Cross-Modal Syntactic Transfer in Bimodal Bilinguals

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Abstract

Bimodal bilinguals are fluent in a spoken and a signed language. Previous research has proven that both languages in the bilingual mind are simultaneously active and that one language can influence the other (i.e. transfer). When speaking, unimodal bilinguals increasingly use elements from both of their languages when speaking. Bimodal bilinguals are able to use elements from sign language such as co-speech gestures and code-blends. Occasionally, elements from sign language intrude their speech due to co-activation of a signed language. However, less is known about cross-modal transfer (i.e. from the sign modality to the speech modality). This study aims to investigate whether sign language influences speech on the syntactic level as a consequence of co-activation in bimodal bilinguals. The speech of twenty one native NGT- Dutch bimodal bilinguals and twenty non-signing Dutch speakers will be analysed when describing spatial relations between objects. The utterances of the bimodal bilinguals were compared to the non-signing participants and were coded for word order (i.e. object mention). Additionally, a within-group analysis of the bimodal bilingual participants was conducted to investigate whether there are correlations between the spoken utterance and the use of code-blends. The results of this study show that the bimodal bilinguals differ from the non-signing participants in the way they talk about spatial relations due to the unique way this is encoded in sign language. The results also point towards a correlation between the use of code-blends and the way spatial relations are described in speech. Thus, language transfer may not just occur within a single modality, but may also occur across different language modalities

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Introduction

Bilinguals[1] have the ability to speak two languages and must find ways to control their language output when they communicate (Traxler, 2011). There is a consensus in the literature that the two languages in the bilingual brain are simultaneously active during language comprehension and production. Spoken languages use the vocal-auditory channel to communicate (Meier, 2002), while signed languages use the visual-manual modality by the use of hands, space and facial expressions to communicate. Languages thus come in different modalities which are expressed through different articulators (i.e. the vocal tract and the hands). As such, we make a distinction between unimodal and bimodal bilinguals. Unimodal bilinguals are bilinguals who are fluent in two languages of the spoken modality, while bimodal bilinguals are fluent in a signed and a spoken language. For purposes of this thesis, we will refer to the term bimodal bilinguals as individuals who have grown up with a signed and a spoken language from birth. Unimodal and bimodal bilinguals have shown that there are ways in which both languages can be used. Code-switches occur in unimodal bilinguals when they switch between languages in conversation. Code-blends are produced by bimodal bilinguals and can be defined as the use of signs through manual movements during speech. The occurrence of code-switches and code-blends is a possible evidence for co-activation. That is, producing two languages within the same utterance can be viewed as possible

[1] There are many different studies that have many different definitions of wat it means to be bilingual. For the purpose of this thesis, I will use the term "bilinguals" to refer to people who have acquired two languages (no matter if signed or spoken) consecutively from childhood and are highly proficient in both their first (L1) and second language (L2). I will use the term "heritage speakers" (see p. 38) to refer to people who have acquired a family language in the home and have acquired their second language through interaction with the environment (e.g., Montrul 2010). Additionally, differences between bilinguals and L2 learners must be taken into account. Learners of an L2 can be any age, and they can vary within different levels of proficiency. It should be noted that these differences are not always clear from reading the literature. Furthermore, I will use the term "bimodal bilinguals" to refer to hearing individuals that have acquired a signed and a spoken language from birth.

evidence of the simultaneous activation of both languages in the mind of unimodal and bimodal bilinguals. Previous literature has argued that unimodal and bimodal bilinguals are different from monolinguals in certain cognitive abilities like executive control, attentional mechanisms and task-switching (Emmorey et al., 2008; Bialystok, 1987; Poplack, 1980).

Due to the use of both the manual and the vocal modality, bimodal bilinguals are able to perceive and produce two different languages from two different modalities (Emmorey, Borinstein et al., 2008). During language production, bimodal bilinguals occasionally appear to simultaneously produce signs and words, often referred to as code-blends(e.g, Emmorey et al., 2005). The way in which code-blends are produced by bimodal bilinguals and code-switches are produced in unimodal bilinguals may provide insight into the cognitive mechanisms that underlie language production due to the simultaneous use and co-activation of two languages.

This thesis will outline the research on unimodal and bimodal bilingual communication and will provide insight in how bilingualism of two different language modalities may affect the way in which these languages interact during language production. In section 1, I will discuss the notion of co-activation in language comprehension and production and will provide and review studies on code-switching in bilinguals and code-blending in bimodal bilingual language production. Additionally, I will discuss language transfer in section 1.3. The present study and its predictions will be discussed in section 1.4. Section 2 will discuss the methods used in this study. Section 3 will focus on the results obtained from the experiment, followed by the discussion and conclusions in sections 4 and 5 respectively.

1. Literature overview

1.2 Co-activation

Previous studies investigating bilinguals have shown activation of both languages during comprehension and production of one language. The active state of both languages in the bilingual mind is also known as cross-language activation or cross-language interaction (e.g., Manhardt, 2015; Hermans et al, 1998; Libben and Titone, 2009; Marian and Spivey, 2003). Additionally, co-activation can be viewed as a process in which one language affects the other without the speaker consciously taking note of this (Ormel and Giezen, 2014). For purposes of this thesis, I will refer to this active state of two languages as co-activation. Co-activation of both languages can lead to competition between the two languages and bilinguals therefore need to possess coping mechanisms that enable them to supress one language while using the other. Unimodal bilinguals experience limitations due to the fact that they use only one articulator for both languages. Thus, unimodal bilinguals need to suppress the language they are not using at a certain moment in time. It has been argued that even the supressed language is never fully deactivated, even when a bilingual is producing their language in a monolingual situation (i.e. a situation where only one language is required)(Grosjean, 1998; 2001) This appears to require certain cognitive abilities in bilinguals that monolinguals do not acquire (e.g., Biyalistok et al., 2009; Costa et al., 2009). Conversely, bimodal bilinguals are fluent in a signed and a spoken language and have the ability to communicate two languages in two separate modalities (i.e. the manual and the auditory modality). Thus, with bimodal bilinguals, the articulatory constraints are lifted and the two languages to not necessarily need to be suppressed and can be blended and produced simultaneously.

Recently, studies investigating the active state of a signed and a spoken language in bimodal bilinguals have found evidence of a similar kind of co-activation in both languages. Independent of the modality, this research suggests that both languages are simultaneously

active during language comprehension and production (e.g., Emmorey et al., 2008, Giezen et al., 2015). Evidence for co-activation comes from comprehension and production studies which will be reviewed below.

1.2.1 Co-activation during language comprehension

There is a large body of literature that shows there is evidence for the co-activation of both languages in bilinguals. An example of a study that provides evidence for co-activation between spoken languages at the phonological level comes from a study by Marian and Spivey (2003), who found cross-language activation during language comprehension. In their study, Russian-English bilinguals listened to English words while their eye-movements were tracked as they looked at pictures. The English target picture was accompanied by four distractor pictures that contained a cross-language phonological competitor. For example, a picture of a stamp was shown which in Russian is translated as *marka*, when the English target word was *marker*. The eye-tracking data showed that the bilingual participants looked more at the picture that contained the cross-language phonological competitor than the other unrelated pictures. Their data suggests that the Russian words were co-activated during the task. Similarly, cognates (words that are similar in form and meaning in two languages) are recognized faster by bilinguals, implying that these words become simultaneously active in both languages when provided with certain input (e.g. Jared and Kroll, 2001). That is, these words seem to have a shared concept and seem to share overlapping lexical representations (Lemhofer, Dijkstra & Michel, 2004). Thus, the time-course of bilingual word processing in the target language is influenced by the activation of words in the non-target language (Dijkstra et al., 1998; Bernolet et al., 2007).

One model that accounts for the way in which languages are simultaneously activated in the bilingual mind was described by Dijkstra & van Heuven (1998, 2002). This model assumes that lexical access during reading is not language selective (i.e. both languages are

simultaneously activated). The BIA+ model predicts that any particular input to the language system will activate multiple potential matching candidates that compete with each other for lexical selection. This competition not only takes place within a single language, but can also extend to words from another language in bilinguals (Traxler, 2011). Libben and Titone (2009) investigated whether nonselective access also occurs for cognates and interlingual homographs (words similar in form but have different meaning in both languages) that were embedded in biased sentence contexts. Through an eye-tracking experiment French-English bilinguals were asked to complete a self-paced sentence reading task. French-English cognates or interlingual homographs were embedded in English sentences that were either low or highly semantically constrained. The results revealed that interlingual homographs slowed down reading, but cognates facilitated reading of the participants and were thus consistent with the assumptions of the BIA+ model.

As for language comprehension studies investigating bimodal bilinguals, Shook and Marian (2012) proved that lexical representations of both spoken and sign language are co-activated in the bilingual mind through an eye-tracking study with hearing bimodal bilinguals. The participants in this study were fluent in both American Sign Language (ASL) and English. They used a visual world paradigm where their participants listened to spoken words while they looked at a display with four pictures of which one was a target and three were distractor pictures. The target-competitor pairs of signs matched on three out of four phonological parameters in ASL including handshape, movement, sign location and orientation of the palm/hand. The authors hypothesized that their participants would look more at competitor items than the phonologically unrelated items in both ASL and English and that bilinguals would look more at competitor items than monolinguals. They found that their participants looked more at the cross-linguistic competitor than other unrelated distractors, suggesting ASL-signs were activated in the English listening experiment. Similarly, Giezen et al., (2015)

showed that ASL-English bilinguals co-activate ASL signs during spoken word recognition. The authors posit that in bimodal bilinguals, co-activation arises at the lexical level despite the fact that signed and spoken languages have distinct phonological systems. Thus, phonological overlap between languages is not necessary for co-activation. According to Giezen et al., (2015), bilinguals require cognitive inhibition skills that enable them to suppress one language while using the other. In a master's thesis, Manhardt (2015) investigated various aspects on language processing in bimodal bilinguals. Regarding cross-language activation in bimodal bilinguals, she investigated bimodal bilinguals of Dutch and Sign Language of the Netherlands (NGT) indicating that bimodal bilinguals looked longer at a cross-language competitor with shared phonological features in Dutch Sign Language (NGT) when the participants listened to Dutch sentences.

These results provide evidence that hearing Dutch-NGT bimodal bilinguals co-activate NGT while comprehending Dutch spoken sentences. During written word recognition, Villameriel et al., (2015) investigated the co-activation of signs while hearing bimodal bilingual participants comprehended spoken words. The participants were vocational interpreters of Spanish Sign Language (LSE) and were asked to make a decision whether the word that they heard was semantically related to the other. The results showed that late learners of LSE were quicker in evaluating semantic relations between words when the translation equivalent of the word had overlapping phonological features when compared to phonologically different words. These studies provide additional evidence that languages are activated during both spoken and written word comprehension independent of language modality.

1.2.2 Cognitive mechanisms during language comprehension

Taken together, these studies show that one language is activated while the other used, independent of modality. It may be possible that the ways in which the underlying processes of co-activation differ for unimodal and bimodal bilinguals (Giezen et al., 2015; Manhardt, 2015). That is, in unimodal bilinguals co-activation operates in a bottom-up fashion, moving from the activation sounds to cohorts and subsequently to lemmas and therefore providing co-activation. However, due to the phonological dissimilarities between spoken and signed languages co-activation might operate in a different manner in bimodal bilinguals. It has been suggested that activation of both a signed and a spoken language actually begins at the semantic or conceptual level (e.g., Shook and Marian, 2012) spreading top down to the lexical level. Shared information about meaning may be fed back to the lexical level and activate words from both spoken and signed language (Shook and Marian, 2012; Manhardt, 2015). It may also be possible that co-activation of two languages at the lexical level can be defined as activations of lexical representations in the form of translation equivalents in both languages which then compete for lexical selection in production and comprehension (Marian and Spivey, 2003). It has been suggested that co-activation during comprehension of a signed and a spoken language in bimodal bilingual individuals may be governed from top-down processes(Marian and Spivey, 2003; Manhardt 2015). Lexical entries may first be activated by auditory input of the spoken language and then activate semantic and conceptual representations. Manhardt argues that languages in the bimodal language system share information at the semantic and conceptual level which then is assumed to feed back to the lexical level which activates lexical entries from the signed language (e.g., Shook and Marian, 2009; 2012). This means that a single system is responsible for the integration of both a signed and a spoken language and that this system is not merely limited to language in one modality (Emmorey et al., 2008).

Overall, the studies mentioned above show that unimodal and bimodal bilinguals' languages are activated simultaneously during comprehension. However, the underlying processes of comprehension differ from those of production in both unimodal and bimodal bilinguals. This thesis will focus on unimodal and bimodal bilingual language production which will be discussed in the following sections.

1.2.3 Co-activation during language production

In addition to studies assessing language co-activation during comprehension, in language production, co-activation becomes evident in bilinguals' language behaviour in such that bilinguals to often use more than one language within the same conversational context (Grosjean, 1998; 2001). A central assumption in speech production is that words are retrieved from the mental lexicon by speakers. This process is referred to in the literature as lexical selection (Dell, 1986; Levelt 1989, 2001). A speaker must select the correct form from a set of activated words due to "spreading activation" from the semantic system to the lexical level (Levelt, 1989). The semantic system thus activates the word that matches meaning and additional semantically related items through the spreading activation mechanism. That is, when a picture of a duck is shown to a person, other related words like "feather" and "goose" are also activated, and are recognized and produced quicker by a speaker (Traxler, 2011). In the literature, it is widely accepted that the level of activation of lexical nodes causes one of the words to eventually be selected for production. The word with the highest level of activation corresponds to the intended meaning that the speaker wants to convey. Extending this to bilingual speech production reveals that the semantic system activates the two lexicons of a bilingual speaker (Costa, Caramazza and Sebastian-Galles, 2000; Poulisse, 1999). Models of lexical access assume that the production of words in one language activates the lexical nodes in both languages of a bilingual speaker. Therefore, the language behaviour shown by bilinguals (i.e. the switching between and mixing of two languages) during production may be

a possible result of the high level of activated words in the non-target language. These language switches are referred to as code-switches and bilinguals switch between languages for various reasons. For example, studies have shown that bilinguals will code-switch between languages more when speaking to other bilinguals (Grosjean, 2001), and in language contact situations (Milroy & Muysken, 1995).

Several previous studies have found co-activation during language production in bilinguals happens in part due to phonological overlap between two languages. Using picture naming tasks participants are quicker in naming cognates and take more time naming interlingual homographs (Libben and Titone, 2009; De Groot et al., 2000). These studies provide evidence that the organization of the languages in the bilingual mind occur in a non-selective manner. For example, Hermans, Bongearts, de Bot and Schreuder (1998) investigated whether or not the L1 interferes during the naming of words in the L2. Using the picture-word interference paradigm, participants were instructed to name pictures in English. During this task, the subjects are presented with a picture that they must name with a prior, subsequent or simultaneous distractor. If a semantically related word is presented at the same time, subjects are much slower to name the picture. This is due to semantic inhibition which slows down speech production. However, phonologically related words that are presented at the same time facilitate the speed in which it takes participants to name the target picture. The activation of semantic information thus happens early in lexical retrieval, while phonological encoding is assumed to happen simultaneously or shortly after lexical selection. Hermans et al., (1998) found that participants took longer to name the picture when it appeared with phonologically related word. Indeed, they found that speakers could not prevent their first language (Dutch) from interfering during English production. The authors argue that co-activation of Dutch during the process of lexical access and retrieval interferes with the time it takes to produce words in English.

The study of co-activation during language production in bimodal bilinguals has only recently been subject of investigation (Emmorey et al., 2012; Blanco-Elorrieta, Emmorey and Pylkkanen, 2018). For example, Giezen and Emmorey (2015) examined cross-language activation in hearing early and late learners of ASL. In a picture-word interference paradigm, their participants were asked to name pictures in ASL while hearing English distractor words. The presented words were either a direct translation, semantically related, phonologically related or entirely unrelated. They found facilitation effects when the distractor words were direct translations of each other or when the words were phonologically similar to the target sign. The authors therefore suggest that cross-language activation occurs at the lexical level in addition to phonological co-activation in bimodal bilinguals.

1.2.4 Code-Switching and code-blending

Evidence for cross language activation can also be found in the production of code-switches. Code-switching can be defined as the mixing of two languages during production. Code-switches occur when a word or phrase in one language replaces a word or phrase in a second language (Li, 1996). When unimodal bilinguals code-switch between languages they practice a range of cognitive abilities like executive control, attentional mechanisms and task-switching (Emmorey et al., 2008; Bialystok, 1987; Poplack, 1980). Code-switching has been studied from several different perspectives, and different studies provide different views on code-switching. For example, some studies looked at code-switching from a sociolinguistic perspective and argued for the social and pragmatic function of code-switches (Blom and Gumperz 1972; Altarriba and Santiago-Riverra 1994; Myers-Scotton 1993). Code-switching can even be utilized as a social communication and negotiation strategy in bilingual interactions (Arnfast and Jorgensen, 2003). Alternation is described by Muysken and Diaz (2000) as the mixing of languages at the structural level, lexical insertion happens at a restricted lexical level and congruent lexicalisation is used as an avoidance of mixing the

structure of two languages. They found that congruent lexicalisation is most often present in the mixing between dialects and between languages. Muysken and Diaz argue that this type of code-switching is an indication of good command of both languages because the code-switch occurs at the point where the grammatical structures of the two languages are compatible (see also Muysken, 2000 for a review).

Poulisse and Bongaerts (1994) investigated the occurrence of unintentional code-switches in bilinguals. The study aimed to analyse the L2 speech production performance of late Dutch-English bilinguals and focussed on slips of the tongue. The results showed an effect of the Dutch language system. The researchers suggest that unintentional use of L1 words in L2 production is related to language proficiency. The more dominant language (Dutch) affected the production of words in the less dominant language (English). Interestingly, the amount of transfer that the participants exhibited became less when the speakers were more proficient in English. Thus, a low language proficiency correlates with the probability of selecting an incorrect lexical item. This suggests that cross-language transfer on the lexical level in the form of unintentional code-switches comes from a lack of language inhibition and can arguably be seen as a lack of language proficiency. More recently, Jarvis (2009) studied the ways in which one language influences the L2 users knowledge and use of words in another language. Unintentional language switches in the L2 due to (usually) L1 influence are believed to be the cause of high levels of activation of L1 words (Jarvis, 2009). Therefore, unintentional language switches happen due to the selection of a word from the non-target language.

Costa and Santesteban (2004) investigated how L2 language proficiency affected the process of lexical selection in speech production. They set out to uncover the mechanisms that allow bilingual speakers to switch between languages in a controlled and conscious manner. The authors examined whether L2 proficiency affected code-switching performance. In a series of

five picture naming experiments, the authors investigated code-switching in L2 learners of Spanish and Catalan and compared them to highly proficient Spanish-Catalan bilinguals. They found that for the L2 learners, switching from the weaker language (L2) to the more dominant language (L1) was more difficult than the other way around. This asymmetrical switch-cost was not present in the highly proficient bilingual group. Thus, language proficiency seems to be a determining factor in the relative ease in which a speaker can switch between their languages.

Code switching with regard to inhibitory control and the language context in which code switching occurs was investigated by Meuter and Allport (1999). The participants were asked to name Arabic numbers from 1 to 9 in either their L1 or their L2. The language in which they were asked to name the numbers was signalled by the background colour of the screen. The experimental trials were the trials in which a participant had to switch languages in order to provide the correct response to the number on the screen. The authors predicted that naming latencies in the switch trials would be slower than in non-switch trials, implying that there is a time cost that correlates with the mechanism of switching between languages. Additionally, the authors hypothesized that when speakers switch from their more dominant L1 to their less dominant L2, the "cost" of switching (i.e. the mental capacity) to the L1 should be larger than switching to the L2. This was indeed what they found. Switching into the easier dominant language is less costly than switching into the more difficult non-dominant language. Additional support for this finding was reported by Jackson et al., (2001). Who assumed that access to L2 representations includes the active suppression of the L1. By examining event-related potentials (ERP's) during language switching, they found an increased negative peak when participants encountered a switch-trial in their L2 compared to L2 non-switch trials. For the L1, there were no differences found in switch trials compared to non-switch trials. This

indicated that there was a larger suppression for the L1 in the switch trials. The first language is often the more dominant language and it thus takes more effort to completely suppress it.

Similarly, with regard to language dominance, Heredia and Altarriba (2001) suggest that when a speaker learns second a language they rely more on their first language in early stages. Code-switches in these early stages would mostly involve intrusions from the L1 as speakers communicate in their non-dominant L2. However, when speakers become more proficient in their L2 and language dominance turns around, speakers could experience influence from the L2 on the L1. Thus, according to the authors, as language dominance changes, so does the way in which unimodal bilinguals access their two languages.

Heredia and Altarriba (2001) investigated the reasons why unimodal bilinguals code-switch and explored the possible explanations for this behaviour. It has been argued that a lack of language proficiency is one of the main reasons for the occurrence of code-switches. For example, a bilingual speaker can consciously code-switch between languages to use a word that is not available in the target language. However, the authors note that language proficiency does not account for the fact that code-switching might be related to lexical retrieval. As stated above, most theories of speech production suggest that the process of lexical access involves two steps. The first involves the selection of the lemma, the second step involves phonological encoding (Dell, 1986; Levelt 1989). During the process of lemma selection, these models propose that semantically and syntactically appropriate lexical items are selected from the mental lexicon. During the stage of lexeme retrieval, the phonological word forms are accessed. Phonological encoding is necessary to subsequently produce word forms (Bongearts, de Bot and Schreuder, 1998). Thus, when a code-switch is produced, a unimodal bilingual speaker may not have access to the correct lemma in the mental lexicon for that particular language, and produces a word in the non-target language.

Unimodal bilinguals use one articulatory system when selecting the target language. There are certain physical restrictions of using the vocal modality of language, namely there is only one set of articulators available. This may result miscommunication due to the fact that unimodal bilinguals use one modality for both of their languages. Conversely, the additional articulators available to bimodal bilinguals due to two modalities of language (i.e. spoken and signed) provide them with the ability to produce language in a way in which switching is not mandatory. Instead of switches, code-blends can be produced.

Code-blends form an interesting phenomenon because there may be different underlying mechanisms in language production that cause them than code-switches. Code-blends are produced when are produced simultaneously. Code-blends utilize both spoken and signed lexical items and bimodal bilinguals may follow parts of either grammatical systems during an utterance (Petroj et al., 2014). In contrast to unimodal bilinguals, the unique nature of bimodal bilinguals allows them to produce their languages through two different modalities. Emmorey, Borinstein and Thompson (2005) aimed to characterize the nature of bimodal bilingualism and wanted to provide insight into the nature of bilingual communication. The results showed that when speaking to another bilingual, the participants did not code-switch between languages. Instead the bimodal bilingual participants produced what Emmorey et al., (2005) termed a code-blend. In the bilingual situation the authors reported that nine out of their ten participants used mainly English: 95% of ASL signs co-occurred with English words and 23% of the English words co-occurred with an ASL sign. Analysis of the code-blends were for the most part (94%) semantically equivalent to spoken English and involved verbs more than nouns. This is in contrast to fact that the code-switches occur mostly with nouns rather than verbs in unimodal bilinguals (Muysken, 2000). Emmorey et al., attribute this result to the subtle semantic differences in the verbs of ASL compared to English. The fact that their

bimodal bilingual participants also showed code-blends when speaking English to a monolingual participant points to “intrusion” of ASL in spoken language.

Similarly, bimodal bilingual children also show mixing of a signed and spoken language. Petroj et al., (2014) investigated the presence of a certain type of code-blending in bimodal bilingual children. In particular, the authors investigated the presence of whispering. That is, the use of English lexical items that are produced without vocal cord vibrations to accompany signing. They argued that the grammar of ASL may be active during English production even when the bimodal bilingual children did not produce overt signs. Their results showed that in the ASL target sessions with bimodal bilingual experimenters, the children whispered more in their English speech than they produced fully voiced speech.

It has been argued that the existence of code-blends can be taken as evidence that signed and spoken languages are simultaneously active in the bimodal bilingual mind. The argument for the simultaneous activation of signed and spoken languages through the analysis of code-blends also comes from studies that examined bimodal bilingual children. The children appeared to reduce the effort of suppressing English while following ASL grammar.

Silimarly, Petitto et al., (2001) examined language mixing and code-blending in three bimodal bilingual children acquiring Langues des Qubecois (LSQ) and French and compared them to three French-English bilingual children. The most striking finding in this study was that the bimodal bilingual children adapted their language mixing rate according to the language of their interlocutor. Further comparisons with the French-English bilingual children showed that the bimodal bilingual children exhibited substantial similarities in their language mixing. The differences between the two groups in this study came down to differences in language modality. Namely, the bimodal bilingual children were able to produce signed and spoken words simultaneously. The code-blend productions of the bimodal bilingual children were mostly semantically equivalent (89%), similar to what was found in the Emmorey et al.,

(2005) study. The authors argue that like unimodal bilingual infants, bimodal bilingual infants have distinct representations of their two input languages. These studies show that bimodal bilingual children, like bimodal bilingual adults do not need to fully suppress their other language and therefore produce code-blends. In the paragraphs below I will explore the underlying mechanisms of bilingualism in unimodal and bimodal bilingual adults.

1.2.5 Cognitive mechanisms during language production

The previous studies discussed here show that there is evidence for co-activation during language production in both unimodal and bimodal bilinguals in the form of code-switches and code-blends. Evidence for the mechanisms underlying co-activation during language production are tip-of-the-tongue (ToT) experiences reported across unimodal and bimodal bilinguals. That is, unimodal bilinguals experience ToTs more than monolinguals which suggests that the underlying mechanism is sensitive to two lexicons and the two phonological systems (Costa & Caramazza 1999; Gollan & Brown, 2006). Furthermore, Pyers, Gollan and Emmorey (2009) investigated the ToT phenomenon in bimodal bilinguals. The authors found that ASL-English bilinguals experienced more ToTs than their monolingual counterparts and were more similar to Spanish-English bilinguals in the way ToTs occurred, despite the two languages having no phonological overlap in the two separate modalities. According to the authors, ToTs reflect incomplete activation of target lexical representations that are due to a reduced frequency of use of the words. The authors conclude that all speakers who use two languages experience ToTs, no matter whether it is a signed or spoken language. The authors argue that ToT's appear to reflect incomplete activation of lexical representations that result from a reduced frequency of use. Thus the ToT state in both unimodal and bimodal bilinguals is a consequence of incomplete lexical retrieval. Therefore, all speakers who need to divide their language use between two languages experience ToT states (Pyers et al., 2009). Further

evidence for the cognitive mechanisms associated with language production can be found when looking at code-switches and code-blends in unimodal and bimodal bilinguals.

Code-switches require the suppression of one language while producing the other. On the other hand, code-blends require simultaneous production of semantic information. The cost of the necessary language switch in unimodal bilinguals does not need to happen when a code-blend is produced. To account for language use phenomena as code-switching and code-blending, Lillo-Martin et al., (2016) proposed the "Language Synthesis" model. The Language Synthesis model is based on the code-switching models developed by MacSwan (2000) and included the central notions of Distributed Morphology (DM) (see Halle and Marantz, 1993). One central approach that MacSwan (2014) takes to code-switching is that it must be "constraint-free". This means that if an element from Language y is not able to check the features from Language x, derivation of the code-switch fails. A central claim of DM states that, that selected elements in two lists (one for each language in bilingual individuals) are abstract and not specified for phonological information (Halle & Marantz, 1993). Code-switches in the model are the result of the insertion of elements from either language in the mind of a unimodal bilingual. Thus, an element from language A can be inserted when the features of language A and language B overlap, leading to a code-switch between languages. According to Lillo-Martin et al (2014), the Language Synthesis model explicitly mentions that elements from each list can have two sources and two phonological levels, one for sign and one for speech.

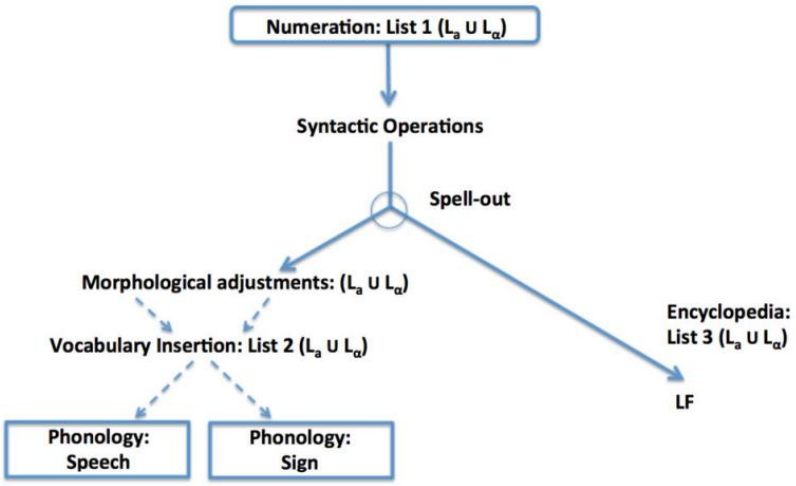


Fig. 1 – The Language Synthesis Model (Lillo-Martin et al., 2016).

The basic premise of the model is that there are two sets of items, which can include roots, functional morphemes and/or vocabulary items. These items enter into a single syntactic derivation. Abstract elements (i.e. roots and functional morphemes) that are selected may come from one of two Lists are linked to either language. Syntactic operations come from one set of elements that feeds into the spell-out. Afterwards, morphological operations enable two sets of language specific elements to be applied. Finally Vocabulary Insertion allows elements from speech and sign to be inserted that lead to the two sets of phonologies through the articulators for sign and speech. While it is clear that the model accounts for code-switches in unimodal bilinguals, adding a second set of phonology for sign language seems to be a simplification of how sign language is represented in the bimodal bilingual mind. A second phonology is logical if the languages are in the same modality (i.e. speech). However, sign language is produced through different articulators and therefore it is plausible that signed languages are represented in a different way in the bimodal bilingual mind than spoken language. Furthermore, as has been pointed out by Branchini and Donati (2016), the model does not take into account the systematic dual and parallel activation of lexical items that has been observed for bilinguals (Ormel and Giezen, 2014). Additionally the model posits that

vocabulary insertion is a late phenomenon due to the separation of the two language modalities. However, according to previous studies on bilingualism, it is also possible that dual lexical access is an early process, which the model does not account for (Branchini and Donati, 2017).

Another model was proposed by Emmorey, Borinstein, Thompson and Gollan (2008), who set out to examine the nature of code-switching and code-blending in bimodal bilingual adults. Through the use conversation and narrative elicitation tasks, they aimed to characterize the nature of bimodal bilingual language mixing and wanted to provide a framework to understand code-blending production. The authors hypothesized that if language choice occurs at the selection of lemma's, bimodal bilinguals should code-switch because only one language is selected. However, if the choice of output language is due to physical limitations of articulatory constraints (as is the case with unimodal bilinguals) then code-blending should occur in bimodal bilinguals. They found that their bimodal bilingual participants displayed a strong tendency to produce semantically equivalent code-blends, producing 82% of the same words or phrases in both spoken and sign language simultaneously (similar to the study by Petitto et al., 2001). Indeed, Emmorey et al., (2008) argue that the primary goal of code-blending is not to convey distinct information in two separate language modalities. An example of a semantically equivalent code-blend found by Emmorey et al., (2008) is displayed in figure 2.

Fig 2 - An example of an ASL–English single-sign code-blend. Underlining indicates the speech that co-occurred with the illustrated sign (From Emmorey et al., 2008, p. 24)

Thus, there must be some cognitive limits to the human capability to simultaneously produce two distinct propositions. Therefore, models of language production are restricted at the level of conceptualization where a single proposition is encoded for linguistic expression (Emmorey et al., 2008; p. 18). Emmorey et al., (2008) adapt Levelt's (1989) model to also include sign language and to account for the production of code-blends.

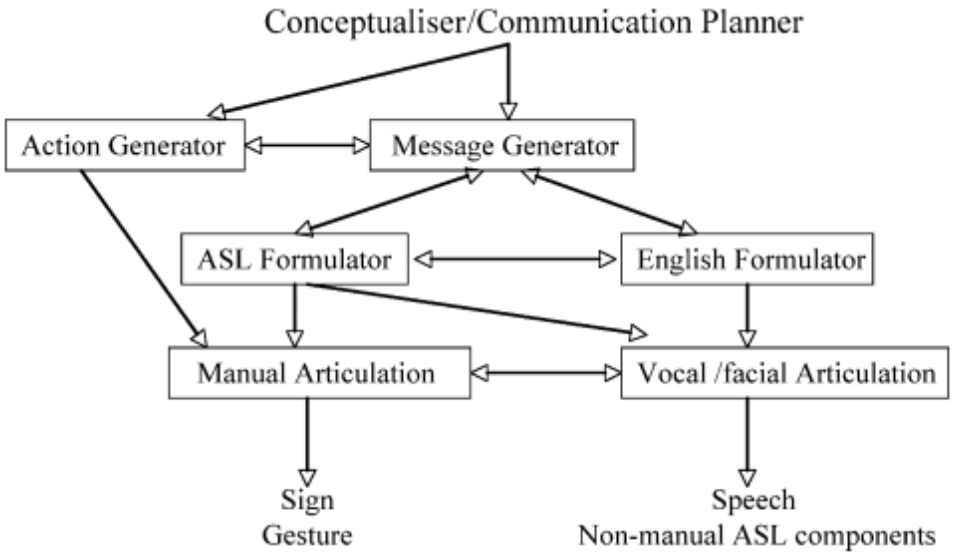


Fig 3 – The speech production model proposed by Emmorey et al., (2008)

The model in (fig 3), assumes that when an individual wants to convey a message, a concept in formed in the Message Generator. This concept from the Message Generator then activates lexical representations in the English and ASL Formulators. The grammatical, phonological and phonetic encodings are distinct for both language modalities. When one of the languages is temporarily the dominant language in the language situation an individual is in, grammatical encoding happens in the Formulator associated with that language (i.e. English grammar encoding in the English Formulator when no sign language is used). However, connected to the Message Generator is the Action Generator which is responsible for hand movements. These hand movements can be co-speech gestures (i.e. gestures accompanying speech) or can be lexical signs from a signed language. Priming for expression of information in the manual modality can happen through the use of co-speech gestures during spoken language production. Manual movements that are produced in the form of co-speech gestures may trigger similarities with signed languages, leading to the production of sign language components entering spoken language production. The movement of the hands may have an effect on the likelihood of ASL components such as verbs or the location of objects being produced during an English utterance, resulting in the consequential production of code-blends. In this way, the model accounts for the production of code-blends as well as co-speech gestures, which are argued to be an integral part of the language production system (e.g., Kita and Ozyurek 2003).

The consequences of accessing two lexical representations simultaneously was examined Emmorey, Petrich and Gollan (2012). examined the cognitive mechanisms underlying code-blend production. To produce a code-blend two lexical representations must be selected simultaneously by a bimodal bilingual individual. Unlike code-switching in unimodal bilinguals which requires one language to be fully suppressed to speak in the other, bimodal bilinguals are not required to fully suppress their two languages (e.g. Emmorey et al., 2008;).

The authors argue that the strong preference for code-blending in bimodal bilinguals must be because dual lexical selection of ASL and English is less costly than inhibiting one of the languages. Therefore, the authors argue that code-blends allow bimodal bilinguals to potentially work around lexical competition without any cognitive switching cost. This implies that lexical selection does not need to be a competitive process when speakers are able to use the hands as well as the tongue.

1.3 Language Transfer

As stated above, co-activation implies both languages are active during comprehension and production. However, it has been argued that the presence or absence of code-switching is governed by pragmatic and sociolinguistic factors, which are not necessarily similar to grammatical competence (Paradis and Genesee, 1996; De Houwer, 1990). Therefore, besides code-blending and code-switching, it is also possible for a bilinguals' two languages to interact in other ways. Cross-linguistic transfer happens when one language influences the structure of the other language (e.g., Ormel and Giezen, 2014; Manhardt, 2015). Effects of cross-linguistic transfer are most common in second language (L2) learners, where elements of the first language (L1) are "transferred" during production of the L2. Cross-language transfer can happen on the phonological, morphological and grammatical levels (Ormel and Giezen, 2014). The sections below will review evidence from studies that have investigated cross-language transfer in within spoken languages and how elements from sign language are transferred into spoken language through the manual modality (co-speech gestures) in language production. First, I will discuss how transfer is present in spoken languages (section 2.1) and then provide an overview of studies that show transfer from sign language into spoken language (section 2.2) through the manual modality.

1.3.1 Language transfer between two spoken languages

In spoken languages, transfer happens within the vocal modality of language. The reason that some elements from one language are transferred to another during language production due to the interference of the more dominant first language (L1) on the less dominant second language (L2). Language interference can happen on several different levels. For example, Voice Onset Times (VOT) can be measured to compare the way in which an L1 influences the L2 with regards to the production of consonants (Antoniou et al., 2012). The VOT can be more like L1 when speakers produce words in the L2, indicating interference from the stronger language. Often, this can be heard in the form of foreign accents to native speakers.

In a study in lexical transfer, Poulisse (1999) examined slips of the tongue (i.e. unintentional word use) in the spoken L2 English production of L1 Dutch speakers. The results indicated that 459 slips of the tongue produced by the participants were L1 lexical intrusions. She argued that word frequency of L1 words and L1 words that have L2 cognates were factors that raised the activation of L1 words during L2 production, causing errors in the production of certain words. These effects of lexical transfer were also investigated with speakers who are fluent in more than two languages (Ringbom, 2001; Cenoz, 2001). According to these studies, besides language proficiency, language similarity plays an important role in the likelihood of unintentional lexical intrusions (Williams and Hammarberg, 1998). There is also another type of lexical transfer that was described by Jarvis (2009) and Ringbom (1987). This type involves word-blends that are comprised out of combinations of formal properties from two different languages (Jarvis, 2009 p. 111). For example, Swedish-English bilingual uttering the phrase "*If I found gold, I would be luckly* " shows influence from Swedish *lycklig* (happy) (Ringbom, 1987, p. 154). According to Jarvis (2009), coinages involve the most clear from of blending because elements from both languages are used in a single word. This type of transfer is most likely to happen when two languages are closely related and thus highly

activated within a bilingual speaker (Dewaele, 1998). Thus, unintentional language switches and the intrusion of individual words seem to occur due to a high level of activation of the non-target language. This activation level then causes interference from competing activated lexemes.

These studies show how the transfer of individual words can have an effect on the way in which bilinguals make errors due to influence of one language on the other caused by high levels of co-activation. This transfer can be viewed as transfer that happens from speech to speech. However, staying at merely the spoken modality does not provide a full picture of the speech production system.

Kita and Ozyurek (2003) have proposed that co-speech gestures are also an inherent part of language production. Co-speech gestures are gestures that are produced during spoken language production and accompany speech. Co-speech gestures are often ignored in the study of language production. Ozyurek (2012) notes however that it remains unclear whether the compositional features and underlying cognitive representations in spoken and sign language are analogous to one another. Investigating gesture may provide a more full picture of the workings of cross-linguistic transfer that reach beyond just studying speech alone. In their investigation on how discourse affects co-speech gesture production, Azar et al., (2017) found that highly proficient Turkish-Dutch bilingual speakers did not differ from monolinguals in their speech or gesture production in the pragmatic marking of pronouns. That is there was no cross-linguistic transfer in terms of gesture production (Turkish being a high gesture language and Dutch a low gesture language). Similarly, Choi and Lantolf (2008) found that L2 English speakers and L2 Korean speakers did not change their L1 co-speech gesture patterns when they expressed manner of motion in their first language. There was no evidence that showed that the L2 has an effect on co-speech gesture production in the L1. Thus it seems that speakers retain their gesture patterns in their languages. Gesture

productions from a high gesture language does not seem to be transferred on to other languages and vice versa.

However, in their investigation of conceptual transfer Brown and Gullberg (2008) found differences in the way monolingual Japanese speakers and Japanese-English bilinguals expressed manner of motion. The Japanese-English bilinguals were less likely to use co-speech gestures when expressing manner of motion compared to their monolingual counterparts. The authors suggest that interactions between lexical items (i.e. as in speech production models) can spread throughout the language system. These interactions may also account for the way in which gesture production occurs when expressing manner of motion.

The studies mentioned above show that bilinguals experience language transfer on several levels. The manual modality of language is an essential part of language production. Furthermore, it is also the same modality in which sign language is articulated. Several studies have investigated the way in which sign language can influence spoken language through the manual modality. Ozyurek (2012) stated that if gesture forms an integral part of language production, co-speech gestures should as such also be found in sign language production. Ozyurek (2012) notes however that it remains unclear whether the compositional features and underlying cognitive representations in spoken and sign language are analogous to one another. Yet, if the cognitive mechanisms in sign and spoken language are similar, the investigation of sign language and co-speech gesture can uncover insight into the role of modality in language production (Perniss et al., 2014)

1.3.2 Transfer between signed and spoken languages

There has not been much research on how sign languages can influence spoken language through the use of the manual modality. Liddell (1998) argues that the presence of gestures in language is not unique to the spoken modality. In particular, co-speech gestures and code-

blends can both be viewed as meaningful manual productions that are produced synchronously with spoken words (Casey et al., 2012; Perniss et al., 2014). It may be possible that knowledge of a different language modality (i.e. sign language) has a different effect on the way co-speech gestures are produced. Research examining the effects of sign language on co-speech gesture shows differences in how signed and spoken languages interact. Signed and spoken languages have in common that the manual modality is used in language production. Casey, Emmorey and Larrabee (2012) studied the effects of learning ASL on English co-speech gesture production. They hypothesized that learning sign language as an L2 may have an effect on the way co-speech gestures are produced accompanying spoken English. This overlap between the articulators that produce co-speech gestures and sign language (i.e. the hands) may cause an increase in the production of manual movements when speakers communicate in their L1 (i.e. spoken language). In a longitudinal study conducted over a one year period they found that their ASL-instructed participants indeed showed differences in co-speech gesture production compared to participants that were instructed in a spoken language with a high gesture rate such as Spanish or Italian (i.e. romance languages). Participants were asked to re-tell a cartoon in a narrative elicitation experiment. Regarding gesture rate, the L2 ASL learners showed an increase in their iconic (i.e., representational gestures that bear a resemblance to their referent) co-speech gesture production and a larger variety of handshapes after one year of ASL instruction. Furthermore, the ASL learners also showed production of ASL signs (i.e. code-blends) in their cartoon retelling while none of the Romanic language learners produced L2 words. Casey et al., (2012) suggest that exposure to sign languages may lower the neural threshold for co-speech gesture production. Additionally, it may be possible that the ASL students become used to producing manual gestures while producing translation equivalents in speech. Thus, the simultaneous production in which semantically equivalent words and signs are conveyed may cause the co-speech gesture system to be primed, resulting

in an increase of manual gestures. Thus, the results of this study indicate very clearly that learning a signed language can cause transfer through the use of the manual modality. The study also shows that there is apparent transfer from a non-dominant language (sign) to dominant language (speech) in L2 learners of sign language.

In a similar study, Casey and Emmorey (2009) found that early bimodal bilinguals produced more iconic gestures and more gestures from a character viewpoint than monolingual English speakers. Gestures from a character viewpoint are used in sign language to depict the actions of a character in the narrative in sign language (McNeill, 1992; Casey et al., 2012). That is, the facial expressions and gestural body movements of the signer are resemble those of the character in the narrative. This "role shift" is used a discourse mechanism to narrate what happens in the story (Emmorey, 2007). Casey and Emmorey's results indicated that 70% of the bimodal bilinguals produced ASL signs simultaneously with spoken English and thus an intrusion of ASL signs was present (e.g. code-blends). The authors take this result as a reflection of a failure to supress ASL production. The results did not show a difference between the gesture rate of bimodal bilinguals compared to monolingual English speakers. The authors argue that this suggests that ASL signs occur instead of co-speech gestures, rather than in addition to them. However, more variety in the types of gestures were found in the bimodal participants, suggesting that knowing ASL affected the semantic content and form of gestures. According to the authors, the results demonstrate that native acquisition of ASL changes co-speech gestures in such a way that it resembles ASL signs. This could be due to the activation of ASL through the use of the hands to create co-speech gestures.

The above mentioned studies show that while gesture rate did not differ between monolingual, L2 learners of ASL and bimodal bilingual participants, the content of the gestures did vary between groups. The Casey et al., (2012) study reported that the increase of gesture rates diminished in their ASL instructed learners after the instruction period was over.

Weisberg et al., (2019) suggest that the effect that ASL had on co-speech gestures after merely one year of instruction was thus not robust in the Casey et al., (2012) study. The L2 learners in the Weisberg et al., (2019) study were late learners of ASL but were all highly proficient and had been using ASL for about ten years. Weisberg et al (2019) examined gesture rate in ASL-English bimodal bilinguals, late L2 signers and monolingual English speakers. The aim of the study was to examine whether fluent L2 signers and early ASL-English bimodal bilinguals exhibited similar patterns of co-speech gesture production. The authors found that in this study, gesture rates did indeed differ among groups. Increased gesture rates were found for both the ASL-English bimodal bilinguals and the L2 signers. Like Casey et al (2012), Weisberg and colleagues suggest that the increase of co-speech gestures in L2 learners might be modality related (i.e. the manual articulators with which co-speech gestures and sign language are produced are the same). According to Weisberg et al., (2019) the lack of difference in gesture rate between bimodal bilinguals and monolinguals in the Casey and Emmorey (2009) study may be attributed to methodological differences. In the Weisberg et al., (2019) study, participants were shown eight short clips of a cartoon which they described immediately afterwards. Contrastively, the participants in the Casey and Emmorey (2009) study, the participants watched and subsequently re-told the entire 7-minute cartoon from memory. Weisberg et al., (2019) argue that the overall increase in gesture production they found for both L2 learners of ASL and bimodal bilinguals when compared to monolinguals can be attributed to shared manual production of sign and speech (co-speech gestures). This can lead to an incorporation of ASL handshapes "into the gestural repertoire of ASL-English bilinguals and L2 learners of ASL" (p.8). Although the above mentioned studies show that knowledge of sign language can influence speech through the manual modality, evidence for increased gesture rate in sign language learners, bimodal bilinguals and non-signers seems to be conflicting. It may very well be possible that measuring gesture

production is not a robust way to conclude if this is caused by knowledge of sign language. Examining the content of the gestures produced by different groups of may provide more solid evidence for the way sign language influences spoken language.

In another study Gu et al., (2018) investigated the effects of Chinese Sign Language (CSL) on co-speech gestures about time in late bimodal bilinguals and non-signing Mandarin speakers. They found an interconnection between the co-speech gesture production system and the sign language production system. The results suggested that the co-speech gestures of speakers that learned sign language at a later age actually changed compared to their monolingual counterparts. The authors propose that performing actions or gestures can activate a change in the way a persons' spatial thinking. The authors argue that learning a sign language might change the way of spatio-motoric thinking (using the body to interact with the physical environment). The authors see this as evidence for an interconnected system between sign and spoken language.

Taken together, sign language is active during spoken language due to the visual-manual modality of gestures and code-blending occurs because the non-selected sign language is not required to be completely inhibited (Gu et al., 2018). Furthermore, it seems that exposure to sign language reduces the neural threshold for gesture production (e.g. Casey et al, 2012; Weisberg et al., 2019). These studies therefore show that sign language can influence spoken language through the manual modality. However, there is not much known on the transfer of syntactic structures from sign language into speech.

1.3.3 Syntactic Transfer

Compared to other domains (e.g., manual, lexical and phonological transfer between languages), much less is clear about the possible transfer of one language on the other at the syntactic level in language production of both language modalities. Within unimodal

bilinguals, some studies have investigated the structural representation of syntax of two languages in the bilingual mind and how spoken languages influence each other on the syntactic level. According to Paradis and Genesee (1996), syntactic transfer can be defined as "the incorporation of a grammatical property into one language from the other". In bilinguals, transfer is most likely to occur if an individual has acquired a more advanced level of syntactic complexity in one language than the other. Some evidence for shared syntactic representations during sentence production in spoken languages comes from syntactic priming studies. Syntactic priming can be defined as "an increased likelihood to produce a target sentence with a grammatical structure that was encountered in a preceding sentence" (Weber and Indefrey, 2009). Sentence production studies that have used syntactic priming to investigate whether grammatical structures are shared between the L1 and L2. That is, it is likely that bilinguals will produce a certain grammatical structure in the target language if they have recently encountered or produced a similar structure in the non-target language. For example, Desmet & Declerq (2006) found cross-linguistic syntactic priming for relative clauses in Dutch-English bilingual language production regardless of differing word orders in the two languages. Similarly, Shin & Christianson (2009) found cross-language syntactic priming in Korean-English bilinguals independent of argument structure. The authors attribute the results to provide evidence for shared syntactic structures between Korean and English, despite them being SOV and SVO languages respectively. The participants in this experiment used English on a regular basis and had spent an average of four years in an English-speaking country. In contrast, Hartsuiker et al., (2004) found that Spanish-English bilinguals tended to produce English passive sentence more often when it followed a Spanish passive than when it followed a Spanish active or intransitive sentence. Structurally, Spanish and English passives are similar to each other in word order, which Hartsuiker et al., (2004) argue to be the cause of their syntactic priming results. The results of the study indicate that word order seems to be

an important factor that determines whether a certain syntactic structure in one language will be used in the other.

The importance of word order for the priming of syntactic structures in unimodal bilinguals has been investigated by Bernolet et al., (2007). They examined whether word order is a necessary feature of shared bilingual syntactic representations, or whether these syntactic structures are nevertheless shared when the word order differs. In a series of five experiments they tested whether there was syntactic priming of simple relative clauses. They found that cross-linguistic priming only occurred when the word order between the prime and target phrases was identical. Thus, in the case of Dutch and German, priming occurred, while no priming effect was found between Dutch and English, where the word order between the prime and target sentence differed. According to the authors, their results indicate that word order is essential for the priming of syntactic structures across spoken languages in bilinguals. However, all participants in this study were native speakers of Dutch who had just several years of experience in their L2 (English or German). Additionally, the authors note that the results of lexical priming studies that found stronger priming effects from L1 to L2 than from L2 to L1, thus they followed this paradigm. The reason for this is that the first language is often stronger and more dominant than the second language, making the latter more susceptible for priming effects and influence from the first language.

Interestingly, not much research has been conducted on the influence from the L2 to the L1 in unimodal bilinguals, thus from the less dominant language to the more dominant language. Pavlenko (2000) examined the way the second language influences the first in late L2 bilinguals within several areas, including phonology, morphosyntax and semantics. She found that late bilinguals exhibit L2 influence on their L1 in these areas when the bilinguals became more proficient in their L2. She additionally suggests that this influence marks a change in language development in which certain areas of the L2 become restructured. However,

Pavlenko (2000) did not investigate the transfer of syntactic structures. One study that addressed this issue is the study by Pavlenko and Jarvis (2002). They examined the directionality of language transfer not only from L1 to L2, but additionally from L2 to L1 on the syntactic level. In a narrative elicitation study, they tested Russian L2 users of English who had learned English between the ages of 13-19 after arriving in the USA. They found that English (L2) influenced Russian (L1) in several areas such as case marking, loan translation of collocations and transfer related to article use. However, the authors did not find any L2 > L1 transfer with regards to word order. The reason for this is that Russian has a more liberal word order than English. They note that the English word order structures are essentially a subset of the variable options for word order in Russian. Interestingly however, was no significant difference in the amount or directionality of the language transfer between the participants regardless of their age of arrival or the influence of external factors. Nonetheless the authors conclude that the limited instances of linguistic L2 > L1 transfer they found suggest that when L2 competence increases, this has an effect on the way syntax is restructured between L1 and the L2 in unimodal bilinguals. It may be possible that other language pairs or may elicit different results of L2 > L1 transfer in different areas of syntax.

It is possible that syntactic structures are transferred differently in bilingual speakers who have learned their languages in a different context. In second language acquisition and late bilingualism, the second language (L2) is learned after the first language (L1) is already fully acquired. Heritage speakers learn two languages from birth (2 first languages (2L1s)) of which they often acquire their heritage (or family) language initially and acquire the environment language simultaneously or shortly afterwards. Heritage speakers form a distinct group of language learners because their initial dominant family language becomes less dominant due to the extensive input of the environment language. The heritage language is often used less than the environment language and is only used in certain contexts (in the

home). Therefore, the heritage language often lags behind in morphosyntactic, grammatical and lexical development in comparison with the speaker's stronger environment language (Montrul, 2012). Montrul (2010) examined the nature of which specific aspects of Spanish heritage speakers' syntax and morphology are fully acquired and which ones stayed underdeveloped. She investigated whether the more dominant environment language (English) affected the less dominant heritage language (Spanish) in different syntactic domains (clitics, clitic left dislocations and differential object marking). The results showed that transfer from English was present in the overt morphological marking of animate direct objects (differential object marking) in Spanish heritage speakers. According to Montrul this showed that some areas of syntax were susceptible to environment language transfer (English) into the heritage language (Spanish). Montrul (2010) posits that the properties of Spanish differential object marking lie at the interface between syntax and discourse. Thus, it is possible that certain syntactic phenomena are transferred differently in heritage speakers compared to L2 speakers.

Several studies have compared heritage speakers with L2 learners in terms of potential vulnerability of morphosyntactic, syntax-discourse and syntax-semantics phenomena. According to De Keyser (2005), inflectional morphology is difficult to acquire for second language learners. The same pattern arises in studies that examine the vulnerability of inflectional morphology in heritage speakers. For example, it has been found that heritage speakers of Russian and Swedish exhibit errors with gender agreement (Hakansson, 1995; Polinksy 2008a). In the case of Swedish, Hakansson (1995) examined verb placement and noun phrase agreement among five expatriate Swedish heritage speakers. The heritage speakers were compared with L2 learners of Swedish. Swedish is a V2 language, meaning that the verb always comes in second place in declarative sentences. The Swedish heritage speakers made more errors with morphology (NP agreement) than the L2 learners. However

they did not violate the V2 rule, in contrast to the L2 learners in the study. Hakansson (1995) concludes that syntax but not morphosyntax resists attrition in the Swedish heritage speakers. Other studies have found omission or simplification of case marking in Russian and Spanish (Montrul and Bowles 2009; Montrul 2012; Polinksy 2008b). Overall, these studies imply that there is transfer from the more dominant environment language to the non-dominant heritage language regarding certain syntactic structures. Within the area of discourse, speakers coherence is achieved through the alternation of differential lexical forms together with accessibility of an entity (Azar & Ozyurek 2015; Traxler 2011). Accessibility of an entity has to do with whether an entity is introduced for the first time, or whether an entity was already mentioned before. Languages differ in how referents are introduced or maintained in a certain discourse. That is, languages can make use of a full pronoun (non-prodrop language) or they can use a null form (pro-drop languages). In the case of the interface between syntax and discourse in bilinguals, Azar et al., (2019) examined reference tracking in Turkish heritage speakers in the Netherlands. The authors used a narrative elicitation study to investigate whether discourse status (re-introduced or maintained referents) and pragmatic contexts influence the choice of referring expression. Turkish and Dutch differ in that they can be classified as a pro-drop (null pronoun is used to mark reference) and non-pro drop (full pronoun is used to mark reference) language respectively. The authors suggest that the use overt pronouns in the bilingual participants were caused by transfer from Dutch (the environment language). It is possible that in bimodal bilingual language production, some grammatical elements from either language are transferred differently.

However, most of the evidence is limited to the study of the vocal modality and have focused on speech patterns finding language transfer from the dominant to the non-dominant language. Not much is known about syntactic transfer from sign language into spoken language. An example of simultaneous morphosyntactic articulation of elements from English

and ASL comes from a study by Pyers and Emmorey (2008). The authors examined whether bimodal bilinguals produced American Sign Language (ASL) grammatical facial expressions while participants expressed parallel syntactic structures in English. Bimodal bilinguals are similar to heritage speakers in that they often learned sign language in the home and learned the spoken language from the environment around them. Pyers and Emmorey (2008) hypothesized that the production of ASL facial expressions in monolingual situations would be an indication of difficulty in language control and inhibition of the non-selected language (e.g. ASL). The results revealed that bimodal bilinguals indeed produce ASL grammatical facial expressions when speaking English. Non-signers were found to only raise their eyebrows about half the time when speaking English compared to the bimodal bilingual participants when producing an English conditional clause. The bimodal bilinguals also did this in synchronicity with the onset of the conditional clause, which indicated the production of a grammatical ASL marker. With respect to furrowed brows (indicating a WH-clause in ASL), bimodal bilinguals almost never showed this when they were asking a WH-question in English. The authors attribute this to the conventions of facial expressions in speech, with furrowed brows often indicating a negative effect. Therefore, bimodal bilinguals were more likely to suppress ASL grammatical markers when it conflicted with conventional facial gesture. Their results indicate that articulation of grammatical elements from a non-selected language is possible. They argue that this is evidence for a dual-language architecture in which grammatical information is integrated and coordinated at all processing levels. Therefore, knowing two languages in two separate modalities may influence the way underlying cognitive systems of language selection and production operate. That is, as a consequence of co-activation, some syntactic structures and morphosyntactic elements may be influenced by the non-target language. These structures “leak through” when the speaker produces an utterance in the target language. The Pyers and Emmorey (2008) study shows

that when sign language is the non-target language, syntactic elements from sign language seem to be able to influence speech within the spoken modality. Additionally, the study shows that the non-target language can influence the target language in speech production. The above mentioned studies show that within the spoken modality, some syntactic phenomena may be vulnerable to cross-language transfer within spoken languages and from sign to spoken language. Morphosyntactic elements from the (non-dominant) sign language can influence (dominant) spoken language in bimodal bilinguals.

However, data is scarce on the whether the syntax-disourse and syntax-pragmatics interfaces are equally susceptible to cross-language transfer in bimodal bilinguals. Koulidobrova (2012) investigated syntactic cross-linguistic interaction of sign and spoken language in ASL-English bimodal bilingual children. The study focused on subject/object omission, as this is argued by the author to be a feature of ASL. Koulidobrova hypothesized that the participants in the study may also exhibit argument omission when speaking English, due to influence from ASL. The study compared ASL-English bimodal bilinguals to Italian-English unimodal bilinguals and English monolinguals within the spoken modality of language. The study examined the English data of two bimodal bilingual children. The results indicated that the bimodal bilingual children indeed differed from monolinguals and Italian-English bilingual children at similar stages of language development. The bimodal bilingual children displayed more subject and object omission than their counterparts. Additionally, they showed ASL-style argument omission, which indicated cross-linguistic influence on the syntactic domain with regards to an area between syntax and discourse (i.e. argument omissison). The author argues, in line with other studies, that bimodal bilinguals do not necessarily need to suppress their languages. According to Koulidobrova (2012) this allows intrusion of sign language in certain syntactic areas during spoken language production. However, the participants in this study were around two years old and thus have not acquired either language fully yet. It is

quite possible that the syntactic cross-language influence from ASL was not a consequence of true syntactic transfer, but rather a consequence of early bilingual language development in children. Lillo-Martin et al., (2014) rightly note that it would not be surprising to find a strong tendency for hearing native signers to become speech dominant, simply because hearing humans are fine-tuned for spoken language. However, there are no studies to date that have examined the possibility of cross-language syntactic transfer from sign into speech in bimodal bilingual adults.

1.4 Present study

As shown in the previous paragraphs, the studies showed considerable evidence that sign languages and spoken languages are active simultaneously. Furthermore, bimodal bilinguals can make use of both signed and spoken languages simultaneously through the production of code-blends. The studies presented above show how transfer on several levels is evident between spoken languages within the same vocal modality and that sign languages can influence the production of co-speech gestures within the same manual modality.

The aim of the present study is to investigate whether sign language can influence speech on the syntactic level as a consequence of co-activation in bimodal bilingual adults. To investigate this, we recruited bimodal bilinguals that are fluent in Sign Language of the Netherlands (NGT) and Dutch from birth. As a control group, we recruited Dutch hearing non-signers. In a picture description task, participants were asked to describe two inanimate objects in Dutch. The pictures were presented shortly on a screen with an arrow pointing to the target picture. Afterwards, the participants described the target picture to a non-signing confederate. The objects in the target picture were situated next to each other (see Fig. 3) so that the participants had to describe two objects.

We aimed out to investigate whether the descriptions provided by the bimodal bilingual participants differed from the descriptions of the non-signers. More specifically, we asked whether it was possible for syntactic structures from sign language across modalities into speech in bimodal bilinguals' descriptions of two objects in space. The reason we opted to elicit descriptions regarding spatial language is because signed and spoken languages differ in the way space is utilized to convey the way in which objects are located in relation to each other.

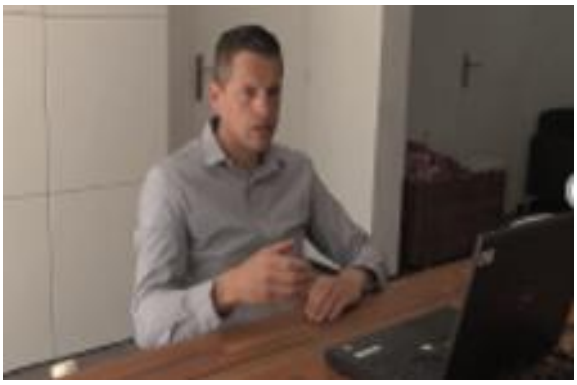
1.4.1 Spatial language: Dutch versus Sign Language of the Netherlands (NGT)

Spoken languages depict spatial relations with a relatively closed class of categories and grammatical forms (Talmy, 2003). In contrast, sign languages are radically different in the way that space is encoded. Firstly, the syntax of sign languages is spatially organized. That is, relations among signs are specified through placing them in signing space. Furthermore, sign languages mark spatial distinctions with a more structural elements and more categories (Talmy, 2003). In sign languages, every person has a signing space in which the signer represents motion events, referents and relations among objects. Signing space refers to the three-dimensional space in front of the signer in which physical space and abstract conceptual structure can be articulated. (Emmorey, 2001). There is a schematic correspondence between the location of the hands in signing space and the position of physical objects in the real world. The spatial relation of objects in relation to one another can be indicated by classifier constructions. Classifiers in sign language are formed by complex handshapes that encode information about spatial relationships. For purposes of this study, we will focus on Sign Language of the Netherlands (NGT).

Fig. 3 – an example of two objects in space in relation to each other

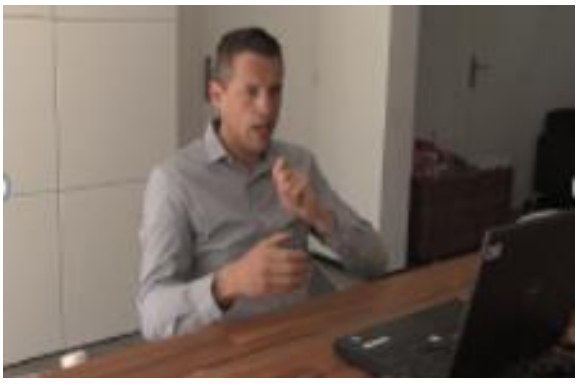
Typically in NGT, a signer would first produce the lexical sign in NGT for “glass”(Fig. 4A). followed by the lexical sign in NGT for “lolly” (Fig. 4B) and then uses certain handshapes to classify these objects. In this case, a round handshape is used for the glass and a long handshape is used for the lolly (Fig. 4C). Typically in sign languages, the larger object is signed first and can be referred to as the Ground object. Subsequently the smaller object is signed and can be referred to as the Figure object. The Figure object is placed in space in relation to the ground. Thus, the mapping of spatial information is a schematic representation of the locations of objects which is illustrated by where the hands are placed in the signing space. This unique way of using space in sign language may also account for the fact that bimodal bilinguals often use classifiers and code-blends during spoken language production.

A



RH: ---GLASS---
LH:

B



RH: ---HOLD---
LH: ---LOLLIPOP---

C

RH: ---HOLD---

LH: ---CLASSIFIER (Lollipop)---

Fig. 4 (A, B, C) – The signing of two objects in space in relation to each other in NGT with the use of classifier constructions. RH = right hand, LH = left hand

Because of this difference in how signed and spoken languages encode spatial relations between objects, we predict that speech may be influenced by sign language in the vocal modality. That is, signed syntax of NGT (ground object is named first and subsequently the figure object) may be incorporated in Dutch speech in which typically the Figure object is mentioned first.

1.4.2 Predictions

We predict, when describing spatial relations between objects in spoken Dutch, syntactic transfer is present in bimodal bilinguals due to the iconic mapping in the signed spatial encodings. The iconic mapping of space, which is a core feature of describing spatial relations in sign language may make its way across modalities into speech. That is, the way in which space is conveyed in signed languages begins with the signing of the bigger object (the Ground object) which is then placed. Subsequently, the smaller object (the Figure object) is

placed in relation to the Ground. The way in which these objects are located in signing space represents the way in which they are located in the real world. This may then result in an NGT-influenced word order in Dutch that differs from the way in which non-signers describe this. We therefore predict that bimodal bilinguals will mention the Ground object prior to the Figure object more often in the picture description task in Dutch. Conversely, the non-signing participants will most likely exhibit a more variable order in which first mention of the Figure and Ground objects as this is syntactically allowed in Dutch. Mentioning the Ground object first may be an indicator that NGT syntax is co-activated and finds its way into the speech production of the bimodal bilingual participants.

As a consequence of co-activation, speaking in an NGT-influenced way (i.e. the order of object introduction and the complexity of utterances) will be reflected in an increased use of code-blends in the bimodal bilingual participants. If cross-modal transfer is evident, it may be possible that the production of code-blends induce NGT activation at a syntactic level, which results in a difference clause structure and constituent order between bimodal bilinguals and non-signers. In this study, we predict that if the bimodal bilinguals produce code-blends, these will be in the form of classifier constructions which influence the speech of the bimodal bilingual participants.

2. Methods

2.1 Participants

The participants consisted of 20 non-signing native speakers of Dutch (11 female) and 21 hearing NGT-Dutch bimodal bilinguals (11 females) (See table 1 for participants' descriptive statistics). The non-signing native Dutch speakers were recruited as a control group. The Dutch-NGT bimodal bilinguals acquired NGT from birth in the family home and all reported to have one or two deaf parents. Dutch was acquired from the wider sociolinguistic

environment. The non-signer group and the bimodal bilingual group were matched on age (independent samples t-test: t(39) = -0.419, p = 0.678).

The two groups were asked to fill in a self-rated language proficiency test prior to the experiment for both Dutch and NGT. A Likert scale was used to score proficiency from 0 (no knowledge) to 5 (native like). The proficiency scores were collected from the non-signers and the bimodal bilingual participants separately for both comprehension and production (Table1). Within the bimodal bilingual group, eight of the participants were trained sign language interpreters. Additionally, all bimodal bilinguals reported to use NGT on a regular basis. Additionally, fluency in Dutch was determined using speech rate. A thirty second speech sample was obtained from a spoken narrative by the participants. To determine fluency in Dutch, speech analysis software Praat was used (Boersma and Weenink, 2001). There were no significant differences in speech rate between the non-signers (M = 3.393, SD = 0.427) and the bimodal bilinguals (M = 3.564, SD = 0.458. All of the non-signers were tested at the Max Planck Institute for Pyscholinguistics in Nijmegen The Netherlands. The majority of the bimodal bilingual participants were tested at their homes. Participation was voluntary and the participants received a financial compensation.

	Non-signers (Dutch)	***Bimodal Bilinguals (Dutch)***
Age (years)	*33.25 (10.95)*	*34.33 (16.62)*
Self-rated proficiency (comprehension)	*4.87 (0.4)*	*4.412 (0.713)*
Self-rated proficiency (production)	*4.8 (0.4)*	*3.765 (0.970)*

SDs are reported between parentheses

Table 1. *Descriptive statistics for native Dutch non-singers and NGT-Dutch bimodal bilinguals. Self-rated proficiency scores contain evaluations of Dutch non-singers and of NGT from bimodal bilinguals from 0 (no knowledge) to 5 (native like).*

Finally, the language dominance scores were collected for the NGT-Dutch bimodal bilinguals. Their language use was reported on a scale from 0 (never use this language) to 5 (always use this language). The bimodal bilinguals reported that they used Dutch very frequently (M = 4.824, SD = 0.373). This differed significantly from their NGT usage (dependent samples t-test: t(20) = -5.167, $p < 0.001$). We see this as indicator that the bimodal bilingual participants in this study can be considered as dominant in Dutch.

2.2 Design and procedure

The data was extracted from a database of a picture description task that was previously conducted by Francie Manhardt within a project led by Asli Ozyurek. The participants were asked to describe pictures of objects they saw on a screen to a non-signing confederate. The confederate was trained before the experiment and instructed not to provide any feedback to the participants. This was done to avoid syntactic priming during the speech production of the participants while they described the pictures. The pictures consisted of a ground and a figure object that were placed next to each other. The pictures were shown for a short amount of time (3 seconds) before the pictures disappeared (an example of the pictures used in the experiment can be seen in figure 3). The participants' task was to describe the picture they had just seen from memory to the confederate. Each participant described 28 trials in total which consisted of pictures with two objects. The participants were video recorded after which their speech and hand movements were coded.

Fig 4. Example of a target item that was described by the participants

2.3 Data Coding

The speech and code-blend data was coded in ELAN annotation software (Wittenburg et al., 2006) after which the data for the 40 participants was further analysed. The coding for the speech data was categorized in the following way. We opted to code the speech according to description. First, the trials were examined per whole description uttered by the participant. Secondly, the clauses used in the speech description will be specified. As part of specifying clause structure, each description was be coded for which object is named first (e.g., Ground vs. Figure object). First mention of the Ground object is typical for sign-like sentence structures (for example of Figure mentioned first see 1 a; for Ground object mention first see 1b).

(1a) Links ligt een potlood en rechts staat een glas

Left lies a pencil and right stands a glass

(1b) Een glazen potje met aan de linkerkant een mandarijn

A glass jar with on the left side a mandarin

A clause was be specified as consisting of a spatial relation and the two objects (see for example 1c and 1d). In (1c) the clause was analysed as containing two objects, as in this case "ernaast" refers back to the Ground object. Since we assess order in which Ground and Figure objects were introduced, descriptions in which only one object was mentioned were excluded

from the analysis (1e). Clauses that contained only one object were excluded from analysis (for example see 1c)

(1c) De roos ligt ernaast

The rose lies next to it

(1d) Er staat een rieten mandje met de roos aan de linkerkant

There stands a straw basket with the rose on the left side

(1e) De roos ligt rechts

The rose lies right

The utterances in which the Ground object was mentioned first were interpreted as sign-influenced speech (i.e. 1b and 1d).

To analyse the manual movements produced by the bimodal bilinguals, each manual production (i.e. each hand movement) within a spoken utterance was segmented to disentangle co-speech gestures from code-blends. A deaf native signer decided in the best of his abilities whether the hand movement made by the participant was either a gesture or a sign. The hand movements categorized as code-blends were analysed to examine whether there is a correlation between code-blends and the way the produced utterances are structured by the bimodal bilinguals in comparison to the non-signing participants.

2.4 Data Analysis

The coded data were analyzed in R (version 3.3.1) (R Core Team, 2013). We used general linear mixed-effects regression models (Baayen, Davidson, & Bates, 2008) with a binominal link using the packages *lme4* (version 1.1-19) and *lmerTest* (version 3.0-1) (Kuznetsova, Brockhoff, & Christensen, 2017) to retrieve p-values. Below, we will first describe how we analyzed the syntactic utterance structure across non-signers and bimodal bilinguals followed by the analysis descriptions on the link between code-blends and bimodal bilinguals' signed influenced speech.

2.4.1 Syntactic utterance structure across non-singers and bimodal bilinguals

To investigate whether sign language knowledge influences bimodal bilinguals' spatial encodings (i.e., signed influenced speech), we assessed the frequency of mentioning of the Ground object versus Figure object first across non-signers and bimodal bilinguals. In the model, Group (categorical predictor: non-signers vs. signers) was entered as fixed effect (predictor) and coded as a numeric contrast, that is, non-signers as -1/2 and signers as +1/2.

2.4.2 The link between code-blends and bimodal bilinguals' signed influenced speech

To investigate whether bimodal bilinguals different spatial encodings might be due to online co-activation of NGT, we linked the frequency of this signed influenced speech to the occurrence of code-blends versus co-speech gestures within the bimodal bilingual group. In the model, Code-blend (categorical predictor: absent vs. present), and Gesture (categorical predictor: absent vs. present) were entered as fixed effects (predictors). Code-blend and Gesture were coded as a numeric contrast, that is, absent as -1/2 and present as +1/2.

For both models, we conducted a backward selection procedure in which insignificant predictors were removed to obtain the most parsimonious model. Next, we removed outliers (i.e., data points with standardized residuals exceeding 2.5 SDs) from the data set. Subsequently, this model was fitted with the same significant predictors to this trimmed data set. The maximal random effects structure that converged in the model was implemented, which included random intercepts for participants and items.

3. Results

3.1 Order of Figure/Ground mentioning across non-singers and bimodal bilinguals

We determined whether the spatial encodings produced by bimodal bilinguals were influenced by knowledge of NGT by assessing the frequency in which the Ground object is mentioned first in the bimodal bilingual and non-signing participants. The model contained a significant main

effect (Group) (β=7.677, *SE*=3.172, *z*=2.420, *p*<0.05) suggesting that bimodal bilinguals produce more utterances in which the Ground object is mentioned first (67.57%) than their non-signing peers (54.46%) (see Figure 5). In this study, multiple clause sentences were excluded from analysis (non-signers, 29.61%, bimodal bilinguals 35.06%).

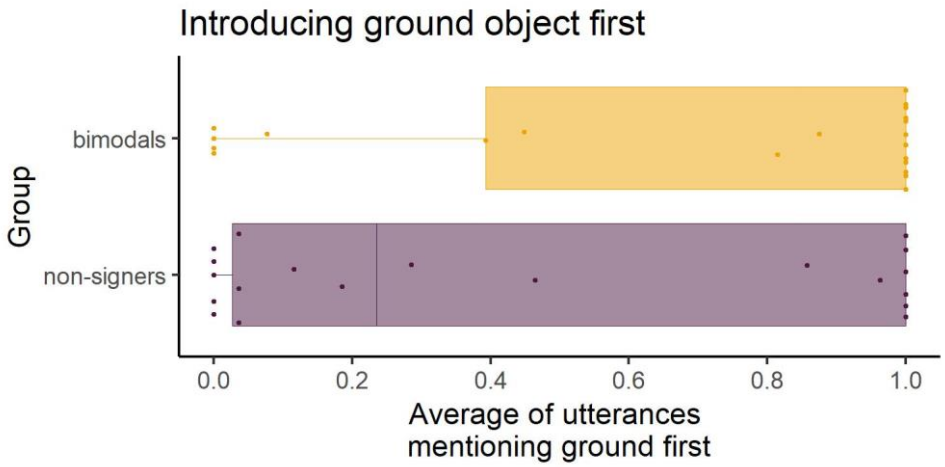


Figure 5. Frequency of utterances in which the Ground object is mentioned first across non-singers (bottom) and bimodal bilinguals (top). Dots represent each data point (participant).

3.2 The link between code-blends and bimodal bilinguals' signed-influenced speech

We will examine whether the order of object mentioning in the utterances of the bimodal bilingual participants is due to co-activation of NGT. To do this, we linked the frequency of this sign-influenced speech to the occurrence of code-blends versus co-speech gestures within the bimodal bilingual participant group. The model contained a significant main effect (Code-Blend) suggesting that the use of code-blends (β=1.441, *SE*=0.662, *z*=2.177, *p*<0.05), but not co-speech gestures (β=0.548, *SE*=0.776, *z*=0.701, *p*=0.48), predicts mentioning the ground object first (see Figure 6).

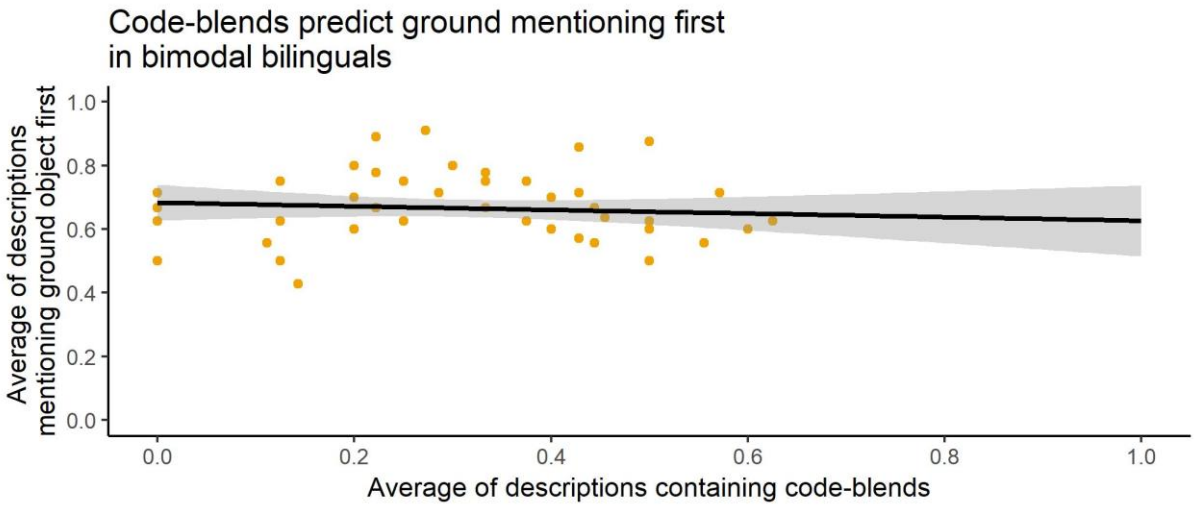


Figure 6. The link between signed influenced speech and the use of code-blends in bimodal bilinguals. Dots represent each data point (utterance).

4. Discussion

This study has investigated the way in which bimodal bilinguals speak about spatial relations between objects. Bimodal bilinguals are fluent in a signed and a spoken language and previous research has provided evidence that both languages, signed and spoken, are active simultaneously in the bimodal bilingual mind. Additionally, evidence from previous studies has proven that one language can influence the other (i.e. transfer). When using speech, bimodal bilinguals use co-speech gestures and signs that "leak" through from sign language in the form of code-blends. This happens because sign language influences hand movements that accompany speech through the manual modality. However, less is known about cross-modal transfer (i.e. transfer from the sign modality to the speech modality).

This study aimed to investigate whether sign language is able to influence speech on the syntactic level as a consequence of co-activation in bimodal bilinguals. First, we predicted that the NGT-Dutch bimodal bilinguals would show a difference in which they would describe pictures of two inanimate objects compared to non-signing native Dutch speakers. We hypothesized that the clause structure of the speech uttered by the bimodal bilingual

participants would contain more utterances in which the Ground object was mentioned first. Mentioning of the Ground object first in an utterance was seen as NGT-influenced speech. Second, we predicted that within the bimodal bilingual participant group, code-blends would occur as a predictor of the way in which the objects on the pictures were described (i.e. Ground object first).

Overall, our study has shown two key findings. First, the results showed differences in the way in which NGT-Dutch bimodal bilinguals and native Dutch non-signer described the pictures during the experiment. The bimodal bilinguals mentioned the Ground figure in the pictures first more often than the non-signing participants. This means that the first prediction is borne out. Secondly, the results showed that the occurrence of code-blends were indeed a predictor of the way in which the bimodal bilingual participants structured their clauses to describe the pictures during the experiment. As such, this also confirmed our second prediction. Below we will further discuss our findings in more detail.

4.1 Differences in the way bimodal bilinguals and non-signers speak about space

Bimodal bilinguals mentioned the Ground figure in the pictures first more often than the non-signing participants. This can arguably be viewed as an indicator that the way in which bimodal bilinguals describe two objects in space differs from non-signers. The way in which the non-signers described the pictures varied greatly (see Fig. 5). Some participants within the non-signing participant group described the Figure object first during the entirety of the experiment, and some non-signing participants chose to mention the Ground object first. We attribute this to the possibility that the non-signing participants chose one strategy (i.e. mentioning of either the Figure object or the Ground object first), and stuck with this throughout the experiment. The fact that the non-signers showed more variability in the first mention of the Figure and Ground object than the bimodal bilinguals shows that Dutch allows different ways in which spatial relations can be described. However, we argue that the

constituent order in the bimodal bilingual utterances (i.e. mentioning the Ground object first) is a consequence of the co-activation of NGT spatial structures. As such, we argue that word order structure (i.e. mentioning the Ground object first) can be viewed as NGT-influenced speech, as this would be the common structure to describe spatial relationships in NGT. These results contrast with those of Emmorey et al., (2005) who did not find any ASL-influenced speech in the monolingual situation (i.e. where the participants re-told a cartoon to a non-signing addressee) during their experiment. However it is unclear how the data was coded and what Emmorey et al., (2005) defined as ASL-influenced speech. The monolingual conditions of the current study (i.e. the confederate did not provide any feedback and was a non-signer) provide certainty that there was no indication that the participants had been syntactically primed to use a certain word order structure in their speech production. The fact that we did find NGT-influenced speech in a situation where there was no indication of stimulating the activation of sign language is in line with previous research that suggests signed and spoken languages are co-activated (e.g., Emmorey, Borinstein et al., 2008; Gu et al., 2017; Casey and Emmorey 2012)

4.2 Code-blends predict NGT-influenced speech in bimodal bilinguals

The results suggested that there was a correlation between NGT-influenced speech and code-blend production. That is, code-blends seemed to be a predictor of first mentioning of the Ground object in the utterances of the bimodal bilingual participants. Comparisons of code-blends versus co-speech gestures with order of mention revealed that code-blends, but not co-speech gestures predicted initial Ground object mention. Thus, we argue that due to co-activation of sign language through the manual modality, the participants produced code-blends which in turn predicted the way in which bimodal bilinguals would describe the pictures (i.e. NGT-influenced speech was produced). However, the relationship between code-blend production and the NGT-influenced utterances was not very robust. The code-

blends that were produced by the bimodal bilingual participants were analysed as being a code-blend and were not viewed separately. That is, there were no differences in segregation of the code-blends in the way they were produced. It would be interesting for future research to uncover whether different types of code-blends (i.e. classifiers or full lexical signs) will yield additional differences between bimodal bilinguals and non-signers in sentence structure during language production.

Taken together, the results suggest that not only is NGT co-activated though manual movements, (e.g., Emmorey et al., 2008; Emmorey et al., 2005; Casey and Emmorey, 2012) but NGT-influenced syntactic structures seem to be active as well in the mind of the bimodal bilingual participants. As such, we propose that the model that was developed by Emmorey et al., (2008) allows for syntactic structures from NGT to influence speech. Because this model assumes separate but linked sign language and spoken language Formulators, we propose that it is possible for syntactic structures from sign language to cross over into the spoken language formulator.

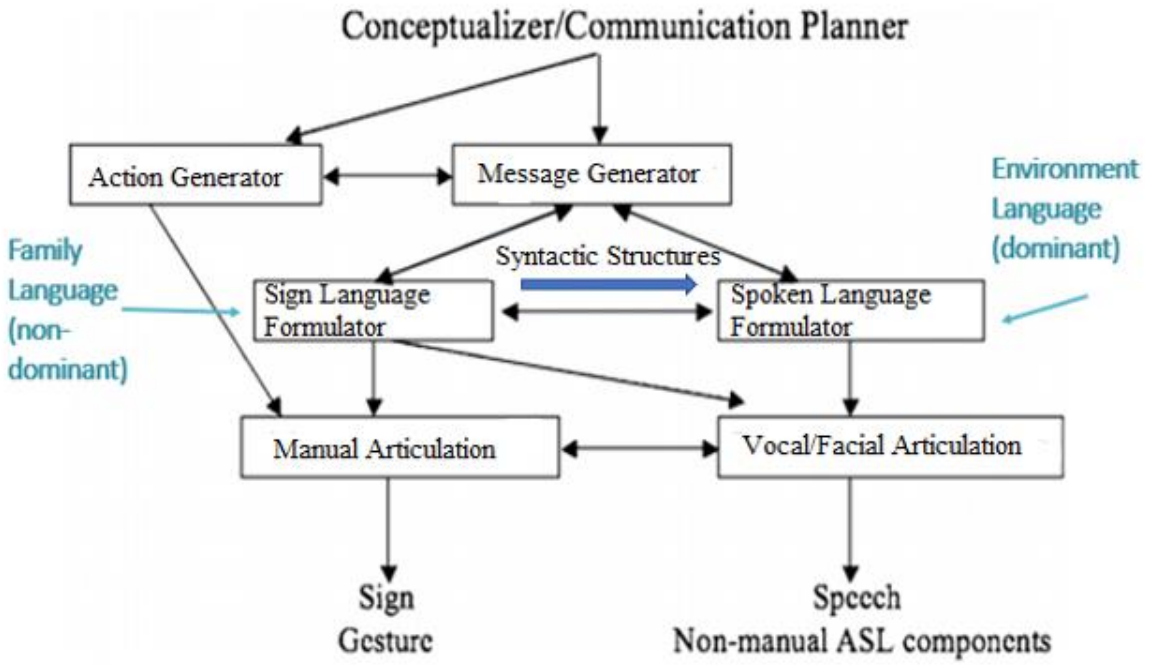


Fig. 8 - Syntactic structures from the sign language formulator travel to the spoken language formulator, inducing NGT-influenced speech production in bimodal bilinguals while describing spatial relations between objects. (Model from Emmorey et al., 2008).

4.3 The domain of spatial language

The spatial domain of sign language differs in a unique way from spoken language, and can therefore be viewed as an area between syntax and discourse that is sensitive to syntactic transfer. According to Sorace and Serratrice (2009), external interfaces such as the syntax-discourse interface link linguistic elements with aspects of world knowledge and cognition. The syntax-discourse interface requires the coordination of syntactic knowledge and real-world domains (Montrul, 2011). As Montrul (2009, 2011) suggested, the domain between syntax and discourse may be an area which is susceptible to transfer of certain grammatical structures in heritage speakers. Bimodal bilinguals resemble heritage speakers in the way they acquired their languages (i.e. sign language at home and spoken language from the environment). It is possible that the iconic domain of spatial language investigated in this study is also especially susceptible to syntactic transfer. In a signed language, spatial elements are placed within the signing space of a signer that wishes to convey where and how exactly these elements are located in the real world. It may be possible that these real world visual to visual mappings are entrenched in the mind of bimodal bilinguals. It may be possible that bimodal bilinguals view objects in space differently from non-signers because they have acquired a different way of expressing spatial relations through learning a signed language. Mentioning the Ground object first and producing sentences with a different constituent order can arguably be the result of needing to be precise about exactly where two objects are placed when conveying this information to another signer. The bimodal bilingual participants in this study all grew up with one or two deaf parents and thus have learned a different way of combining real world information with the way it is easiest to convey to an individual that

does not use speech. Because of this, it may be possible that grammatical structures regarding spatial language within the syntax-discourse interface are possibly susceptible to cross-modal transfer from signed into spoken language. Properties at interfaces that require the integration of different levels of real-world knowledge with linguistic elements are argued to be inherently more complex (Montrul, 2009). As such, it may be that at these levels, integration of syntactic structures between a signed and spoken language cause language influence to occur in a different way.

4.4 Language dominance

The fact that the bimodal bilingual participants produced utterances in which the Ground object was mentioned first as a consequence of co-activation of NGT yields another interesting implication. Namely, the bimodal bilingual participants all reported to be dominant in Dutch. Interestingly, the findings point towards non-dominant language transfer (from NGT) into the dominant language (Dutch) within the domain of spatial language. Montrul (2010) found influence from English, the dominant (environment) language on Spanish the non-dominant language in Spanish heritage speakers. It may very well be possible that the lift in articulatory constraints in bimodal bilinguals allows influence from non-dominant NGT when describing spatial relations in Dutch. The participants in this study were examined in a monolingual situation, and it seems that the non-dominant sign language influences the dominant spoken language at the syntactic level (i.e. word order) when describing spatial relations. We propose that the two Formulators (see fig. 8) interact in such a way that there is cross-modal syntactic transfer possible from the non-dominant language (NGT) on the dominant spoken language (Dutch). We suggest that non-dominant language transfer of syntactic structures on the dominant language is modality driven. That is, the differences in modality between signed and spoken languages may allow for this type of transfer to occur.

It seems that signed languages do not only influence spoken language in the manual modality through co-speech gestures, but can also influence spoken language in the vocal modality through syntactic structures. Furthermore, the area of language investigated here (i.e. spatial language) may be formed in a different way in bimodal bilinguals than in non-signers. Previous studies have shown that knowing a signed language may influence the way an individual experiences spatial relations (e.g., Gu et al., 2017). Our results suggest that when speaking about spatial relations between objects, sign language syntax (i.e. constituent order) becomes highly co-activated during language production. Some studies argue that syntactic transfer in bilinguals usually happens due to shared syntactic structures between languages (e.g., Pavlenko and Jarvis, 2002). The parallel activation of syntactic structures in both Dutch and NGT can be the possible result of the word order in NGT essentially being a subset of the Dutch word order (as in Pavlenko and Jarvis, 2002). However, the fact that the results showed a significant difference between the order in which the objects were mentioned, suggests that there might be underlying processes responsible for NGT-influenced speech. It is possible that bimodal bilinguals activate syntactic structures between NGT and Dutch while speaking. At least in the domain of spatial language. This in turn leads to influence from the non-dominant language (NGT) onto the dominant language (Dutch). Not only is this result surprising, it also provides additional evidence of how intertwined the languages are in bimodal bilinguals, who arguably show parallels with heritage speakers.

4.5 Directions for future research

The reason there were so few utterances that contained multiple clauses was a possible effect of the simplicity of the pictures the participants were asked to describe. The results may have yielded differences in the way the utterances were formed if there were more than two objects in the picture-description task. Additionally, it is clear that even now, the bimodal bilingual participants produced more multi-clause sentences than the non-signers. This in itself may

point towards a direction of the added complexity in the speech production of bimodal bilinguals which is a consequence of influence from NGT. Furthermore, the pictures all contained static inanimate objects. It would be interesting for future research to investigate whether syntactic cross-modal transfer is present when pictures contain animate objects. Humans are especially tuned to recognize animate objects and this may influence the way in which speakers refer to moving animate objects during language production (e.g., Silverstein 1976). It would be interesting to examine whether differences in syntactic structure found here are also present, or even more so, in bimodal bilinguals. For example, the way in which objects move in space may provide a chance to examine the type of verbs used by bimodal bilinguals and non-signers. Additionally, this study did not investigate verb use among bimodal bilinguals and non-signers. It may be possible that production of certain verbs differs between the two groups, which may indicate further syntactic transfer from signed languages into speech. Nonetheless, the differences in syntactic structure during language production found between bimodal bilinguals and non-signers indicates that sign language can have an effect on the way in which speech is produced on the syntactic level.

5. Conclusions

This study has set out to investigate whether there can be cross-modal transfer from a signed language into speech in bimodal bilinguals when they describe spatial relations. Through a picture description experiment we found that bimodal bilinguals exhibit NGT-influenced speech when describing two objects and their spatial relation relative to each other. Furthermore, the results indicated that the presence of code-blends in bimodal bilingual speakers was a predictor for the way the participants structured their sentences (i.e. code-blends correlated with the mentioning of the Ground object first). The results indicate that language transfer is not merely a unimodal phenomenon that allows influence within the manual modality (i.e. signs to co-speech gesture), but language transfer can also be present

across language modalities. That is, the iconic way in which spatial representations are formed in a signed language is a sensitive area for cross-modal transfer into spoken language. Additionally, the results in this study have shown that within this area of language and this language pair allows for cross-modal influence from the non-dominant family language (NGT) to the dominant environment language (Dutch). In sum, this study contributes to the understanding of how two languages from different modalities are connected and has provided new insights into the underlying cognitive mechanisms of bilingual language co-activation during production. Future research is needed to disentangle the complexities of different types of code-blends and the additional way in which humans use language when perceiving and conveying concepts from and to the outside world around us.

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