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Worlds shaped by words: a cross-linguistic investigation into the neural mechanisms of lexico-syntactic feature production

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CHAPTER 1

General introduction

Imagine a language task in which you are asked to identify the word that does not belong to the set, e.g., “apple, banana, stick”. The intuitive choice for many people may be “stick”, as the other two are fruits. However, speakers from different linguistic backgrounds may offer additional divergent responses. In addition to categorising nominal entities based on semantic categories (e.g., furniture, fruit, clothing, etc.), some languages employ a grammatical gender system or a classifier system for nominal classification (Kilarski, 2013; Seifart, 2010). For example, in German, all nouns are categorised according to grammatical gender into masculine, neuter, or feminine (Corbett, 1991). Therefore, in such a classification task, German speakers may exclude “banana” (in German: *Banane*) due to its feminine grammatical gender, contrasting with the masculine “apple” (*Apfel*) and “stick” (*Stock*). By contrast, in some Asian languages, such as Mandarin Chinese, the classifier system is a more common approach to subcategorising nouns. Based on the semantic features (e.g., animacy, shape, size, function, size, etc.) encoded in lexical representations (Shi, 1996; Tai, 1994; Tai & Chao, 1994; Tai & Wang, 1990), specific noun categories are restricted to co-occurring with a limited set of classifiers. For instance, nouns denoting vehicles must pair with the classifier “辆 (*liàng*)”. Hence, for native speakers of Mandarin Chinese, the odd-one-out among “apple, banana, stick” may be “apple”. This is because both “banana” (in Mandarin Chinese: 香蕉 *xiāngjiāo*) and “stick” (棍子 *gùnzi*) pair with the classifier “根 (*gēn*)” used for long objects, whereas “apple” requires “个 (*gè*)”.

Grammatical gender and classifier systems, as two of the most widespread nominal classification systems across languages, not only serve to classify nouns but also play an active role in language production. When producing a German noun phrase or sentence, the grammatical gender of the noun governs the lexical form and morphological inflection of associated adjectives, determiners, and pronouns (e.g., in

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German: *Das ist einNEU rotesNEU BuchNEU.* – “This is a red book.”). Similarly, when producing a Chinese noun phrase to quantify nouns, it is mandatory to use a classifier that aligns with the physical or conceptual attributes of the referent (e.g., in Chinese: *这是一本CL 红色的书* – “This is a red book”; the classifier 本 (*běn*) is used for nouns denoting bound printed materials). Grammatical gender and classifiers are regarded as *lexico-syntactic features*, referring to intrinsic grammatical properties of nouns that govern agreement with related elements within a sentence. These features are assumed to be stored in the *mental lexicon* alongside the *lemma* of a word (Levelt et al., 1999; Nickels et al., 2015; Wang et al., 2019; for a review, see Schriefers & Jescheniak, 1999). How speakers rapidly retrieve and process these lexico-syntactic features associated with nouns during phrase or sentence production has long been a prominent topic in psycholinguistic research. This dissertation investigates the neural mechanisms underlying the processing of these lexico-syntactic features (i.e., grammatical gender in German and classifiers in Mandarin Chinese) from a cross-linguistic perspective by analysing the behavioural and electrophysiological (EEG) responses of native speakers of Mandarin Chinese and German, as well as Chinese learners of German.

1.1. Existing evidence for the processing of lexico-syntactic features during speech production

Some speech production models have proposed theoretical assumptions regarding the processing of lexico-syntactic features during language production (for reviews, see Schiller & Alario, 2023; Schiller & Sá Leite, in press; Wang & Schiller, 2019). This dissertation primarily draws on two influential models: the *Levelt-Roelofs-Meyer* (LRM) model (Levelt et al., 1999) and the *Independent Network* (IN) model (Caramazza, 1997). According to the LRM model, speech production unfolds in a serial sequence of stages. The process begins with *conceptualisation*, wherein the speaker formulates the intended message and activates the corresponding concept node. The concept is then subject to *lexicalisation*, whereby the associated lemma node in the mental lexicon is retrieved. While the activated lemma node proceeds to the next stage of phonological encoding, it also automatically spreads activation to the lexico-syntactic features associated with it, such as the grammatical gender node. If the intended utterance includes lexical items that explicitly realise lexico-syntactic features (e.g., gender-marked determiners or adjectives within a noun phrase), these lexico-syntactic features will proceed to the stage of lexical selection, where their corresponding lexical forms are retrieved and encoded. In contrast to the LRM model, the IN model proposes three distinct and independent networks: the *lexico-semantic network*, the *syntactic network*, and *phonological lexemes*. Lexico-syntactic features like grammatical gender are stored within the syntactic network. During the production of noun phrases that include gender-marked words, these features are activated within the syntactic network.

Scholars have employed classic experimental paradigms such as the *picture-word interference* (PWI) paradigm and the *blocked cyclic naming* (BCN) paradigm to investigate the processing of lexico-syntactic features in speech production (see section 1.5.1 for a detailed exposition of the experimental paradigms). In the PWI paradigm, participants are presented with a target picture superimposed with a

distractor word. The task requires participants to name the picture while ignoring the distractor. In the BCN paradigm, target pictures are grouped into either *homogeneous* blocks (where all items share a congruent feature) or *heterogeneous* blocks (where such features differ). These items are presented repeatedly in randomised order within each block, and each complete presentation of all items is referred to as a *cycle*. The experiments involved in this dissertation were designed based on these two paradigms.

A substantial body of research employing the PWI and BCN paradigms has demonstrated the activation of grammatical gender information during noun phrase production in Indo-European languages (for reviews and meta-analyses, see Bürki et al., 2023; Sá Leite et al., 2019, 2022; Schiller & Alemán Bañón, in press; Schiller & Sá Leite, in press; Schriefers & Jescheniak, 1999; Wang & Schiller, 2019). One notable finding is the *gender congruency effect*, also referred to as the *determiner congruency effect* in Schiller & Caramazza (2003). This effect is reflected in shorter naming latencies when the grammatical gender of the distractor matches that of the target noun, compared to when they are incongruent in the PWI paradigm. In the BCN paradigm, this effect manifests as faster naming in homogeneous blocks, where all target items share the same grammatical gender, compared to heterogeneous blocks (Vigliocco et al., 2002). The present dissertation will also focus on the *gender congruency effect* in research involving grammatical gender processing.

In contrast to grammatical gender, the cognitive processes underlying classifier production have received comparatively less attention. Only a limited number of studies using the PWI paradigm have reported a *classifier congruency effect*, which is characterised by shorter naming latencies when the classifier associated with the distractor is congruent with that of the target noun (Huang & Schiller, 2021; Li et al., 2006; Wang et al., 2019; Wang & Schiller, submitted; Zhang & Liu, 2009). However, findings on whether *classifier congruency effects* can be reliably observed have been inconsistent across studies, and there is still room for improvement in both the experimental materials and methodological approaches. Building on previous research, **Chapters 2 and 3** of this dissertation further investigate the processing of classifiers by re-examining existing findings and exploring new dimensions. Specifically, **Chapter 2** employs the PWI paradigm, with refined experimental materials and data analysis methods, to test whether a *classifier congruency effect* can be observed during the production of quantifier-classifier phrases by native Mandarin speakers. **Chapter 3** adopts the BCN paradigm to examine whether a *classifier congruency effect* can also be detected by comparing naming responses in classifier-congruent versus classifier-incongruent blocks. The results of **Chapters 2 and 3** aim to provide more comprehensive empirical evidence for classifier processing and contribute Mandarin-based insights to the theoretical models of lexico-syntactic feature activation in language production.

1.2. Cross-linguistic differences in lexico-syntactic features: Grammatical gender vs. classifiers

While grammatical gender and classifiers serve analogous functions in noun classification, noteworthy differences exist between them. In some Indo-European languages, each noun is generally associated with a specific grammatical gender. The grammatical gender of some animate nouns aligns with biological sex (e.g., in German,

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Hahn “rooster” is masculine, while *Henne* “hen” is feminine). In some cases, gender assignment follows morphological or phonological regularities (e.g., German nouns with the suffixes *-chen* or *-lein* are typically neuter). However, for most nouns, gender assignment is arbitrary (Corbett, 1991). For instance, the word for *sun* is feminine in German (*die Sonne*) but masculine in French (*le soleil*), whereas *moon* is masculine in German (*der Mond*) but feminine in French (*la lune*).

Unlike grammatical gender, the mapping between Chinese classifiers and nouns is often many-to-many (Zhang & Liu, 2009). A single classifier can be used with multiple semantically compatible nouns. For example, the classifier 只 (*zhī*) can be used with various animals, such as cats, rabbits, and birds. Likewise, a single noun may pair with different classifiers to convey nuanced semantic details (Wang et al., 2025). The noun 面包 (*miànbāo*, “bread”), for instance, may take the classifier 块 (*kuài*, “chunk”) to refer to a loaf or 片 (*piàn*, “slice”) to refer to a slice, emphasising differences in shape and quantity. Given that the relationship between classifiers and nouns is constrained by semantic features and that classifiers help refine the meaning of the referent, a key question arises: Do the semantic features encoded in classifiers actively participate in the cognitive process of classifier selection during language production?

Several EEG studies on sentence comprehension have shown that mismatches between classifiers and nouns can elicit ERP components related to syntactic processing, such as the Left Anterior Negativity (LAN) and P600 (e.g., Chan, 2019; Hsu et al., 2014; Zhang et al., 2012). Importantly, these mismatches have also been found to elicit the N400, an ERP component typically associated with semantic processing (e.g., Chou et al., 2014; Hsu et al., 2014; Qian & Garnsey, 2016; Zhou et al., 2010). In language production, several experiments using the PWI paradigm have reported an N400-like ERP component associated with the *classifier congruency effect*, which aligns with the time window for semantic processing (e.g., Huang & Schiller, 2021; Wang et al., 2019).

Semantic constraints between classifiers and nouns in Mandarin often require alignment on features such as shape, size, animacy, or function (Shi, 1996; Tai, 1994; Tai & Chao, 1994; Tai & Wang, 1990). One noteworthy type of classifiers are shape classifiers, which encode visual shape properties such as dimensionality (e.g., point, line, plane, volume). For example, the classifier 条 (*tiáo*) refers to long, thin objects and can only be used with nouns that share this property (e.g., 河 river, 绳子 rope, 蛇 snake). Since existing evidence shows that classifier processing involves semantic information (e.g., Chou et al., 2014; Hsu et al., 2014; Qian & Garnsey, 2016; Zhou et al., 2010), it is worth investigating whether specific semantic features, such as shape, contribute to this cognitive process. Using the BCN paradigm, Bi et al. (2010) found that naming latencies were significantly slower in homogeneous blocks, in which classifiers shared similar shape features, compared to heterogeneous blocks. This was interpreted as a *shape interference effect*, indicating that visual shape information embedded in classifiers was processed during quantifier-classifier phrase production. However, their behavioural data could not determine whether the activation of shape information occurred at the pre-lexical or lexical level of processing. Building on this study, **Chapter 3** of this dissertation (published as J. Wang, Witteman, and Schiller, 2025) re-examines the *shape interference effect* using the BCN paradigm and

complements it with data from event-related potentials (ERPs). This study aimed to clarify the processing stage at which the visual shape information of classifiers is engaged by analysing the temporal dynamics of EEG responses during Chinese noun phrase production. The findings are expected to provide additional evidence that classifier processing in Mandarin, unlike grammatical gender, involves semantic feature activation, thereby supporting the view that classifiers represent a semantically grounded lexico-syntactic system.

1.3. Processing lexico-syntactic features in a second language

Despite the inherent arbitrariness or complex semantic constraints governing the mapping between nouns and lexico-syntactic features (i.e., grammatical gender, classifiers), native speakers can rapidly and automatically access this information during speech production, selecting contextually appropriate lexical forms. For second language (L2) learners, however, whether such native-like automaticity can be fully acquired remains contentious. A series of L2 studies employing the PWI paradigm has demonstrated that L2 speakers can exhibit effects similar to the *gender congruency effect* observed in native speakers during bare noun or noun phrase production (for a meta-analysis study, see Sá Leite et al., 2020). This suggests that L2 speakers can automatically activate the grammatical gender features associated with the nouns they produce, indicating that the successful acquisition of an L2 gender system is possible. Nevertheless, it is important to recognise that most of the research has concentrated on typologically related language pairs. Languages such as German, Dutch, Italian, and French exhibit broadly comparable grammatical gender systems (Aikhenvald, 2016; Corbett, 1991). In such cases, *cross-linguistic influence* (Lemhöfer et al., 2008) may arise when L1 and L2 gender features converge or diverge, with L1 features either facilitating or impeding L2 feature acquisition (Sá Leite, Tomaz, et al., 2022; Soares et al., 2018; Von Grebmer zu Wolfsturn et al., 2021a, 2021b).

For L2 learners whose L1 lacks a grammatical gender system (e.g., Mandarin Chinese speakers), the question of whether novel L2 functional categories can be established has been the subject of considerable debate. According to the *Failed Functional Features Hypothesis* (Hawkins & Chan, 1997), if functional categories in the L2 involve uninterpretable features (e.g., the grammatical gender system) absent from the learner's L1, adult L2 learners are unlikely to acquire them successfully. By contrast, the *Interpretability Hypothesis* suggests that although the lexical specification of uninterpretable features like gender poses significant challenges for acquisition, feature checking remains possible, albeit native-like proficiency is rarely achieved (Tsimpli, 2003; Tsimpli & Dimitrakopoulou, 2007). Another influential proposal, the *Missing Surface Inflection Hypothesis* (Prévost & White, 2000), suggests that while abstract functional categories and features in the L2 can be acquired, learners often encounter difficulty in mapping these abstract features onto their morpho-phonological forms.

Although Mandarin Chinese learners of German possess classifiers as a type of lexico-syntactic feature in their L1, classifiers differ substantially from grammatical gender in how they categorise nouns and combine with them to form noun phrases.

As such, the grammatical gender system in German can be regarded as a novel functional category for native Mandarin speakers. While Mandarin speakers possess cognitive mechanisms for processing lexico-syntactic features, it remains an open question whether these mechanisms can be extended to support the acquisition and processing of new lexico-syntactic features that are absent in the L1 but present in the L2. To date, research examining grammatical gender processing in Mandarin-German bilinguals remains limited. **Chapter 4** of this dissertation presents two experiments using the PWI paradigm to investigate whether a *gender congruency effect* can be observed in late L2 learners of German whose L1 is Mandarin. By collecting both behavioural and EEG data during the production of German noun phrases, **Chapter 4** explores the extent to which late L2 learners, whose L1 lacks the target functional categories, can acquire the mechanisms necessary to process grammatical gender in an L2. To further examine at which stage of L2 noun phrase production the gender processing occurs, Experiment 1 in **Chapter 4** manipulated the semantic relatedness between the distractor and the target word, while Experiment 2 manipulated their phonological relatedness. Previous studies have shown that naming latencies increase when the distractor and target belong to the same semantic category, known as the *semantic interference effect* (Bürki et al., 2020). In contrast, when the distractor and target share phonological features, naming latencies are shorter than in phonologically unrelated conditions, resulting in a *phonological overlap effect* (Meyer, 1996; Meyer & Schriefers, 1991). For possible explanations of these effects, please see below. By examining the presence and timing of these effects, we aim to determine the temporal relationship between L2 gender processing, semantic processing, and phonological encoding.

1.4. Lexico-syntactic features of semi-lexical nouns

Grammatical gender is an inherent property of nouns, and previous research has primarily focused on how regular nouns spread activation to grammatical gender features during language production. However, whether the same processing mechanisms extend to non-canonical noun types remains unclear. Some nouns, through processes of grammaticalization, gradually lose semantic content and begin to exhibit characteristics more typical of function words. These words no longer fully exhibit the defining properties of either prototypical content or function words and are, therefore, classified as *semi-lexical* words (Corver & Van Riemsdijk, 2001; Emonds, 1985; Ross, 1972, 2004; Van Riemsdijk, 1998). For example, some auxiliary verbs and prepositions are often categorized as members of this irregular lexical category (Emonds, 1985). The first noun (N1) in German *pseudo-partitive* constructions can also be considered semi-lexical (Koptjevskaja-Tamm, 2001; Selkirk, 1997; Van Riemsdijk, 1998). For instance, in the German phrase *eine_{FEM} Scheibe_{FEM} Käse_{MAS}* (“a slice of cheese”), the two nouns — *Scheibe* (N1, “slice”) and *Käse* (N2, “cheese”) — occur juxtaposed to each other but play distinct syntactic roles. N1 has lost much of its referential content and no longer functions as a typical content word. Instead, it serves as a quantification unit for N2, which is the semantic head of the phrase. In the meantime, N1 exhibits functional properties of determining the grammatical gender and number agreement for the entire noun phrase (Löbel, 1989;

Rutkowski, 2007; Selkirk, 1997). For example, the selection of the determiner is governed by the grammatical gender of *Scheibe*, not *Käse*.

Given this intermediate status between content and function words, semi-lexical nouns may be processed differently from prototypical lexical nouns. This raises two questions: (1) Can semi-lexical nouns still activate their associated grammatical gender features during noun phrase production? (2) If so, does the activation pathway for grammatical gender differ in any way from that observed in regular nouns? **Chapter 5** of this dissertation reports an experiment using the PWI paradigm to investigate these questions. Specifically, we compare the *gender congruency effect* in regular and semi-lexical nouns in the production of German noun phrases. By examining differences in naming latencies across the two noun types, we aim to investigate whether semi-lexical nouns in German pseudo-partitive constructions engage grammatical gender processing via a distinct mechanism.

1.5. Methods used

1.5.1. Experimental paradigms

1.5.1.1. Picture-word interference paradigm

The experiments reported in **Chapters 2, 4, and 5** of this PhD dissertation primarily employed the *picture-word interference* (PWI) paradigm, which is derived initially from the *Stroop task*, a classic experimental task in cognitive psychology (Glaser & Dünghoff, 1984; Starreveld & La Heij, 2017; Van Maanen et al., 2009). In the *Stroop task*, participants are required to name the ink colour of a word or nonword. When the meaning of the word is incongruent with its ink colour (e.g., the word “BLUE” printed in red ink), naming is significantly slower than when label and colour are congruent or when the stimulus is a nonword. This phenomenon, first identified by J. R. Stroop (1935), is known as the *Stroop effect*.

The PWI paradigm shares a similar design and has been widely used to investigate the cognitive mechanisms underlying word production. In this paradigm, a target picture that needs to be named is presented simultaneously with a distractor word, which is usually superimposed on the image. Researchers investigate different stages of language processing by manipulating the congruency between target and distractor items at various levels of linguistic representation. For example, when the target and distractor belong to the same semantic category (e.g., *cat* and *dog*), naming latencies are typically longer than in semantically unrelated conditions (e.g., *cat* and *river*). This phenomenon is known as the *semantic interference effect* (Bürki et al., 2020). It suggests that, while naming the target picture, conceptual nodes belonging to the same semantic category as the target are also co-activated. If the distractor word is among the co-activated lexical candidates, it competes with the target's lemma for selection by further activating the co-activated lexical candidate, thereby increasing naming latency. Beyond semantics, the PWI paradigm has also been widely used to investigate phonological and orthographic information processing. When the distractor word shares phonological or orthographic features with the target, naming latencies are typically reduced (e.g., Jescheniak et al., 2003; Knipsky & Amrhein, 2007; Lupker, 1982; Meyer & Schriefers, 1991; Posnansky & Rayner, 1977). These

facilitation effects suggest that overlap at the form level can facilitate word form encoding.

Building on this foundation, the present dissertation applies the PWI paradigm to systematically explore the processing of lexico-syntactic features across different languages, speaker populations, and lexical categories. **Chapter 2** examines the *classifier congruency effect* by manipulating whether the target and distractor nouns can co-occur with the same classifier in Mandarin Chinese (e.g., 书 *shū* “book” and 杂志 *zázhì* “magazine” both requiring the classifier 本 *běn*). **Chapter 4** manipulates three variables in the PWI paradigm: gender congruency, semantic relatedness, and phonological relatedness (e.g., Axt “axe” and Amt “bureau” share the initial phonemes) between the distractor and the target noun. In **Chapter 5**, in addition to manipulating grammatical gender congruency, the experiment also varies the lexical category of the distractor. Specifically, whether it is a regular or semi-lexical noun that can appear in a German pseudo-partitive construction.

1.5.1.2. Blocked cyclic naming paradigm

In addition to the PWI paradigm, **Chapter 3** of this dissertation employs another widely used experimental method for investigating the cognitive mechanisms underlying language production: the *blocked cyclic naming* (BCN) paradigm. Target pictures are typically grouped into homogeneous and heterogeneous blocks in this paradigm. In homogeneous blocks, stimuli generally share a common linguistic feature, such as belonging to the same semantic category, having the same grammatical gender, or overlapping in phonological segments or orthographic forms, compared to heterogeneous blocks. Each block consists of a set of pictures that are presented in random order and are repeated to form multiple cycles. In homogeneous blocks where all items share a specific linguistic feature, repeated naming induces enhanced activation of stimuli. This higher activation level exerts either facilitative or inhibitory effects on subsequent naming performance, depending on whether or not it involves a competitive lexical selection process. Naming latency differences between homogeneous and heterogeneous blocks typically emerge starting from the second cycle (Belke et al., 2017). For example, when all items in a homogeneous block belong to the same semantic category, naming tends to be slower than in heterogeneous blocks (Belke et al., 2005; Belke & Stielow, 2013; Crowther & Martin, 2014; Schnur et al., 2006). In contrast, naming latencies are significantly reduced when stimuli within a homogeneous block share grammatical gender (Vigliocco et al., 2002) or orthographic form (Wang et al., 2022).

In **Chapter 3**, homogeneous and heterogeneous blocks were constructed based on two criteria: classifier congruency and shape similarity (see also J. Wang, Witteman, and Schiller, 2025). We compared blocks in which the target and distractor nouns either shared or did not share the same classifier to examine whether a facilitation effect similar to those observed in grammatical gender processing also occurs in the context of classifier processing in Mandarin Chinese. This also enables us to offer complementary evidence for classifier activation, extending findings from previous studies that employed the PWI paradigm (Huang & Schiller, 2021; Li et al., 2006; Wang et al., 2019; Wang & Schiller, submitted; Zhang & Liu, 2009). Additionally, by comparing blocks with similar or dissimilar visual shapes, we explore whether

semantic features beyond semantic categories play a role in lexical access during speech production.

1.5.2. Electroencephalography (EEG)

Electroencephalography (EEG) is a non-invasive electrophysiological technique that has been in use for over a century (Müller-Putz, 2020). It is widely used in neurolinguistic research and serves as a valuable complement to traditional psycholinguistic measures (e.g., accuracy and reaction time) by providing millisecond-level temporal resolution, which enables researchers to track the fine-grained neurocognitive dynamics underlying language processing. EEG measures voltage fluctuations caused by the synchronised activity of cortical neurons via electrodes placed on the scalp. A core analytical approach in EEG research is the examination of event-related potentials (ERPs) — systematic voltage changes that are time-locked to specific cognitive events (Woodman, 2010). Different ERP components have been associated with distinct aspects of language processing, such as semantic and syntactic processing (for an overview, see Leckey & Federmeier, 2019). This dissertation focuses on three ERP components relevant to language production: P300, P600, and N400.

The P300 is a positive-going waveform that is typically observed in centro-parietal regions and peaks around 300 ms after stimulus onset (Fabiani et al., 1987; Polich, 2011). It is classically observed in *oddball* paradigms, where infrequent or unexpected stimuli are presented within a stream of frequent, predictable ones (Polich, 2011; Sutton et al., 1965). Previous findings suggest that the P300 triggered by novel or infrequent stimuli reflects the allocation of attentional resources due to context updating (Donchin, 1981). P300 effects have also been reported in the BCN paradigm, where heterogeneous blocks elicit stronger P300 amplitudes than homogeneous blocks (Wang et al., 2018). This suggests that increased cognitive effort is required to manage shifting or inconsistent contextual cues. In **Chapter 3** of this dissertation, the P300 component is employed as a neural index to compare classifier-congruent and classifier-incongruent blocks within the BCN paradigm, examining the activation process of classifiers during noun phrase production.

When a stimulus conflicts semantically with its preceding context, it typically elicits a negative-going ERP component known as the N400, which peaks around 400 ms after stimulus onset and is most prominent over centro-parietal scalp regions (for a review, see Kutas & Federmeier, 2011). The N400 is widely understood to reflect processes involved in semantic integration, particularly the effort required to link incoming stimuli with long-term memory. Semantically anomalous or unexpected stimuli that are harder to integrate into the context tend to elicit larger N400 amplitudes, indicating increased processing effort (Brown & Hagoort, 1993; Kutas & Federmeier, 2000; Kutas & Hillyard, 1980; Lau et al., 2008). N400 effects have also been reported in studies investigating the *classifier congruency effect* using the PWI paradigm (Huang & Schiller, 2021; Wang et al., 2019). In these studies, distractor words whose classifiers were incongruent with those of the target nouns elicited stronger N400 responses than classifier-congruent distractors, suggesting the activation of classifiers during lexical access in speech production. **Chapter 2** of this dissertation extends this line of research by investigating whether the N400 effect can

be reliably replicated during quantifier-classifier phrase naming using a PWI paradigm.

In contrast to semantic violations, syntactic anomalies typically elicit a P600 (Hagoort et al., 1993; Osterhout & Holcomb, 1992). This late positive-going ERP component begins around 500 ms and peaks approximately 600 ms post-stimulus onset, most prominently over centro-parietal scalp regions. The P600 is generally interpreted as an index of syntactic integration, re-analysis, or repair processes (Friederici, 1995; Kaan et al., 2000; Osterhout et al., 1994; Osterhout & Holcomb, 1992). Previous studies have shown that grammatical gender mismatches, for example, disagreements between determiners and nouns, can evoke P600 responses (Barber & Carreiras, 2005; Foucart & Frenck-Mestre, 2011; Gunter et al., 2000; Hagoort & Brown, 1999; Molinaro et al., 2011). **Chapter 4** of this dissertation investigates whether a comparable ERP pattern can be observed in Chinese-German bilinguals, focusing on whether gender-incongruent stimuli elicit larger P600 amplitudes than gender-congruent stimuli during the production of German noun phrases. This provides an opportunity to assess the extent to which late L2 learners whose first language lacks grammatical gender (i.e., Mandarin Chinese) have developed mechanisms for processing grammatical gender in their L2.

1.5.2.1. Web-based language production experiment

Recent advancements in web-based experimental platforms have made it increasingly possible to conduct psycholinguistic research remotely. These platforms demonstrate notable advantages. By eliminating the spatial and temporal constraints of traditional laboratory settings, researchers can efficiently reach participant populations from diverse geographical locations. Several studies focusing on language production have shown that effects exceeding 10 ms effect sizes can be reliably detected using web-based platforms (Bridges et al., 2020; Fairs & Strijkers, 2021; He et al., 2021; Stark et al., 2022; Vogt et al., 2021). **Chapter 5** of this dissertation employed web-based experimental platforms to recruit participants and collect behavioural data, with the aim of providing empirical evidence that may inform future evaluations of both the strengths and limitations of web-based language production experiments.

1.6. Overview of this dissertation

This dissertation aimed to uncover how lexico-syntactic features — grammatical gender in German and classifiers in Mandarin — are processed during noun phrase production across different types of words (e.g., regular vs. semi-lexical nouns) and language backgrounds. The key research questions are: (1) Is it possible to reliably observe the activation of classifiers when naming Chinese noun phrases? (2) Are semantic components of classifiers, such as visual shape features, activated during noun phrase production? (3) Can late L2 learners of German, whose L1 lacks grammatical gender, process grammatical gender features? (4) Do semi-lexical nouns activate lexico-syntactic features in the same way as regular nouns? To address these questions, the present dissertation employs multiple experimental paradigms and collects both behavioural and EEG data from native speakers of Mandarin Chinese, native speakers of German, and Chinese-speaking learners of German.

Chapter 2 of this dissertation adopts a PWI paradigm, in which native Mandarin Chinese speakers were asked to complete a quantifier-classifier phrase production task. Classifier congruency and semantic relatedness between the target and distractor words were manipulated. Building on previous research, this experiment introduced methodological refinements in stimulus design and data analysis to test whether the *classifier congruency effect* can be reliably observed, providing further evidence on whether classifier information is activated during the production of quantifier-classifier phrases in Mandarin Chinese (see J. Wang, Witteman, and Schiller, submitted-b).

Chapter 3 of this dissertation adopts a BCN paradigm, in which native Mandarin Chinese speakers were asked to complete a quantifier-classifier phrase production task. Within each cycle, we manipulated the classifier congruency of the target nouns and the shape similarity of the associated classifiers. On the one hand, the experiment aimed to examine the *classifier congruency effect*, to determine whether classifier nodes are activated during the production of quantifier-classifier phrases. While previous evidence for this effect has primarily been obtained using the PWI paradigm, the present study aimed to extend this line of research by examining classifier processing through the BCN paradigm. On the other hand, we aimed to investigate the *shape interference effect*, with a particular focus on identifying the time window during which visual shape information is processed, as revealed by ERP data (see J. Wang, Witteman, and Schiller, 2025).

Chapter 4 centres on the acquisition and processing of lexico-syntactic features in L2 learners. Using the PWI paradigm, we conducted two German noun phrase naming experiments with Mandarin Chinese learners of German (see J. Wang, Witteman, and Schiller, submitted-a). In the first experiment, we manipulated grammatical gender congruency and semantic relatedness, while in the second experiment, we manipulated grammatical gender congruency and phonological relatedness. These experiments were designed to investigate whether *gender congruency effects* can be observed in late L2 learners and to investigate the time course of L2 grammatical gender processing. We aimed to explore how lexico-syntactic features are activated and selected in L2 context, and the extent to which L2 learners whose L1 lacks grammatical gender can acquire the mechanisms necessary to process such features in the L2.

Chapter 5 reports a web-based experiment with native German speakers, using the PWI paradigm. The experiment manipulated both grammatical gender congruency (congruent vs. incongruent) and the noun category of the distractor (regular noun vs. semi-lexical noun). We sought to examine how the noun category of distractors influences the processing of grammatical gender during the production of noun phrases (see J. Wang, Witteman, and Schiller, re-submitted). While most theoretical and empirical work on grammatical gender processing has focused on regular nouns, this study aimed to extend the discussion to non-canonical noun types, i.e. semi-lexical nouns. The investigation of semi-lexical nouns challenges the traditional dichotomy of content vs. function words, offering empirical support for the view that lexical categories may lie on a continuum.

Chapter 6 synthesises findings across studies, discusses theoretical implications, and suggests avenues for future research.

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