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Accessing Words from the Mental Lexicon

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Abstract and Keywords

This chapter describes how speakers access words from the mental lexicon. Lexical access is a crucial component in the process of transforming thoughts into speech. Some theories consider lexical access to be strictly serial and discrete, while others view this process as being cascading or even interactive, i.e. the different sub-levels influence each other. We discuss some of the evidence in favour and against these viewpoints, and also present arguments regarding the ongoing debate on how words are selected for production. Another important issue concerns the access to morphologically complex words such as derived and inflected words, as well as compounds. Are these accessed as whole entities from the mental lexicon or are the parts assembled online? This chapter tries to provide an answer to that question as well.

Keywords: mental lexicon, speech production, lexical access, discrete processing, serial processing, cascading processing, interactive processing, morphologically complex words, compounds, online assembly

1 Speech Production Mechanisms

Producing speech is a seemingly automatic process. We produce speech at a rate of 4–6 syllables per second. On average, words in Germanic languages such as Dutch or English are less than 1.5 syllables in length, which means that speakers of these languages utter about 3–4 words per second (not taking pauses into account). Even a conservative estimate of 3 words per second amounts to more than 5,000 words in a half-hour conversation (something which is not usually considered to be a complicated activity). In reality, however, speaking is one of the most complex forms of skilled serial behaviour, involving the planning of numerous processes (Lashley 1951). To produce speech, we need to translate our intentions into articulatory motor actions in order to set air molecules in motion so that our interlocutors can decode these vibrations into semantic content. There are about 40 muscles involved in movements of the speech apparatus (MacNeilage 2008). These muscles are orchestrated in a fine-grained way, and subtle changes in the positioning of the articulators can have tremendous effects on the auditory perception of the speech signal. MacNeilage (2008) estimates that each second of speech involves about 225 different muscle activations, i.e. one muscle event every 5 milliseconds.

In the last decades, comprehensive models of language production have been developed which describe the details of the speech production process (e.g. Bock and Levelt 1994; Caramazza 1997; Dell 1986; Fromkin 1971; Garrett 1975, 1980; Levelt 1989; Levelt et al. 1999). Among other processes, speaking comprises the encoding of meaning, the selection of words, the retrieval of syntactic features, and the encoding of phonological and phonetic form (for a detailed but concise overview see Griffin and Ferreira 2006). Models of speech production so far cover mostly single-word or single-utterance production, whereas in real conversations speakers construct narratives and engage in dialogues.

Researchers exploring language production generally agree that the encoding of meaning, including conceptual-semantic processing, precedes the encoding of form, including phonological-phonetic processing (or phonological encoding; see Schiller 2006). It is fair to say that there is as yet little agreement regarding the precise flow of information within the speech production system. Some models assume that information flows in a temporally strictly serial (or discrete) manner from conceptual preparation to the initiation of articulation (Bloem and La Heij 2003; Butterworth 1989; Garrett 1980; 1988; Levelt 1989; 1999; 2001; Levelt et al. 1999). More precisely, while semantic concepts activate many lexical candidates, only a single candidate is selected and further encoded at the phonological level (but see Roelofs 2008, who demonstrates that under certain task conditions a limited amount of cascading activation can be observed). The selection of that candidate, i.e. the target lexical item, is dictated by the intention of the speaker.

This process is generally assumed to be *competitive*, i.e. alternative candidates compete for selection. If more candidates are activated (especially when the activation levels of other candidates are high), lexical selection will take longer compared to when there are few competitors (or when competitors' activation is low). The intended candidate will typically have the highest level of activation at a particular point in time, and will therefore be selected. The empirical workhorse for testing the claim of lexical selection by competition has been the Picture–Word Interference paradigm (henceforth PWI; a variant of the Stroop task). In this paradigm, to-be-named pictures are accompanied by superimposed or auditorily presented distractor words (Glaser 1992; Glaser and Düngelhoff 1984; Glaser and Glaser 1989; Posnansky and Rayner 1977; Rosinski et al. 1975). When distractor words are of the same semantic category (picture: BED, distractor: table), it usually takes longer than when they are not (distractor: apple).

Recently, the process of competitive lexical selection has been challenged by an alternative account called the Response Exclusion Hypothesis (REH; Mahon et al. 2007). The REH states that lexical selection does not depend on the number and activation of potential competitors, and that spreading of activation only has a facilitative effect. Instead, selection takes place at a later (post-lexical) stage, namely the stage where production-ready representations enter an output buffer in which they will reside, ready to be pronounced. In the PWI paradigm, the distractor words are assumed to have access to this buffer prior to the picture, and need to be removed before the picture's name can be pronounced. The response buffer is believed to also contain a basic semantic mechanism, which can detect whether or not a distractor word is a suitable response in a particular setting (i.e. the verb 'sleep' is not a suitable response when the task is naming an object but not the action, e.g. 'bed').

Mahon et al. (2007) observed facilitation for the 'bed–sleep' combination, which they attribute to the spreading of activation arising from the activation of these multiple semantic items (bed, sleep) and 'sleep' was not a suitable candidate for production. In contrast, if the distractor were 'table', it would be suitable (or 'response-relevant' in REH terms) when the task is object naming and hence would have an extended stay in the buffer, which would have resulted in a longer naming latency for the 'bed–table' combination. The claims of the REH sparked an intense discussion (e.g. Abdel Rahman and Melinger 2009; Mahon et al. 2012; Spalek et al. 2013; Starreveld et al. 2013) on whether or not lexical selection is by competition (a matter still under debate).

As stated earlier, some models are called *discrete* because they make the claim that the stages of word retrieval or lexical access are operating in strict temporal succession. In contrast, another class of models assumes that the temporal relationship between the stages in speech production is not discrete. Instead, these models assume that processing proceeds in *cascade* or is even *interactive* (Caramaza 1997; Dell 1986; 1988; Humphreys et al. 1988; MacKay 1987; Stemberger 1985). According to cascading and interactive models of lexical access, all lexical candidates activate their phonological forms before any single candidate has been selected as the target item. These models are called *cascaded* or *interactive* because activation of lexical items cascades from higher levels (lexical-semantic) to lower levels (phonological-phonetic), and processing at lower later levels can start as early as possible. Let us illustrate serial and cascaded models of lexical access by using the example of naming the picture of an animal, i.e. a *cow*.

According to discrete theories of lexical access, the picture of a *cow* will activate the concept COW as well as many other concepts belonging to the same category such as *donkey, horse, pig*, etc. via the spreading of activation of a category node (FARM) ANIMAL. Activated concepts automatically activate their corresponding lexical entries—or *lemmas*, in Levelt's terminology. However, following Levelt et al. (1999), 'only selected lemmas will become phonologically activated' because 'it would appear counterproductive to activate the word forms of all active lemmas that are not selected' since 'their activation can only interfere with the morphophonological encoding of the target' (p. 15). Therefore, discrete theories of lexical access predict that the names of category members of the picture, i.e. *donkey, horse, pig*, etc., are not phonologically encoded since they are not selected for production.

Evidence from speech errors (e.g. Garrett 1975; 1980), tip-of-the-tongue states (e.g. Brown and McNeill 1966; Vigliocco et al. 1997), aphasic speakers (Goodglass et al. 1976), and electrophysiological measures (Schmitt et al. 2000; Van Turennout et al. 1997) suggested that lexical-semantic processing generally precedes phonological processing in language production. Here, we will restrict ourselves to discussing behavioural data from studies employing speeded naming paradigms. Probably the best-known empirical evidence for discrete lexical processing is the study by Levelt and collaborators from 1991. In the sixth experiment of this study, participants were asked to name a series of pictures. In about one-third of the trials, an auditory stimulus (a word or a non-word) was presented 73 ms after picture onset. In these cases, participants were requested not to name the picture but to make a lexical decision to the auditory stimulus by pressing one of two buttons. When the stimulus was a word, it belonged to one of the four conditions: identical, semantic, phonological, or unrelated. For instance, when a desk was depicted, the auditory word was *bureau* ('desk') in the identical condition, *stoel* ('chair') in the semantic condition, *stoep* ('pavement') in the phonological condition, and *muts* ('cap') in the unrelated condition. In a previous experiment, a word that was phonologically related (e.g. *buurman* 'neighbour') to the picture (e.g. *bureau* 'desk') yielded a strong phonological facilitation effect in lexical decision, demonstrating the phonological activation of the picture name *bureau*. The phonological condition in the current experiment, however, included a word (i.e. *stoep* 'pavement') that was phonologically related to a semantic alternative, namely *stoel* ('chair'). If semantic alternatives such as *stoel* ('chair') become phonologically activated when seeing *bureau* ('desk'), a phonologically related word like *stoep* should exhibit an effect on lexical decision latencies. The results, however, showed that for words in the phonological condition there was no effect, while there was an effect for the identical and semantic conditions, demonstrating that semantic alternatives were at least partially activated. Levelt et al. (1991) argued on the basis of their results that non-selected semantic alternatives are not phonologically encoded in language production, supporting the discrete processing view.

More evidence in favour of discrete lexical access comes from a seminal study by Schriefers et al. (1990). They asked participants to name a set of pictures (e.g. *bureau* 'desk') and presented auditory distractors at three different stimulus onset asynchronies (SOAs): 150 ms before picture onset (–150 ms), simultaneous with picture onset (0 ms), and 150 ms after picture onset (+150 ms). Semantically related distractors (e.g. *stoel* 'chair') slowed down the naming process relative to an unrelated distractor (e.g. *fles* 'bottle') only at the earliest SOA, while phonologically related distractors (e.g. *buurman* 'neighbour') facilitated picture naming at SOAs 0 ms and +150 ms, but not at the early SOA of –150 ms. The fact that semantic distractors had an effect early in processing whereas phonological distractors exerted a late effect supported the general notion that semantic processing preceded phonological processing (but see Jescheniak and Schriefers 2001 as well as Starreveld 2000 for early phonological effects). However, more important here is the fact that semantic and phonological effects *did not overlap in time*, suggesting that lexical-semantic processing has to be completed before phonological processing can start (but see Damian and Martin 1999, who found overlapping semantic and phonological effects). The findings of Schriefers et al. have been taken to support discrete models, in which lexical access proceeds in two serially ordered stages —retrieval of lexical-semantic representations and retrieval of phonological word forms—which do not affect each other.

The claim about strict temporal seriality between semantic and phonological activation has not remained unquestioned. In contrast to serial theories of lexical access, cascaded theories predict phonological encoding of *cow* as well as of all the category members, i.e. *donkey, horse, pig*, etc. The reason is that there is no principled boundary for the spreading of activation. According to cascaded models, once the lexical level has been activated, there is no principled reason to prevent activation from spreading further to phonological forms of words.

For instance, Dell and O'Seaghdha (1991; 1992) argued that the methodology of Levelt et al. (1991) was not sensitive enough to pick up the phonological activation of multiple lexical candidates because semantic alternatives (e.g. *stoel* 'chair') will only receive a fraction of the activation that the target (e.g. *bureau* 'desk') receives. A word like *stoep* ('pavement'), which is phonologically related to the alternative, *stoel*, will receive even less activation. Therefore, the effect of a mediated prime like *stoep* for *bureau* might be difficult to detect.

To enhance the phonological activation of alternative lexical candidates, Peterson and Savoy (1998) investigated near-synonyms. More specifically, they presented a set of pictures and asked participants to name them. On half of the trials, a word appeared in the middle of the picture after a variable SOA. On these trials, participants were asked not to name the picture, but instead to read aloud the word. Twenty of these word-naming trials occurred with ambiguous pictures, i.e. pictures for which participants reliably use two different names. An example of would be COUCH, for which on average in 84 per cent of the cases the dominant name *couch* is used while the secondary name *sofa* occurred on average in 16 per cent of the cases. The words were either phonologically related to the dominant name (e.g. *count*—COUCH) or to the secondary name (e.g. *soda*—SOFA) or unrelated (e.g. *horse*). The question Peterson and Savoy (1998) were asking was whether or not a priming effect could be obtained for words that were phonologically related to the secondary meaning (e.g. *soda*). Note that discrete and cascaded models of lexical access make different predictions here. Discrete models predict phonological priming only for dominant-related words (e.g. *count*) because most participants would select the dominant name (e.g. *couch*) on most trials. Since non-selected lexical items never become phonologically encoded, no effect for *soda* is predicted. Cascaded models, however, predict priming for both types of word, since even lexical candidates that are ultimately not selected do get phonologically activated. Results showed robust phonological priming effects for both dominant-related and secondary-related words, suggesting that during the lexicalization of a picture, lexical candidates that correspond to the picture's dominant and secondary meaning become activated up to the phonological level.

In a similar study, Jescheniak and Schriefers (1998) replicated the findings by Peterson and Savoy (1998) with a different methodology in German. In their study, again pictures were presented some of which are ambiguous in German (e.g. *Schäfer–Hirte*; both meaning 'shepherd') together with auditory distractor words that were phonologically related to the dominant name of the picture (e.g. *Schädel* 'skull') or the secondary name of the picture (e.g. *Hirn* 'brain'). Their results revealed reliable effects, i.e. faster picture-naming latencies, from both types of phonologically related distractor in the picture–word interference task, and supported cascaded processing but not discrete models of lexical access. Levelt et al. (1999) accommodated Peterson and Savoy (1998) as well as Jescheniak and Schriefers (1998) by suggesting that under certain circumstances, multiple appropriate lexical candidates might be selected and phonologically encoded. Near-synonyms such as *couch* and *sofa* would be one such case, sub- and superordinates such as *rose* and *flower* might be another under certain circumstances.

Cutting and Ferreira (1999) also made an attempt to distinguish discrete and cascaded models by using homophone pictures such as BALL. A ball could be a sport utility (ball_{toy}) or a formal dancing event ($\text{ball}_{\text{social event}}$), i.e. two different meanings with maximal phonological overlap. Shortly before the onset of a picture (SOA –150 ms), participants were presented with auditory distractor words that were related to the depicted meaning (e.g. *game*–ball_{toy}) or the non-depicted meaning of the homophone (e.g. *dance*–$\text{ball}_{\text{social event}}$), or unrelated (e.g. *hammer*). Cutting and Ferreira's (1999) question was whether the picture of a toy ball would be named faster in the presence of a distractor word that is related to the non-depicted meaning of the homophonic picture (i.e. 'dance' related to [dance] ball) than in the unrelated condition. Moreover, would naming the same picture at the same SOA be slower in the presence of a distractor word that is related to the depicted meaning (i.e. 'frisbee' related to [toy] ball) compared to the unrelated condition? Their reasoning was that if phonological effects were observed at the same time as semantic effects, this would be evidence for semantic and phonological processing having different time courses, and a discrete model would be supported. If, on the other hand, phonologically related distractors do affect picture naming at the same time as semantically related distractors, that would be evidence for an overlapping time course of semantic and phonological processing implying cascading processing.

Results revealed that distractors that were related to the non-depicted meaning of the homophonic target picture name facilitated naming relative to the unrelated condition. At the same SOA, semantic interference effects (e.g. *frisbee*–ball_{toy}) were found. Presumably, the distractors that were related to the non-depicted meaning (e.g. *dance*) activated a cohort of meaning-related word forms (including $\text{ball}_{\text{social event}}$), which activated their corresponding lexical representations. These lexical representations in turn activated their corresponding word forms. That way the homophonic word form *ball* receives activation from two sources, i.e. from the selected ball_{toy} and the non-selected $\text{ball}_{\text{social event}}$. Cutting and Ferreira (1999) argued that phonological processing could be affected by semantically processed stimuli even though these stimuli are not semantically similar to the target. The phonological and semantic processing of non-target lexical items under the same timing conditions suggests that semantic and phonological processes operate with overlapping time courses, supporting cascaded models of lexical access. Levelt et al. (1999) suggested an alternative explanation: the distractor word *dance* may co-activate its associate ball$_{\text{social event}}$ semantically and phonologically in the perceptual network. The word form *ball* in the perceptual network could then directly pre-activate its corresponding word form in the production network, leading to faster naming latencies of the picture of a ball$_{\text{toy}}$.

Using a picture–picture interference paradigm, Morsella and Miozzo (2002) provided more evidence demonstrating that semantically irrelevant stimuli get phonologically encoded. Participants in their study were shown two pictures overlapping each other, one in green and one in red, and were asked to name the green pictures as fast and as accurately as possible. Pictures' names were either unrelated (e.g. BED$_{\text{green}}$–HAT$_{\text{red}}$) or phonologically related (e.g. BED$_{\text{green}}$–BELL$_{\text{red}}$). Results showed significantly faster naming latencies for the related than for the unrelated pairs in English, but not in Italian, where exactly the same picture pairings were used without the pictures' names being phonologically related. The authors argue that their finding can best be accounted for by cascaded models of lexical access which hold that unselected lexical nodes, i.e. the red distractor picture, activate their phonological representations. Thus, BELL may activate its phonological representation including the segments /b/, /ɛ/, /l/. When the target BED gets phonologically encoded, some of its segments, i.e. /b/ and /ɛ/, were already activated by the distractor and therefore their selection is facilitated, leading ultimately to faster production of the target word. On the whole, their data can be accommodated by cascaded models of lexical access but not by discrete models, which do not assume phonological activation of non-selected candidates. However, one may argue that speakers activate all visible picture names, i.e. the green as well as the red in this case, even though they were only required to name the green object, and that when there was phonological overlap between the picture names, naming times became faster. Navarrete and Costa (2005) replicated and extended the findings of Morsella and Miozzo (2002) in Spanish (but see e.g. Jescheniak et al. 2009 for a failure to replicate Morsella and Miozzo's results).

This overview showed that there is empirical evidence for both positions, i.e. the discrete and the cascaded/interactive theory of lexical access. In fact, these two positions are heavily debated in the literature. What has become clear is that the extreme positions are no longer tenable—instead, propositions such as *limited cascading* have been made (e.g. Roelofs 2008).

2 Accessing Morphologically Complex Forms

In this section, we discuss lexical access and encoding of morphologically complex words. Morphologically complex (as opposed to simplex) words are word forms that consist of more than one meaningful sub-unit, i.e. morpheme (see Booij this volume). Morphologically complex forms can be inflected, derived, or compounded word forms. Inflected forms (e.g. *walks, walked, walking*) belong to the same syntactic word class, while derived forms belong to different syntactic word classes, such as *walker* (a noun derived from the verb *to walk*; someone who walks) or *walkable* (an adjective; something that can be walked).

Compounds are combinations of free morphemes with internal structure. One morpheme determines the compound's syntactic category and usually its semantic class (the so-called *head*: Di Sciullo and Williams 1987; Selkirk 1982). Compounding is in principle a recursive mechanism, i.e. compounded words can be used to create another compound. For example, *snowball* (SNOW + BALL) can be concatenated with FIGHT to form *snowball fight*. Semantically transparent compounds such as *snowball fight* are usually distinguished from semantically opaque compounds, which are not related to the meaning of their constituting morphemes (e.g. *deadline keeping*: Sandra 1990; Zwitserlood 1994).

2.1 Representation of Complex Words

We will discuss how complex word forms are represented in the lexicon and how they are encoded in the process of speech production. For instance, are morphologically complex words represented individually? Full-listing models have made such claims (e.g. Butterworth 1983; 1989). However, agglutinative languages such as Hungarian, where syntactic or semantic functions are expressed by highly productive affixes added to the root morpheme, make full-listing models rather implausible (see Waksler 2000 for additional evidence against full-listing models). Decompositional models suggesting a morpheme-by-morpheme construction, on the other hand, may not be able to account for the experimental evidence alone, either. Instead, a dual-route model including both mechanisms may be favoured (Frauenfelder and Schreuder 1992).

Separate access of morphemes is suggestive of decomposed preparation of compound words (Caramazza et al. 1988; Levelt et al. 1999; Taft and Forster 1976). That is, compounds do not have to be stored and accessed as whole units. This conception is in accordance with linear frequency effects of the constituents but not of the whole compound; higher constituent frequency is associated with shorter naming latencies (e.g. Bien et al. 2005; but see Janssen et al. 2008 for contrasting results in Chinese and English).

The error analysis of aphasic patients' compound production also supports the decompositional view. Misproductions were found to be morpheme-based, i.e. errors such as constituent substitutions decreased with decreasing transparency and increasing frequency of the constituting morphemes (Blanken 2000; see also Badecker 2001; Hittmair-Delazer et al. 1994; but see Bi et al. 2007). Furthermore, some dysgraphic patients show morphological boundary effects in their spelling behaviour (Schiller et al. 2001).

2.2 Processing of Complex Words

There is considerable evidence that morphological structure plays a role in speech production planning (Roelofs 1996; 1998; Zwitserlood 2000). However, Waksler's (2000: 227) statement, that '[w]ords with multiple affixes, different morphological types of affixes, and most of the different affixation processes used in languages have yet to be systematically examined in the production domain', is still true after more than a decade.

The production of words is assumed to be prepared serially. There is much evidence suggesting that phonemes and other phonological components of words are encoded incrementally, from beginning to end (e.g. Meyer 1990; 1991; Schiller 2005; 2006; Wheeldon and Levelt 1995). It has also been suggested that morphologically complex words are prepared incrementally from left to right (Roelofs 1996; Roelofs and Baayen 2002). For instance, Roelofs (1996) compared production latencies of sets of words that were homogeneous regarding their initial syllable (e.g. *bijbel, bijna, bijster*; 'bible', 'almost', 'loss') with sets of words that were heterogeneous (e.g. *bijbel, hersens, nader*; 'bible', 'brain', 'further'). Phonological overlap resulted in a facilitation of 30 ms in homogeneous sets. However, if the initial syllables also constituted morphemes (e.g. BIJ in *bijvak, bijrol, bijnier*; 'subsidiary subject', 'supporting role', 'kidney'), the facilitation was significantly larger; homogeneous sets were now produced 74 ms faster than heterogeneous ones. In contrast, non-initial morphemes in homogeneous sets (e.g. BOOM in *stamboom, spoorboom, hefboom*; 'pedigree', 'barrier', 'lever') did not lead to a significant preparation effect. Roelofs (1996) concluded that morphemes are planning units in the production process, and that language production proceeds incrementally from left to right.

Speech errors sometimes include inflectional and derivational morphemes, e.g. *he liked I would hope you* instead of *he hoped I would like you* or *groupment* instead of *grouping*. There is evidence suggesting that inflectional suffixes, e.g. -*ed*, pattern differently in errors than non-morphemic word endings, supporting a morphological interpretation of inflectional errors (Bybee and Slobin 1982). The existence of naturally occurring derivational errors may be taken as support that roots and derivational affixes are stored separately (Fromkin 1973). In an experimental study, Pillon (1998) reported significantly more stranding errors for morphologically complex words than for monomorphemic control words. However, Pillon did not control for semantic relatedness between the target and error. Therefore, more 'morphological' errors could have occurred for morphologically complex words (such as *troupeau traînard ® traîneau troupard*) than for monomorphemic words (such as *cadeau bâtard ® bâteau cadard*) due to the additional semantic relatedness in the former words. Melinger (2003) compared laboratory-induced errors between English prefixed words derived from free stems involving a high degree of semantic relatedness (e.g. *reload–unload*) with words derived from bound roots involving a low degree of semantic relatedness (e.g. *induce–reduce*). She observed more errors in naming prefixed words than control words and, most importantly, no difference in the distribution of errors between free-stem and bound-root prefixed words. Her results demonstrate that morphological errors are more frequent than phonological errors in laboratory-induced paradigms, and that there is no correlation between semantic relatedness ratings and error frequency. These data suggest that morphemes are processed as units by the speech production system, and that the lexical representation of words must include information about their morphological structure.

Zwitserlood et al. (2000) investigated morphological effects in language production by comparing the standard, immediate picture–word interference paradigm with a delayed variant. In the delayed variant, the prime word is read aloud and precedes the overtly named target picture by 7–10 trials. That is, in any trial only one stimulus is presented to the participant; consequently, effects during picture naming are not conflated with the reading of prime words.

Importantly, in the delayed paradigm, picture naming was facilitated by some 30 ms when a morphologically related complex prime word preceded the picture by 7–10 trials (Zwitserlood et al. 2000; see also Feldman 2000). This facilitation could not be explained by semantic or phonological form overlap between prime words and target pictures. When the same pictures were paired with semantic or phonological primes, inhibition and facilitation effects, respectively, were observed in the immediate but not in the delayed variant of the paradigm (Zwitserlood et al. 2000). That is, in contrast to morphological effects, semantic and phonological effects are suggested to be short-lived and not effective after seven or more intervening trials. Subsequent experiments suggested that similar facilitation effects result from a morphological relation of the picture name with derivations and compounds irrespective of the position or the related morpheme (prefix vs. suffix; initial vs. head constituent; Zwitserlood et al. 2002). It was proposed that the facilitation effects arise at the word form level where the morphologically complex words and the pictures activate the same word form representation, whereas the respective representations are distinct at the conceptual and lemma level (Zwitserlood et al. 2000; 2002; Zwitserlood 2004).

Dohmes et al. (2004) compared picture-naming latencies in two sets of German items using the delayed variant of the picture–word interference paradigm (long-lag priming paradigm: Zwitserlood et al. 2000; Feldman 2000). In the first set, picture names (e.g. *Ente* 'duck') were primed by either a semantically transparent or opaque compound (e.g. *Wildente* 'wild duck', and *Zeitungsente,* lit. 'newspaper duck', 'false report'). In the second set, prime words corresponded to semantically transparent compounds (e.g. *Buschrose* 'bush rose') or contained the complete picture name (e.g. *Rose* 'rose') only formally (e.g. *Neurose*, 'neurosis'). In each set, the priming effects were measured relative to an unrelated condition and picture naming latencies were facilitated by about 30–40 ms only for the morphologically primed conditions, but independent of the transparency status (i.e. transparent or opaque).

Koester and Schiller (2008; 201) replicated Dohmes et al. (2004) in Dutch. Target picture names (e.g. *ekster* 'magpie') were primed by semantically transparent or opaque compounds (e.g. *eksternest* 'magpie nest'; *eksteroog*, lit. 'magpie eye', 'corn/induration of the skin'); a different set of targets (e.g. *jas* 'coat') was primed by semantically transparent compounds (e.g. *jaszak* 'coat pocket') or form-related words containing the complete picture name without being a morpheme (e.g. *jasmijn* 'jasmine'). Compound-picture pairs were selected such that picture names and primes overlapped either in the first or the second morpheme. In a long-lag priming paradigm using the same timing parameters as in Dohmes et al. (2004), significant morphological priming effects of about 30 ms were obtained for both transparent and opaque primes but not for form-related words. Furthermore, there was no statistical difference between transparent and opaque primes.

Koester and Schiller (2008; 201) argue that their effects cannot be explained by the semantic or phonological relationship between primes and targets because semantic and phonological effects do not survive the distance between prime and target in a long-lag priming paradigm (Feldman 2000; Zwitserlood et al. 2000). The effects are therefore suggested to be due to the morphological relation between prime and target.

Morphological priming effects are extremely robust, even surviving a language switch (Verdonschot et al. 2012). For instance, reading aloud the Dutch compound *tongzoen* ('French kiss') or *landtong* ('finger of land') facilitated the naming of a picture of a *tongue*, even after 7–10 intervening naming trials and even when those intervening trials were in a different language (English in this case). In fact, there was no statistical difference in the magnitude of the effect for intervening trials in the same language as the target or in a different language. Even more recently, Kaczer et al. (in preparation) demonstrated that the priming effect still holds when novel compounds were produced, e.g. *Appelgezicht* ('apple face'), for naming a target picture of an *apple*. The priming effect for the novel compounds was even stronger than for existing compounds, such as *Appelmoes* ('apple sauce'). This was presumably because participants focused even more on the separate constituents than in the case of existing compounds. In a second session, this difference between novel and existing compounds disappeared, presumably because the novel compounds were no longer novel to the participants. However, both novel and existing compounds still yielded a morphological priming effect when compared to unrelated compounds. The ERPs reflected those morphological priming effects in the second session, but were less clear in the first session (Kaczer et al., in preparation).

Others have denied a psycholinguistic basis for morphological representations. Rather, morphological effects are supposed to emerge as the result of semantic and word-form processing as well as from their interaction (Joanisse and Seidenberg 1999; 2005; Plaut and Gonnerman 2000). However, if semantic processes influenced the facilitation effects reported by Koester and Schiller (2008; 201), semantic transparency should have resulted in a difference between transparent and opaque conditions. Specifically, one would expect increased RTs for the production of picture names (e.g. *ekster* 'magpie') primed by transparent (e.g. *eksternest* 'magpie nest') relative to opaque compounds (e.g. *eksteroog* 'corn') due to lexical competition (Glaser and Glaser 1989; Levelt et al. 1999). Importantly, the absence of a difference between the transparent and opaque conditions cannot be explained by a putative phonological effect that overshadowed the semantic one because the transparent and opaque conditions did not differ with regard to their phonological overlap with the picture names. Similarly, if phonological processes influenced the observed effects, form overlap should have resulted in significant facilitation. However, facilitation for naming a target picture (e.g. *jas* 'coat') was only found for morphologically related primes (e.g. *jaszak* 'coat pocket'). In other words, the absence of an effect for mere form-related primes (e.g. *jasmijn* 'jasmine') suggests that the effect for morphologically related primes is not due to phonological overlap because the phonological overlap was the same in both conditions. Moreover, together with the absence of a semantic influence, the semantic relation with the target picture name cannot account for the facilitation for morphologically related primes. Rather, it is suggested that the effects are due to the morphological relation between primes and targets, and that these relations are explicitly represented in the mental lexicon (Badecker 2001; Zwitserlood et al. 2000). Thus, the results from the long-lag priming paradigm in German (Dohmes et al. 2004; Zwitserlood et al. 2000; 2002) and Dutch (Kaczer et al., in preparation; Koester and Schiller 2008; 201; Verdonschot et al. 2012) are consistent with the conception of morphology as being independent of semantics (Aronoff 1994; but see Marslen-Wilson et al. 1994). These findings support decompositional models of (compound) word production. The effect of a morphological relation between compound constituents and picture names suggests that the morphemes are available to the parser and may be planning units in language production (Roelofs 1996; Roelofs and Baayen 2002). Morphologically complex words, at least compounds, do not seem to be stored and prepared as whole-word forms. That is, a full-listing account (e.g. Butterworth 1983) is incompatible whereas full-parsing and dual-route models are compatible with the present data (Badecker 2001; Bien et al. 2005; Blanken 2000; Levelt et al. 1999; Stemberger and MacWhinney 1986; Taft 2004).

3 Conclusion

In this chapter we have discussed the way in which words are accessed in our mental lexicon. We have reviewed evidence in favour of discrete models of lexical access as well as cascaded/interactive models, including the response exclusion hypothesis. At the moment, it seems that limited cascading of activation can best account for the experimental findings. We further discussed the lexical representation of, and access to, morphologically complex words. We have seen that a full-form representation of complex words yields many problems. Rather, it seems that we store complex words in terms of their constituting morphemes, and that the morphological relations between words are particularly strong, even surviving a switch to a different language.

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