The lexico-semantic representation of words in the mental lexicon = De lexico-semantische representatie van woorden in het mentale lexicon

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CHAPTER 5

General Discussion

In the current thesis, we explored the neurocognitive mechanisms of word production in native Mandarin Chinese speakers. To this end, we systematically manipulated the following variables: i) the congruency between target and distractor regarding a single semantic feature, ii) the congruency between target and distractor regarding multiple semantic features and iii) the similarity between target and distractor regarding the probability distributions of lexico-syntactic features. Specifically, in **Chapter 2**, we studied the effect of animacy as an example of a single semantic feature. In **Chapter 3**, we investigated the differences between semantic category effects and shape effects to determine the effect of multiple semantic features. Finally, in **Chapter 4**, we examined the effect of classifier probability distribution-similarity to understand the encoding of lexico-syntactic features having multiple grammatically correct options. Together, these studies increased our understanding of the role of semantic features and lexico-syntactic features in word production, allowing us to propose extensions to Levelt's model of language production to increase its generalizability.

With respect to the role of animacy in word production, we

observed an animacy interference effect. Given our results, we concluded that the previously described semantic category interference effects (Bürki et al., 2020; Huang & Schiller, 2021; Wang et al., 2019) are at least partially caused by these more elementary semantic features. From the perspective of Levelt's model, we posit that this contribution of animacy, being a semantic feature, might be realized through proximity-driven spreading of activation at the conceptual level. That is, concepts congruent in a given semantic feature (e.g., animacy) might be located closer to each other in the semantic network compared to concepts that are incongruent with respect to that semantic feature. This is theoretically analogous to the hypothesized role of semantic categories in Levelt's model (Collins & Loftus, 1975; Roelofs, 1992, 1993, 1996). We also pointed out that the role of semantic features identified in our study is not mutually exclusive with the more established role of semantic categories (Levelt, 1999; Levelt et al., 1999; Roelofs, 1996).

Regarding the role of multiple semantic features in word production, we found that the (main) semantic category effect is stronger than the (main) semantic 'shape' feature effect with respect to the spreading of activation. Furthermore, we identified an interaction effect between the semantic category and the semantic 'shape' feature with respect to naming accuracies (behavioural effect), in addition to an interaction effect at the electrophysiological level. Seen within the framework of Levelt's semantic network model, it is possible that with increasing feature overlap between word pairs, there may be an increase in the proximity between their corresponding conceptual nodes.

Regarding the encoding of lexico-syntactic features with multiple grammatically correct options, we found that distractors with dissimilar classifier distributions resulted in a more positive P600-like effect, but no behavioural effect compared to distractor nouns with similar classifier distributions. Based on this result, we propose that, when producing a given bare noun, multiple compatible classifiers are activated simultaneously. This activation of multiple compatible classifiers for a given bare noun is irrespective of whether the classifier(s) is (are) selected. Combining our findings with those of previously published studies, we argue that the di-

chotomous encoding of lexico-syntactic features as is assumed in Levelt's model can (and should) be generalized to the probabilistic encoding of lexico-syntactic features. As such, the model can accommodate both lexico-syntactic features with only one grammatically correct option and lexico-syntactic features having multiple grammatically correct options.

5.1 Implications of the results described in this thesis

Pooling the evidence presented throughout this thesis, we suggest that any cognitive model of word production should accommodate for (1) semantic features, (2) the number of semantic features, and (3) lexico-syntactic features having multiple grammatically correct options.

In **Chapter 2**, we postulated that if we accept Levelt's semantic network model, our findings suggest that it could be possible that conceptual nodes congruent in a given semantic feature (e.g., animacy) might be located closer to each other than conceptual nodes that are incongruent with respect to that semantic feature. Similarly, based on the results of **Chapter 3**, we propose that if we accept the semantic network structure proposed by Levelt and colleagues, with increasing feature overlap between word pairs, the proximity between their corresponding conceptual nodes in the binary semantic network assumed by Levelt's model may increase. We do emphasize that based on the experimental results obtained from these chapters, we cannot make claims about the architecture of the semantic network. In other words, semantic features could influence pre-activation in other ways than proposed by Levelt and colleagues. Lastly, the results described in **Chapter 4** led us to propose a method for extending the encoding of lexico-syntactic features in Levelt's model to accommodate multiple options for a given noun through the incorporation of an empirical lexico-syntactic feature probability distribution, e.g., the Mandarin Chinese classifier probability distribution in this thesis.

Overall, our results show how Levelt's model could be adapted to more accurately describe the process of word production, especially in the context of non-Indo-European languages although the essence of the model remains unchanged by our results

5.2 Looking beyond Levelt's model of language production

For reasons described previously, the results in this thesis have been discussed in the framework of Levelt's model of language production. However, the implications of these findings regarding semantic features and lexico-syntactic features are not only limited to Levelt's model, nor is it limited to models of language production. In this section, we seek to provide an overview of the implications of our findings regarding the representation of semantics and activation of lexico-syntactic features in the context of other models of language production and language comprehension theories.

5.2.1 The implications of the organization of semantic network

With respect to semantics, the organization of the semantic network is thought to include the following two components. First, how the *nodes* in the semantic network are related to semantic representation. Second, how the *connections* between nodes in the semantic network reflect their corresponding semantic relationship. Regarding how meaning is represented in nodes, Levelt's model, as illustrated in Figure 5.1, posits that concepts, such as 'car', are represented as holistic concept nodes. In contrast, various alternative models of language production (e.g., Caramazza, 1997; Dell, 1986, 2013; Dell & O'Seaghdha, 1992; Miozzo & Caramazza, 2003; Oppenheim et al., 2010) and theories of language comprehension (Matheson & Barsalou, 2018) propose that the concept 'car' is represented by a set of corresponding semantic features, such as having an engine, wheels, seats, steering, brakes, and lights (as shown in

Figure 5.2), which can be interpreted as a 'set node'.

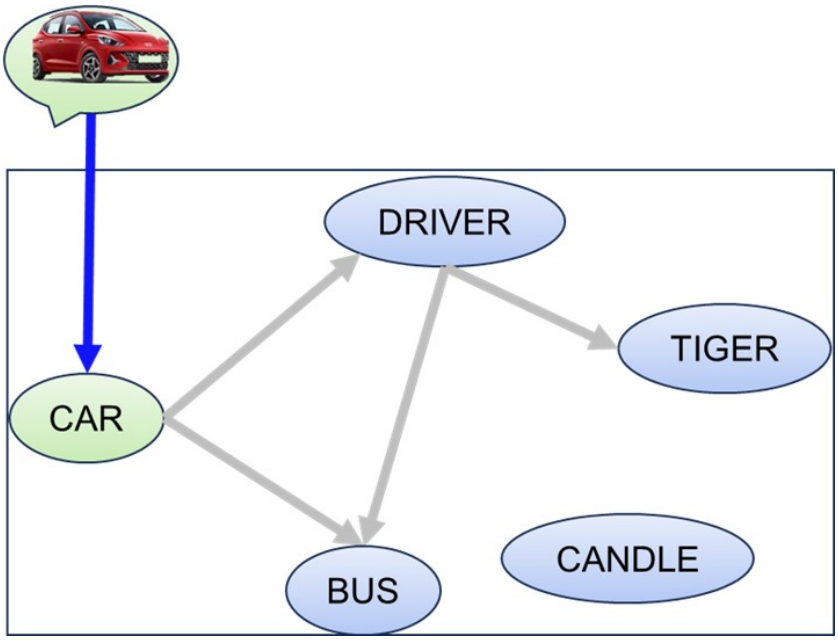

Figure 5.1: The semantic network in Levelt's model.

With respect to how the connections between nodes reflect their semantic relationship, in Levelt's model, as illustrated in Figure 5.1, conceptual nodes that belong to the same semantic category, such as 'car' and 'bus' (or share semantic features, like 'car' and 'drive', see Chapters 2 and 3), are positioned closer together in the semantic network compared to nodes that do not belong to the same category, such as 'car' and 'tiger' (or do not share semantic features, like 'car' and 'tiger'). Conversely, in alternative models of language production (e.g., Caramazza, 1997; Dell, 1986, 2013; Dell & O'Seaghdha, 1992; Miozzo & Caramazza, 2003; Oppenheim et al., 2010) and theories of language comprehension (Matheson & Barsalou, 2018), the strength of the connections between nodes varies. Concepts with more overlapping features, such as 'car' and 'bus', have stronger connections than those with fewer overlapping features, such as 'car' and 'tiger', as shown in Figure 5.2, in the semantic network.

Although the respective assumptions are seemingly quite differ-

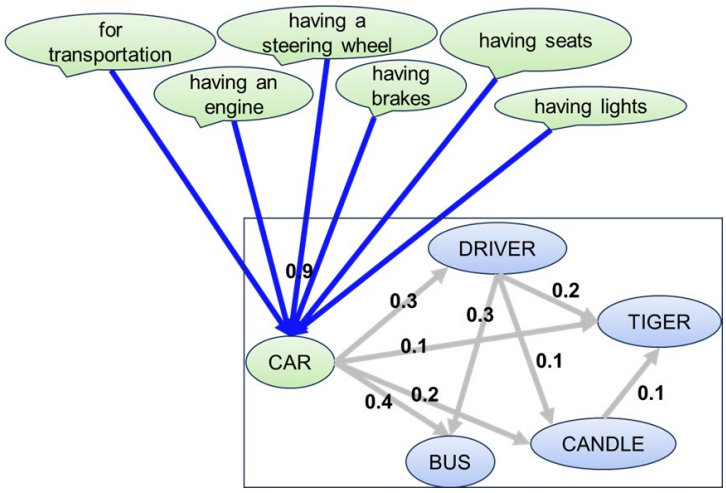

Figure 5.2: The semantic network in alternative models (Caramazza, 1997; Dell, 1986, 2013; Dell & O'Seaghdha, 1992; Miozzo & Caramazza, 2003; Oppenheim et al., 2010) and theories of language comprehension (Matheson & Barsalou, 2018). The number on the arrows refers to the strength of connections between 'set' nodes.

ent, the organization of the semantic network for Levelt's model vs. these alternative models (e.g., Caramazza, 1997; Dell, 1986, 2013; Dell & O'Seaghdha, 1992; Miozzo & Caramazza, 2003; Oppenheim et al., 2010) and theories (Matheson & Barsalou, 2018) are difficult to tease apart experimentally. First, all the models and theories employ the meanings of words as the nodes for constructing the semantic network. Second, they all argue that the semantic relationships are reflected by the connections between nodes in the semantic network, albeit in different ways. Therefore, our conclusions regarding semantic features in **Chapters 2** and **3** in the context of Levelt's model are also consistent with the role of semantic features in these alternative models and theories.

The activation of lexico-syntactic features with multiple grammatically correct options

Considering that the experiments described in this thesis are, to the best of our knowledge, the first to investigate the activation of lexico-syntactic features with multiple grammatically correct options in the context of language production models, no direct comparison with existing literature is possible. However, various studies have explored the mechanism of selecting the final option amongst all compatible options of lexico-syntactic features for a given noun when forming sentences or phrases (Liu et al., 2019; Zhan & Levy, 2018). Given that a classifier must be activated before it can be selected for a given noun according to Levelt's model, two logical possibilities exist during the activation process. Either only the selected classifier is activated (option 1), or multiple compatible classifiers are activated (option 2). Considering that existing studies focused on the selection mechanism, and that this selection process occurs after the activation of classifiers as per Levelt's model, such studies can indirectly provide us with insights regarding the activation of lexico-syntactic features with multiple grammatically correct options.

To elaborate, if only the selected classifier is activated, there must be at least one linguistic factor leading to its activation. To investigate this possibility, Liu et al. (2019) conducted a corpus study to determine whether the semantic categories of a given noun and/or the semantic features that are emphasized by the adjectives preceding the given noun contain enough information to determine the selection of classifiers for the given noun. That is, whether or not the semantic categories of a given noun and/or the semantic features that are emphasized by the adjectives preceding could i) predict the selection of the classifiers for the noun in the corpus and ii) measure the uncertainty of this prediction. They found no overall predictive relationship between the semantic categories and/or semantic features of a given noun and the selection of classifiers for that noun. This indicates that these common linguistic factors (i.e., semantic categories and semantic features of the noun) cannot determine the activation of the selected classifiers. Although

other linguistic factors might lead to the activation of the selected classifiers, there is currently insufficient evidence to support the possibility that only the selected classifier is activated.

Regarding the possibility of multiple compatible classifiers being activated, Zhan & Levy (2018) used the contextual predictability of a noun by the preceding words to define the intended meaning of the noun in a corpus study. Then, they used this calculated contextual predictability as a predictor to model the choice of classifiers in the corpus while controlling word frequency of the noun. They found that in the absence of sufficient contextual information about the noun (i.e., low contextual predictability), the general classifier "个" (/ge4/) is chosen. In other words, the general classifier "个" (/ge4/) is always a possible choice irrespective of the intended meaning of the noun. However, when sufficient contextual information is available, another – more suitable – classifier will be chosen. As such it can be argued that the general classifier "个" (/ge4/) plays the role of a placeholder, always being activated for every noun. However, the general classifier "个" (/ge4/) was not always selected for every noun. Hence, their results align with our own findings and conclusions. Namely, multiple compatible classifiers are activated in word production.

5.3 Limitations and future work

At the level of experimental setting, this thesis has the following limits. First, we only included native Mandarin Chinese speakers residing in the Netherlands, who typically have higher English proficiency compared to those in mainland China. Considering that the first language encoding can be influenced by second language proficiency (Aveledo & Athanasopoulos, 2016), future studies should consider adjusting for or controlling the impact of English on Mandarin Chinese, particularly in the representation of semantic and lexico-syntactic features. Second, our study only focused on Mandarin Chinese, leading the generalizability of our findings to other languages remains uncertain. Thus, future research should investigate the encoding of lexico-syntactic features in other languages,

such as Japanese, to validate the broader applicability of our results. Last, we concentrated on language production at the word level. However, the representation of semantics and lexico-syntactic features is also influenced by the context in which they occur. Future studies should explore these representations at the phrase or sentence level.

Regarding the semantic organization of words, our investigation into the semantic organization of words focused on the role of semantic features within a small-scale semantic network through experimental studies. The results do not allow for conclusions about how (using what cognitive architecture) meaning is represented. Computational modelling studies can shed more light on this issue.