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The activation and selection of lexico-syntactic features in speech production: behavioural and electrophysiological evidence from L1 and L2 speakers

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CHAPTER 1

General introduction

1.1. Background

What are the behavioral and neural mechanisms underlying the production of accurate words, particularly in a non-native language communication? Besides content words such as nouns and verbs, closed-class items such as determiners and suffixes are crucial for constructing grammatical speech. Distinct from the selection of content words primarily driven by semantic information conveyed in discourse, the selection of closed-class items is mainly determined by various factors related to collocative nouns, such as lexico-syntactic features like grammatical gender (hereafter *gender*) in Indo-European languages (Alario & Caramazza, 2002). This thesis centered on this specific aspect of the speech production process, namely the selection of lexico-syntactic features in noun phrase (NP) production of non-native language learners. Language learners, especially late learners, were generally defined as individuals who learned the L2 after the age of fourteen (Rossi et al., 2006). This thesis explored language learners combining behavioral and electroencephalography (EEG) methods in the study of speech production. In this thesis, a non-native language is abbreviated as *L2* to distinguish it from the native language (*L1*). The thesis placed particular focus on two effects related to the processing of lexico-syntactic features in two languages, namely the *gender congruency effect* observed in Dutch and the *classifier congruency effect* observed in Mandarin Chinese (hereafter referred to as *Chinese*). In addition, the study also explored the *semantic interference effect* related to the processing of semantic information.

The gender congruency effect, reflected by more efficient processing of

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gender congruent nouns (i.e., nouns with the same gender categories within a language) compared to gender incongruent nouns (i.e., nouns with different gender categories within a language), has been widely observed in NP production in Dutch and German (La Heij et al., 1998; for reviews, see Schiller, 2013 as well as Wang & Schiller, 2019; for a meta-analysis see Bürki et al., 2023). This is because gender determines the choice of determiners in NPs in these languages with relatively simple morphological structures. For instance, the Dutch language has two gender values: common and neuter gender. It uses the determiner “de” for common gender nouns and “het” for neuter gender nouns (e.g., *de tafel*_{com} “the table”; *het huis*_{neu} “the house”). The classifier congruency effect is characterized by faster processing of classifier congruent nouns compared to classifier incongruent nouns in Chinese (Huang & Schiller, 2021; Wang et al., 2006). Classifiers were considered comparable to gender in psycholinguistic research. In Chinese NPs, it is standard practice to include a classifier between a quantifier and the noun (e.g., 一张桌子 “*yi zhang zhuo zi*” [one CL desk]). Despite the choice of classifiers reflecting, to some extent, the inherent properties of the referred objects of the nouns, such as animacy, shape, and function, the selection of classifiers depends on the noun itself rather than on semantic information (Croft, 1994; Lakoff, 1986; Tai, 1994; Tai & Wang, 1990; Tai & Chao, 1994; Tien et al., 2002; Bi et al., 2010). Note that classifiers in research refer exclusively to those individual classifiers specifying distinct units of entities that lack direct equivalents in English (e.g., Chinese: 两张桌子 “*liang zhang zhuo zi*” [two CL desk] vs. English: two desks). For more details about classifiers see Section 2.1.3 in Chapter 2.

Both effects have been observed in L1 NP production in languages with relatively simple morphological structures, such as Dutch and Chinese. However, they are not observed in single noun production in these languages when determiners or classifiers are unnecessary (Starreveld & La Heij, 2004; Wang et al., 2019). This demonstrates parallels in terms of selection by competition when Dutch gender and Chinese classifiers are required in NP production. The characteristics and function of both features can be accounted for by the Levelt, Roelofs, and Meyer (LRM) model (Levelt et al., 1999), which predicts that in single-word production, lexico-syntactic features such as gender are localized in the lemma stratum between the

concept layer and the word-form layer and receive activation from the lemma stratum. However, both effects have been less studied in language learners in the L2 context. Therefore, this thesis explored the processing of lexico-syntactic features in L2 speech production to gain insights from gender congruency and classifier congruency effects within relatively less-studied populations, such as Dutch learners of Chinese and Chinese learners of Dutch, whose L1 and L2 are morphological simple languages with gender and classifier.

Distinct from both gender and classifier congruency effects, the semantic interference effect is primarily related to the processing of semantic information in content words. It is characterized by faster processing of semantically unrelated nouns compared to semantically related nouns when participants are required to name pictures accompanied by a printed noun (Glaser, 1992; La Heij, 1988). This semantic interference effect is distinct from the semantic facilitation effect observed in lexical priming tasks, where participants read a target word preceded by a prime word. This thesis included the semantic interference effect as a control and reference to detect whether language learners activate and select semantically-related nodes in L2 production.

Furthermore, this thesis explored the role of linguistic similarity in lexico-syntactic features on L2 gender processing. Linguistic similarity in this thesis refers to the presence of corresponding lexico-syntactic features in both L1 and L2, rather than orthographic or etymological correlations. Language populations with classifiers and/or gender in both their L1 and L2 were categorized as the feature-similar group, while those without classifiers or gender in their L1 but with gender in their L2 were categorized as the feature-dissimilar group. More specifically, we compared Chinese learners of Dutch, representing the feature-similar group, to English learners of Dutch, representing the feature-dissimilar group. Previous studies have suggested that L2 processing would be influenced by knowledge in L1, with higher similarity in features between L1 and L2 resulting in more similar performance (Foucart & Frenck-Mestre, 2011; Sabourin et al., 2006; Sabourin, 2001; Sabourin & Stowe, 2008; Zawiszewski & Laka, 2020). Consequently, there might be a processing advantage for speakers with feature-similar languages compared to speakers with feature-dissimilar

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languages (Zawiszewski & Laka, 2020). However, it remained unclear whether speakers with classifiers in their L1 have an advantage in processing the gender of an L2 compared to those with no lexico-syntactic features in their L1. Therefore, this thesis compared Chinese-Dutch speakers and English-Dutch speakers at behavioral and neural levels.

In addition, this thesis made an endeavor to transition from lab-based settings to web-based settings in conducting an L2 speech production experiment with overt articulation online. Previous studies have suggested the feasibility of conducting time-sensitive speech production experiments and recording audio data online (Fairs & Strijkers, 2021; Stark et al., 2022; Vogt et al., 2021). Therefore, the web-based experiment has been considered an efficient alternative in the restrictions of the pandemic. The experiment was programmed and run on the Gorilla Experiment Builder (Anwyl-Irvine, Massonnié, et al., 2020), an experiment platform that is fully compliant with the EU General Data Protection Regulation and with NIHR and BPS guidelines. Taking advantage of online experiments, this thesis tested classifier processing in English learners of Chinese across a broader geographical range and explored the challenges and solutions for online speech production experiments.

In order to obtain language history information and grasp participants' proficiency levels, the experiments in this thesis employed a series of proficiency tests and background questionnaires to quantify language profiles. This is important in L2 research because individual differences may lead to variation in results (Midgley et al., 2009; Morishima, 2013; Ojima et al., 2005). It is necessary to test participants with relatively comparable proficiency levels within a group to ensure the validity of results. This thesis primarily collected language background information through self-reported information, including the age of acquisition for each language, the order of acquisition, the self-assessing of language abilities such as listening and speaking, etc. (Li et al., 2020). As a complementary vocabulary tests such as LexTale-Dutch (Lemhöfer & Broersma, 2012), an Elicited Imitation task targeting listening and speaking abilities (Yan et al., 2020), and small tests targeting the basic knowledge of lexico-syntactic features were applied in experiments.

1.2. Electroencephalography measurement

In this thesis, we measured behavioral data including accuracy and naming latencies, as well as electrophysiological activities, namely electroencephalography (EEG). EEG is a measurement method used to track event-related potentials (ERPs). ERPs reflect the real-time voltage changes of cognitive processes related to particular events in the continuously measured EEG, providing high-resolution data that is unable to be obtained through behavioral measures (Mueller, 2005). These brain dynamics can be linked to semantic or syntactic processing (Friederici et al., 1999; Steinhauer et al., 2009). EEG and ERP have been widely employed in L1 and L2 speech production studies (Aristei et al., 2011; Christoffels et al., 2007; Costa et al., 2009; Dell'Acqua et al., 2010; Strijkers et al., 2010; for review, see Ganushchak et al., 2011). This thesis primarily focused on two ERP components: the N400 and the P600.

The N400 component is generally linked to lexical-semantic integration and co-activation processes, and it is characterized by a negative voltage amplitude peak at around 400 ms post-stimulus onset (Baggio & Hagoort, 2011; Chen et al., 2017; Hoshino & Thierry, 2011; Lau et al., 2008; Leckey & Federmeier, 2019; Thierry & Wu, 2007; Wu & Thierry, 2010; for review, see Kutas & Federmeier, 2011). N400 amplitudes can vary in response to semantic violations in words, characterized as more negative amplitudes in centro-parietal regions for semantically inappropriate words compared to semantically appropriate words. This difference is attributed to the easier integration of semantically appropriate words into contexts, whereas inappropriate words require more cognitive effort to process (Brown & Hagoort, 1993; Hagoort, 2008; Lau et al., 2008; Osterhout & Holcomb, 1992). This ERP pattern is known as the N400 effect (Chwilla et al., 1995, 1998; Kutas & Hillyard, 1980, 1984). N400-like effect responses to classifier incongruity have been reported in recent speech production studies in Chinese, characterized by more negative amplitudes for classifier-incongruent conditions compared to classifier-congruent conditions, reflecting the classifier congruency effect (Huang & Schiller, 2021; Wang et al., 2019). In addition, the N400-like effect has also been observed to be associated with the gender congruency effect, with more negative amplitudes

linked to gender-incongruent conditions compared to congruent conditions (Paolieri et al., 2020; Wicha et al., 2003). In this thesis, we used the N400 component to explore the processing of semantic information, classifiers, and gender in L2 and L1 production.

The second component is P600, which is typically linked to syntactic violations (Hagoort et al., 1993). It is manifested as a positive-going voltage amplitude that starts at around 500 ms and peaks at around 600 ms post-stimulus onset in centro-parietal regions (Steinhauer et al., 2009; Swaab et al., 2011). P600 amplitudes may vary in response to syntactic violations, resulting in more positive amplitudes for syntactic violations compared to non-violations. This phenomenon is recognized as the P600 effect, which has been robustly reported in studies across different languages related to gender processing, such as gender agreement violations have been observed to trigger more positive P600 amplitudes compared to non-violations (Barber & Carreiras, 2005; Caffarra & Barber, 2015; Hagoort, 2003; Hagoort & Brown, 1999; Molinaro et al., 2011). Despite the P600 effect not being consistently observed in late language learners with lower proficiency levels (Hahne, 2001; Hahne & Friederici, 2001) and also being found in non-syntactic violations (Shen et al., 2016; Van Herten et al., 2005; Bornkessel-Schlesewsky & Schlewsky, 2008), this thesis used the P600 component to track gender processing, as it is a relatively reliable index for syntactic processing.

1.3. Chapter overview

This thesis explored the processing of two similar lexico-syntactic features: classifiers in Chinese and grammatical gender in Dutch, in (non-)native NP production across diverse language groups.

Chapter 2 focused on classifier processing in NP production for Dutch-Chinese L2 speakers and Chinese L1 speakers. Building upon previous studies on the classifier congruency effect in Chinese L1 production (Huang & Schiller, 2021; Li et al., 2021; Wang et al., 2019) and the LRM model (Levelt et al., 1999), this chapter examined how classifier congruency and semantic relatedness affected L2 accuracy, naming latencies and ERP patterns of Dutch-Chinese speakers, who possess gender in their L1, and compared them with Chinese L1 speakers.

Chapter 3 explored gender processing in NP production for Chinese-Dutch L2 speakers and the same Dutch(-Chinese) L1 speakers from Chapter 2. This chapter examined how gender is selected in Dutch NP production by speakers whose L1 uses classifiers. Specifically, we examined the effects of gender congruency and semantic interference in NP production of Chinese-Dutch L2 speakers and Dutch(-Chinese) L1 speakers and compared both groups at behavioral and neural levels.

Chapter 4 followed the previous two chapters on classifier and gender processing and took a further step to examine the role of similarity in lexico-syntactic features (i.e., classifier and gender) in the gender processing of L2 NP production. This chapter used an identical experimental design and theoretical basis as Chapter 3 to test English-Dutch speakers who lack gender and classifiers in their L1, categorizing them as a feature-dissimilar language pair. Subsequently, we compared them with Chinese-Dutch speakers from Chapter 3 who were categorized as a feature-similar language pair due to the presence of classifiers in their L1. The comparative analyses aimed to explore whether there was a gender processing advantage for L2 speakers of languages with lexico-syntactic features over L2 speakers of languages without a corresponding feature.

Chapter 5 transitioned from the lab-based setting to the web-based setting, programming and running an online L2 speech production experiment. We used an identical experimental task and proficiency tests as Chapter 2 to study classifier processing in English-Chinese speakers. Experimental procedures and technical settings were modified to adapt to the web environment. This chapter reported advantages and challenges and discussed solutions in terms of conducting L2 experiments with overt articulation online.