard errors) - .33 (hours spent weakly on backward interpretation) ± .53 (standard errors). According to this model, the modulation of the Fz decreased by 0.04 µV for each semester, by .20 µV for each time interval spent on backward translation, by .33 µV for each time interval spent on backward interpretation and increased by .11 µV for each time interval spent on English media. Only the time spent on reading in German was significant ($p = .02$). The other factors were not significant: semester ($p = .47$), hours of weakly exposure to English media ($p = .21$), hours spent weakly performing backward interpretation ($p = .53$).

As the time spent on reading in German was significant in both models, this might have an influence on the modulation of the N2. The other factors, especially the semester, seem to have no influence.

8.3 Discussion

In the present study, translation students of different semesters participated in a word translation test. They were presented with single cognate and non-cognate stimuli. The hypotheses to be tested were that a) cognates should be translated faster than non-cognates; that b) the cognate facilitation effect should decrease with translation experience because the links between lexemes in the mental lexicon change with experience in favor of non-cognate translation equivalents; that c) there will be a difference in the N2 for cognates and non-cognates because cognates have a higher activation level and thus need to be inhibited more strongly according to Green's (1998) IC model; and finally d) that the modulation of the N2 between cognates and non-cognates decreases with translation experience because the inhibition processes go hand in hand with the activation processes and the latter should change according to hypothesis b).
In this chapter, the results will be discussed in regard to the hypotheses listed above and described in detail in Chapter 7. But before considering the behavioral and electrophysiological results, I will discuss the questionnaire and language test data.

8.3.1 Measuring experience

To achieve a more fine grained measurement for the level of experience of the participants, a language test as well as a questionnaire were used. The analysis of these data showed that the participants' self rating of their language level correlated with their results in the language test. They thus seemed to have rather good intuition in terms of their proficiency. This is in line with previous studies (e.g. Marian et al. 2007; see also García et al. 2014). In an extensive questionnaire study, Marian and colleagues (2007) compared, for example, self reported language proficiency levels with standardized language proficiency measurements and found a strong correlation. The authors' interpretation was that self reported proficiency levels are a reliable measurement of language proficiency.

Another striking result was that the participants' results in the language test did not correlate with their semester. This is rather surprising because we would expect that constant exposure to translation and thus the two languages involved not only leads to increased translation experience but also to increased language proficiency. This result shows, however, that translation experience does not go hand in hand language proficiency. This is in line with theoretical assumptions of other researchers (e.g. Obler 1983; PACTE 2017; Vildomec 1963; see also García et al. 2014) who suggested that it is not enough to be bilingual but that special capacities are required for translation. It further allows us to differentiate between the effects of language proficiency and translation experience on the behavioral and electrophysiological data collected in the present investigation. These data and their implications for the hypotheses developed in Chapter 7 will be discussed below.

8.3.2 Behavioral and brain responses during word translation

The behavioral results showed a clear cognate facilitation effect. Participants translated cognates significantly faster than non-cognates. This is in line with previous studies on cognates in word translation tests (Christoffels et al. 2006; de Groot 1992b; García et al. 2014; Kroll et al. 2002; Kroll & Stewart 1994; see also Chapter 3.4). Hypothesis a) can thus be accepted. Contrary to what I hypothesized, there was no interaction between the CFE and variables linked to translation experience. The only variable which interacted with the CFE was the time the participants spent with German media. Hypothesis b) thus has to be rejected. A possible explanation of this result would be that translation experience has no effect on the representation of words in the mental lexicon. But this result could also be due to some shortcomings of this study which will be presented below in Chapter 8.3.3. The interaction of the CFE with German media is an interesting and unexpected result. The implications of this for existing theories of language processing and the translation process as well as for further studies will be discussed in Chapters 8.3.4 and 8.3.5.

The ERP analysis showed a significantly larger N2-like component for cognates than for non-cognates. The component was observed in a time window of 225-330 ms, which is in line with the literature on the N2 in motor tasks (Pfefferbaum et al. 1985; Falkenstein et al. 1999; Bartholow et al. 2005; see also Chapter 6.2.1 for a review of the N2 in motor and linguistic tasks) as well as in linguistic tasks (Christoffels et al. 2007). The difference between the mean amplitudes for the two conditions was largest over fronto-central electrodes, which is also in line with the literature on the N2 (e.g. Bartholow et al. 2005; Bruin & Wijers 2002; Yeung et al. 2004). I thus assume that the observed ERP component is the N2 that has been reported in the literature and linked to inhibition (Carriero et al. 2007; Dong et al. 2009; Eimer et al. 1993; Falkenstein et al. 1999; Falkenstein 2006; Kok 1986; Jackson et al. 2001). The fact that the N2 is larger overall for cognates than for non-cognates in word translation can be interpreted in favor of language non-specific lexical activation during translation. Cognates are activated more strongly due to their similar form and meaning and the lexical activation mechanism of interactive activation (e.g. Costa et al. 2000, see also Chapters 3.2.2 and 3.4). According to Green's IC model (Green 1998; see also Chapter 4.1), more inhibition should be expected for more highly activated words in order to avoid errors. The higher mean amplitude for the more highly activated cognates is thus in line with Green's model. And the present study is thus also in line with Price and colleagues' (1999, see also Chapter 4.2) study. The interpretation of their PET study was that translation requires mental inhibition processes. The present investigation can also be interpreted in this direction. If no inhibition was required during translation, there should have been no difference in the N2 between cognates and non-cognates. This means, at the same time, that the participants did not use language specific lexical selection mechanisms as suggested for example by Costa and Santesteban (2004, see also Chapter 4.2). Hypothesis c) can thus be accepted. This is an important finding as it shows that mental control processes play an important role during translation. Inhibition processes have already been included in different, very influential monolingual and bilingual language processing models such as the IA (McClelland & Rumelhart 1981, see also Chapter 3.1.1), the BIA and BIA+ (Dijkstra & van Heuven 1998, 2002, see also Chapter 3.2.1) and the IC model (Green 1998, see also Chapter 4.1). It might thus also be worth considering mental control processes such as inhibition and monitoring when modeling the translation process. Further implications of the results of the current investigation for translation process models as well as speech processing models will be discussed below in Chapter 8.3.4.

As for the CFE, there was no interaction between factors linked to translation experience and the modulation of the N2. The only factor which interacted with the N2 was the time the participants spent reading in German. Hypothesis d) thus has to be rejected. As the CFE also did not interact with factors linked to translation experience, this result was to be expected. In Chapter 7, I speculated whether the modulation of the N2 interacted with translation experience in cases of absence of interaction between translation experience and CFE. This could have been interpreted as a changing mechanism of language control: more experienced translators engage in more language specific selection mechanisms that do not require inhibition. But as this was not the case, the results of the present investigation cannot be interpreted in favor of Ibáñez and colleagues' (2010, see also Chapter 4.2) hypothesis that translation experience leads to language specific selection mechanisms. As for the missing interaction between the CFE and translation experience, explanations for the present results might also lie in shortcomings of the study. They will be discussed below in Chapter 8.3.3. And as for the CFE, exposure to German media (time spent reading in German) unexpectedly interacted with the modulation of the N2. Implications of this finding will be discussed in Chapter 8.3.4.

8.3.3 Shortcomings of the study

The present word translation test study was, on the one hand, motivated by the assumptions of the gravitational pull hypothesis (see Chapter 5.2) according to which links in the mental lexicon change with translation experience. On the other hand, the study was motivated by a prestudy (see Chapter 5.5) where translation students translated a text with a high cognate density. The number of cognates in the target texts decreased with the semester of the participants. I suggested that changes in the structure of the mental lexicon as assumed by Halverson could thus be investigated on the translation of cognates. If translation students try to avoid cognates during translation, this should lead to increased link strength for non-cognate word pairs and decreased link strength for cognate word pairs. These changes should be reflected in a decreased CFE for more experienced translation students. The results, however, showed no interaction between semester and CFE or modulation of the N2. A first explanation of the results that was already given above in Chapter 8.3.2 would be that translation experience does not have an effect on the representation of cognates in the mental lexicon. But this result might also be due to the design of the current study. Several factors that might be interpreted as shortcomings, or at least as points that should be considered for further research, will therefore be discussed in this chapter.

A first important factor why I did not observe interaction might of course be that I did not use the same sample for the prestudy as for the current investigation. Although the participants were all students in different semesters at the same institution, they might not be completely comparable. Especially for the prestudy, only very few data on language proficiency, language history and translation experience were gathered. Different statistical methods were used. In the prestudy, the data were only correlated to the semester. In the present investigation a more elaborated statistical approach was chosen: a multiple regression analysis.

Another important factor is that in the prestudy, students translated cognates in a linguistic context whereas in the present study, single words were translated. Van Hell and de Groot (2008, see also Chapter 3.4) showed that mechanisms of word translation are also present when a linguistic context is presented. It might however be possible that there are specific mechanisms linked to the processing of context which were not investigated in this study, and that these mechanisms interact with experience. In future studies, it might thus be worth replicating the pre-study in order to test whether the results were reliable. In addition to that, mechanisms linked to the processing of context should be investigated in controlled studies in order to investigate possible interactions with experience.

But the present study was not only motivated by the results of the pre-study. Halverson suggested that links in the mental lexicon change with translation experience. Other researchers also suggested that links between lexemes in L1 and L2 change with translation experience (de Groot 1992b; García 2014; Paradis 1984, see also Chapter 3.3) and especially García and colleagues suggested that this might be due to constant self-correction of translation students. The self-correction of cognates for German translation students translating from English into German was reported by Kußmaul (1989, see also Chapter 5.4). The fact that I did not find an effect in the CFE might be due to the range of experience levels of the participants. García and colleagues (2014) suggested that changes occur already at the very beginning of the translators' training. Although a rather large range of experience levels was used for the present study (from 2nd to 11th semester), no true novices participated. An effect might thus have been unnoticed due to the already relatively advanced students. But the opposite could also be true. No real professional translators participated in the present study. Changes in the links between lexemes could occur only after extensive professional translation experience. In future studies on translation experience, the range of the amount of experience should be larger and include real novices as well as professional translators with at least several years of professional experience.

8.3.4 Implications for speech processing models and translation process models

Beside the shortcomings listed above which should be taken into consideration when designing new experiments, the results of the present investigation can also help to develop and improve existing speech processing models and translation process models. The implications of the results will be discussed in the following.

First of all, the implications of the missing interaction between the CFE and translation experience has to be discussed. This could of course be due to the shortcomings mentioned above. But another possible explanation is that there are in fact no facilitating links between lexemes which could be strengthened by translation experience. Several researchers suggested their existence (e.g. de Groot 1992b; Garcia 2014; Paradis 1984, see also Chapter 3.3). But as mentioned earlier, some models of language processing do not contain facilitating links between lexemes (e.g. Dijkstra & van Heuven 2002; Dell 1986; McClelland & Rumelhart 1980). This is of course only a very speculative explanation because the links in the mental lexicon of translators could also be strengthened via the conceptual route. De Groot (1992b) suggested for example that it might be either route that could be strengthened with translation experience.

> “Translating a word will strengthen the memory connection (whether direct or indirect by means of conceptual representation) between the translations, and the stronger this connection, the more skilled translating between these words will be.“ (de Groot 1992b: 1002)

But we might still consider and further test models which do not contain facilitating links between lexemes, such as Dells' (1996, see also Chapter 3.1.2) language production model or the BIA+ (Dijkstra & van Heuven 2002, see also Chapter 3.2.2), for psycholinguistics as well as translation studies.

The electrophysiological results of this investigation showed that inhibition plays an important role during the translation of single words. Until now, translation process models which consider mental control processes mainly focus on monitoring. The literature review in Chapter 4 showed that monitoring as well as inhibition are important sub-components of language control and are inter-dependent. A shortcoming of the monitor models in translation studies is, however, that they build on serial language processing models (see also Chapter 4). These kinds of models cannot explain all speech phenomena (see also Chapters 3.1.1 and 3.1.2). Interactive activation models are much better at explaining language processing. This is why I will not try to suggest changes to the existing monitor models. But I suggest that existing models of psycholinguistics such as the BIA+ (Dijkstra & van Heuven 2002, see also Chapter 3.2.2) and the IC (Green 1998, see also Chapter 4.1), which include inhibition mechanisms, should be used more frequently in translation studies to investigate translation phenomena.

A translation process theory which is already based on recent findings and models from psycholinguistics, such as interactive activation models, is the gravitational pull hypothesis by Halverson (2003; 2010; 2017; see also Chapter 5.2). But Halverson did not include language control processes in her theory, only activation mechanisms. As the results of the current investigation showed that activation and inhibition go hand in hand, a future version of the gravitational pull hypothesis might thus profit from including inhibition processes such as those suggested by the BIA+ or the IC model.

The present study showed also a surprising result. The period of exposure to German media interacted with the CFE and the time the participants spent reading in German interacted with the modulation of the N2. Many studies on bilingual language processing focus on the level of experience in the L2 (e.g. Kroll & Stewart 1994; Costa & Santesteban 2004), but these results suggest that exposure to L1 might play an important role, too. The time participants listen to German or read in German might influence the lexical representations in their L1 and increase their resting activation level (see Figure 22).

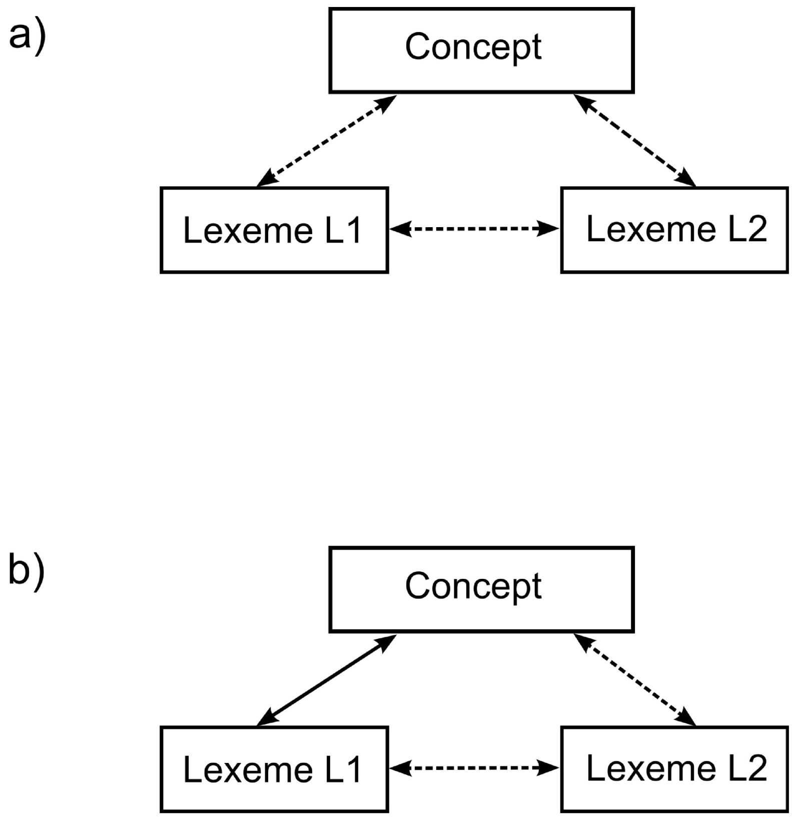

Figure 22: Possible changes in the representation of L1 lexemes in participants with a high amount of exposure to German media

This could then be reflected in the time they need to translate words and decrease the advantage of the CFE: if all L1 lexemes are highly activated, the cognate status might have a smaller impact on the activation level and thus production time. According to Green's (1998) IC model, a higher activation level of L1 lexemes could also decrease the necessity for inhibition during translation which is then reflected in a decreased modulation of the N2. There would be less competition between L1 and L2 lexemes if the L1 lexemes were highly activated. It might therefore be worth considering the influence of L1 competence for future versions of the IC model for example, but of course also for translation process models, in particular the gravitational pull hypothesis. As the present study was not designed for measuring proficiency in L1, these assumptions are of course only speculative. More research needs to be conducted in order to investigate the influence of L1 competence on inhibition processes and word translation dynamics. Some proposals for future research will be made in the following chapter.

8.3.5 Future research

To sum up, the present study was designed to investigate changes in the mental lexicon in translation trainees predicted by Halverson's gravitational pull hypothesis and the role language control plays in this context. The initial hypothesis, that changes of cognate processing occur with translation experience, had to be rejected. Unexpectedly, a correlation between German media exposure and behavioral and electrophysiological responses was found. In future studies on bilinguals but especially also on translators, exposure to L1 should thus play a greater role. At least in the present study, it was apparently more important than L2 proficiency. The L1 proficiency level might therefore be an important factor for translation competence. For this purpose, the questionnaire used could for example be modified by including more questions about L1 exposure and by using more fine grained scales. In addition to that, L1 competence could be measured by using language tests designed for native speakers. The language test which was used for the L2 competence in the present investigation (Dialang, see also Chapter 8.1) also exists for German. But it might not be precise enough to discover differences in native-like competence levels as it was designed for language learners. A measurement which has been suggested to assess L1 skill, for example in children, is to measure vocabulary size (e.g. Proctor et al. 2006; Sparks et al. 2009). This could be one option to further study the impact of L1 proficiency on the structure of the mental lexicon and inhibition processes in translators.

In addition to investigating the role of L1 proficiency, the research question which was central to this thesis (Do the representations of cognates and non-cognates and language control mechanisms change with translation experience?) should be further investigated by overcoming the shortcomings listed in Chapter 8.3.3. This includes replicating the present study with participants with a wider range of experience levels, as well as the investigation of the cognitive processing of cognates presented in context.

And finally, as the electrophysiological results showed that inhibition plays an important role in translation, this line of research should also be continued. The impact of inhibition on translation processes has hardly been investigated. This is also the case for the event-related potential technique which is not yet very common in translation studies. It might be very interesting to further explore the ERP-technique as well as inhibition in a translation studies context.

9 Conclusion

In translation studies, a major research interest lies in the nature of translated language. For this purpose, different phenomena have been described and classified. They have been investigated with corpus linguistic means for several decades. In addition to just classifying the frequency difference of linguistic elements in translations, several suggestions have been made on the cognitive causes of these differences. Halverson's gravitational pull hypothesis is one of these very influential theories. It is based on psycholinguistic models which derive from a large number of empirical studies. One assumption made by Halverson is that the links between lexemes are strengthened by repeated translation.

Based on this hypothesis, I tested in this thesis, whether the links between lexemes of cognates and non-cognates are influenced by translation experience. The frequency of cognate use had previously been shown to be affected by translation experience. This kind of stimulus was thus also used in the present thesis to investigate differences in the lexeme links.

Besides the structure of the mental lexicon, the role of inhibition during cognate translation as well as its interaction with translation experience was also investigated in this study. Although Halverson did not include inhibition in her gravitational pull hypothesis, it was investigated in this study because it was proposed to be an essential part of language processing in psycholinguistics.

To investigate the interaction between the structure of the mental lexicon and translation experience, the well established word translation test was used. This paradigm has been previously used by many researchers in psycholinguistics to investigate lexical access and the mental lexicon. Inhibition was investigated with the ERP component N2 which has also been used in many previous studies to study the mechanisms of mental control.

By using these methods, I also suggested how highly controlled paradigms such as the word translation test but especially neurolinguistic methods such as ERPs that require a controlled experimental setup can be used to investigate research questions from the field of translation studies. The use of these methods is still not very common in translation studies. They can, however, be very beneficial and offer many new insights into the translation process.

The results of this study showed that lexical activation and inhibition went hand in hand during the translation of single words. Theories on the translation process do not always contain mental control components. An example for such a theory is the gravitational pull theory by Halverson. The results of the present study suggest therefore that future versions of translation process models should consider inhibition.

Although the results gave fruitful insight into the role of inhibition during translation, they could not be interpreted in favor of the initial hypothesis that links between lexemes are strengthened with translation experience. This was part of the assumption of Halverson's gravitational pull hypothesis and also motivated by a small pre-study which showed that the number of cognates in translations decreases with translation experience.

Possible explanations for the absence of interactions with translation experience might lie in the theory as well as in the experimental design. According to recent models of lexical access, such as the BIA+, there might be no activating links between lexemes but only inhibitory links. In accordance with Halverson and other researchers from the field of psycholinguistics such as de Groot and Paradis, I assumed that there were activating links between lexemes. This view might have to be reconsidered and replaced by a model closer to the BIA+.

But the design of this study might also have caused the absence of interaction with translation experience. Changes due to experience might occur much earlier than the second semester or only after gaining professional experience. This has been suggested by several scholars such as García and Ibáñez. But for practical reasons, the range of experience was limited in the present study. If this study was to be replicated, it should contain a wider range of experience levels, including real novices and participants with professional experience.

The study also showed a surprising result, that is, an interaction between the time spent on German media consumption and the cognate facilitation effect as well as the modulation of the N2. This study was not designed to investigate the influence of the L1 on the mechanisms of language processing. These surprising results might however motivate future studies on the role of the L1 for bilingual language processing and also translation. In the past, many studies concentrated on the influence of L2 competence, but L1 competence might be of major importance, too. This might also play a role when considering translator training. At least at the FTSK in Germersheim where the participants of this study were trained, classes to improve L1 competence are not obligatory at present.

To conclude, this study showed that inhibition processes play an important role during translation. They should be considered for future theories on the translation process and should be further investigated. A surprising result was that the measurements of this study interacted with the exposure to L1 media. The role of L1 competence should therefore also be further investigated and their implications for translator training should be discussed.

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Appendix I: Questionnaire

Fragebogen für sprachliche und translatorische Kenntnisse

Vom Versuchsleiter auszufüllen

Datum:	
VP-Nr.:	
Experiment:	

Bitte füllen Sie den nachfolgenden Teil aus.

Persönliche Daten

1. Alter			
2. Geschlecht	□ m □ w		
3. Was ist Ihre Muttersprache			
4. Sind Sie mehrsprachig aufgewachsen?	□ Ja □ Nein		
Wenn ja:	4.1 In welchem Land sind Sie aufgewachsen?	4.2 Wann haben Sie angefangen Deutsch zu sprechen?	4.3 Wann haben Sie angefangen Ihre weitere Sprache zu sprechen?
5. Welche Sprachen sprechen Sie neben Deutsch?			

Fremdsprachenerwerb: Englisch

6. In welchem Alter haben Sie begonnen Englisch zu lernen?	

7. Wie haben Sie vor allem Englisch gelernt? (bitte ankreuzen)	Sprachunterricht	Aufenthalt in einem englischsprachigen Land	Anderes (bitte spezifizieren)
8. Wie viele Jahre haben Sie Englisch gelernt?			
9. Haben Sie ein Sprachzertifikat erworben (z.B. TOEFL)?	□ Ja □ Nein Wenn Ja, wann und welches?		
10. Waren Sie schon einmal in einem englisch-sprachigen Land?	□ Ja □ Nein Wenn ja, wann, wie lange und warum?		

Fremdsprachenerwerb: eventuell zweite Fremdsprache/Studiensprache

11. In welchem Alter haben Sie begonnen Ihre zweite Fremdsprache zu lernen?			
12. Wie haben Sie vor allem diese Sprache gelernt? (bitte ankreuzen)	Sprachunterricht	Aufenthalt in einem Land in dem diese Sprache gesprochen wird	Anderes (bitte spezifizieren)
13. Wie viele Jahre haben Sie diese Sprache gelernt?			
14. Haben Sie ein Sprachzertifikat erworben (z.B. TOEFL)?	□ Ja □ Nein Wenn Ja, wann und welches?		
15. Waren Sie schon einmal in einem Land, in dem diese Sprache gesprochen wird?	□ Ja □ Nein Wenn ja, wann, wie lange und warum?		

Berufliche Erfahrungen

16. Welchen Beruf üben Sie derzeit aus?	Student/in	Englischlehrer	Übersetzer oder Dolmetscher	Sonstiges (bitte spezifizieren)
16.1 Wenn Student/in	Studienfach	Studiensemester	Bereits abgeschlossener Studiengang? Wenn ja, welcher?	Sprachenkombination
	Haben Sie vor Ihrem Studium bereits eine Berufsausbildung absolviert? Wenn ja, welche?			
16.2 Englischlehrer	Welchen Abschluss haben Sie gemacht	Wann haben Sie Ihren Abschluss gemacht?	Wen bzw. wo unterrichten Sie?	Welches Niveau unterrichten Sie?
16.3 Wenn Übersetzer/ Dolmetscher	Welchen Abschluss haben Sie?	Wann haben Sie Ihren Abschluss gemacht		Was ist Ihre Sprachkombination?

Sprachkenntnisse & translatorische Kenntnisse

17. Als wie gut schätzen Sie Ihre Deutschkenntnisse ein? Von 1(sehr schlecht) bis 100 (sehr gut)	

18. Als wie gut schätzen Sie Ihre Englischkenntnisse ein? Von 1(sehr schlecht) bis 100 (sehr gut)						
19. Als wie gut schätzen Sie Ihre Fremd-sprachenkenntnisse in Ihren weiteren Arbeitssprachen ein? Von 1(sehr schlecht) bis 100 (sehr gut)						
20. Als wie gut schätzen Sie Ihre Fähigkeiten ein, von Deutsch nach Englisch zu übersetzen? Von 1 (sehr schlecht) bis 100 (sehr gut)						
21. Als wie gut schätzen Sie Ihre Fähigkeiten ein, von Englisch nach Deutsch zu übersetzen? Von 1 (sehr schlecht) bis 100 (sehr gut)						
22. Wie oft sprechen Sie Englisch? Mit wem und wie lange?						
23. Wie viele Stunden pro Woche lesen Sie deutsche Texte? (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25
24. Wie viele Stunden pro Woche lesen Sie englische Texte? (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25
25. Wie viele Stunden pro Woche hören Sie deutsches Radio und sehen Sie deutsche Filme/Serien/ Fernsehen? (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25

26. Wie viele Stunden Pro Woche hören Sie englisches Radio oder sehen Sie englische Filme/Serien/ Fernsehen? (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25
27. Wie viele Stunden pro Woche übersetzen Sie von Deutsch nach Englisch (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25
28. Wie viele Stunden pro Woche übersetzen Sie von Englisch nach Deutsch? (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25
29. Wie viele Stunden pro Woche dolmetschen Sie von Deutsch nach Englisch? (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25
30. Wie viele Stunden pro Woche dolmetschen Sie von Englisch nach Deutsch? (bitte ankreuzen)	0-5	5-10	10-15	15-20	20-25	+25

Appendix II: Stimulus lists

Cognate stimuli

Word	Frequency	Word length	Translations	Concreteness
acceptance	2629	10	24	2.21
activity	11410	8	19	2.72
affair	3187	6	15	2.45
analysis	13151	8	12	2.56
category	3325	8	6	2.82
comment	5242	7	7	3.29
competence	1487	10	10	1.78
complexity	1736	10	9	1.87
compromise	2057	10	6	1.8
cooperation	1289	11	9	2.03
description	5091	11	8	2.43
detail	6123	6	8	2.5
discipline	5508	10	9	2.24
distance	6601	8	8	3.17
division	8946	8	28	2.8
effect	23103	6	11	1.8
energy	12125	6	5	3.11
existence	6472	9	8	1.54
factor	6213	6	14	2.79
fantasy	1290	7	5	1.59
idea	21072	4	13	1.61
intelligence	3431	12	11	2.24
licence	7676	7	6	4.57
literature	5246	10	5	4.1
magic	3114	5	5	2.9
method	8962	6	12	2.41
observation	2786	11	12	2.12
orientation	1045	11	6	2.43
perspective	3038	11	10	2.38
plan	14773	4	9	3.4

prevention	1555	10	8	2.2
problem	28559	7	10	2.68
program	4066	7	7	3.43
project	15265	7	6	3.62
reaction	5430	8	10	2.41
respect	9925	7	10	2.04
result	21918	6	10	2.85
routine	3105	7	8	2.7
scandal	1428	7	10	2.13
sector	8695	6	7	3.41
sequence	4214	8	11	3.1
significance	4607	8	11	1.68
tendency	2893	12	10	1.83
variable	2827	8	10	2.24

Non-cognate stimuli

Word	**Frequency**	**Word length**	**Translations**	**Concreteness**
achievement	3067	11	13	2.37
amount	15296	6	11	2.74
appearance	5294	10	14	2.57
approval	3873	8	18	2.33
attempt	11226	7	8	2.22
attention	13295	9	11	2.3
awareness	3536	9	7	1.84
choice	11849	6	8	1.9
complaint	1798	9	9	2.69
consciousness	2547	13	3	2.32
damage	8294	6	10	3.2
darkness	3154	8	5	3.85
decrease	1201	8	12	2.68
development	32078	11	23	2.41
discovery	2779	9	5	2.36
disease	8862	7	4	3.45

draft	2987	5	17	3.15
education	26113	9	12	2.93
excuse	2938	6	7	2.29
fear	8977	4	6	2.57
growth	12798	6	16	2.89
illness	3214	7	3	3.54
improvement	4161	11	12	2.6
increase	16796	8	21	2.61
judgment	3217	8	7	1.68
meaning[19]	*8000*	*7*	*5*	*1.85*
necessity	1779	9	8	2.08
promise	3813	7	7	2.09
property	12506	8	17	3.9
proposal	4203	8	5	2.75
question	25673	8	6	3.36
request	4419	7	15	2.59
requirement	3214	11	14	2.52
retirement	3398	10	13	3.03
safety	8542	6	7	2.37
schedule	2460	8	17	3.48
size	12515	4	15	3.13
struggle	4329	8	4	2.79
success	13245	7	6	2.21
temptation	1066	10	5	1.84
usage	1170	5	13	2.07
violence	5521	8	5	3.07
weakness	1688	8	10	2.59
wealth	3770	6	6	2.63

[19] This stimulus was removed from the analysis as the formal overlap to a German word other than the translation equivalent (*Meinung*) was too large.