Parallel activation of different word forms – investigation of speech production by means of associates

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Content

1 Introduction

Speaking seems to be one of the easiest and most natural human capabilities. In Germanic languages, three to four words can be spoken in one second, this means a rate of more than five thousand words in a half hour conversation. A more detailed view on the phenomenon of speaking shows that the task is not as easy as it seems. Children have to undergo a long learning process acquiring their mother tongue. While they are able to produce the first meaningful words usually at the age of eight to 18 month, they start uttering more complex structures like sentences only at the age of three and a half years. That the process is sometimes complicated even for adult speakers can be seen in the various kinds of errors that are produced while speaking. Errors occur, because speech production involves several stages of encoding, in order to transform intentions into articulatory motor actions.

Speech production has been investigated with various approaches in the last centuries. The first corpora of speech errors were already collected at the end of the 19th century (e.g. Meringer & Mayer, 1895). The first experimental paradigms to investigate the processes during speech production were invented in the first half of the 20th century (e.g. Stroop, 1935). After a period of analysing speech errors and several experimental studies, the first models of speech production were developed (e.g. Fromkin, 1971; Garrett, 1975; Dell, 1986). On the basis of these models and other influential studies (e.g. Bock, 1982; Kempen & Hoenkamp, 1987) the most accepted model was introduced by Levelt in 1989. While there is strong agreement on the overall structure of this model, some details have been discussed over the intervening years and are still disputed in recent investigations. The stages of lexical access are an important topic of the discussion.

Three models containing different assumptions on lexical access are presented in this dissertation, the *discrete two-stage model* (e.g. Levelt, Roelofs & Meyer, 1999), the *cascading model* (e.g. Humphreys, Riddoch & Quinlan, 1988) and the *interactive feedback model* (e.g. Dell, 1986). By means of a series of twelve experimental studies a contribution to the recent discussion on the different assumptions of these models is made.

Based on the *picture-word interference paradigm* (e.g. Lupker, 1979), a new method for experimental investigation is introduced. *Associate naming* is a task using mediated priming such that participants are confronted with a picture of a common object and an interfering stimulus, related to the picture, while they are asked to name a word associated to the picture name. This task is constructed in order to collect data about the encoding of words that are not the target responses in the experiment. Evidence for phonological activation of these words can help to differentiate between the models under consideration.

Chapter 2 provides a historical review on the development of the investigation of speech production in the first paragraph. Error analysis (e.g. Fromkin, 1971) and the picture-word interference paradigm (e.g. Lupker, 1979) are introduced as the main methods of this research area. A wide variation of distractor words was used in the experimental studies so far. The second paragraph will give an overview of some studies that yielded results implemented into the actual models of speech production, by using different kinds of interfering stimuli. A description of the main structure of one of the most accepted speech production models (Levelt, 1989) completes chapter 2.

The assumptions of the most important models of lexical access are introduced in chapter 3. First, a more detailed view on the distinctive stages in the discrete two-stage model (e.g. Levelt, Roelofs & Meyer, 1999) is given. Secondly, *spreading-activation models* are presented. As a first representative of these models, the cascading theory is described. Besides the different assumptions concerning the spreading of activation between the stages of lexical access, the cascading model of Humphreys, Riddoch and Quinlan (1988) contains different rules for lemma selection compared to the discrete two-stage model. So, the second paragraph includes a short overview of the *theory of lateral inhibition* (e.g. Berg & Schade, 1992). The interactive feedback model is topic of the following section. Chapter 3 is concluded with a description of a mental model (Kintsch, 1998), in order to present a theory that is dealing with the mental representation of semantically related concepts including associates.

In chapter 4 a summary of some recent studies reported in the literature is offered. The results of these studies usually support one of the three models under consideration. Different techniques of mediated priming are applied in the experiments described in the first section. The concept of the experimental studies using the associate naming task is derived from these techniques. In the final section of chapter 4 the ideas and assumptions underlying the series of experiments, reported in chapter 5, are introduced.

Chapter 5 contains the description of twelve experimental studies conducted in the scope of this dissertation. A study using the associate naming task is always preceded by a common picture-word interference experiment, in order to control the material, which is used in the experiment conducted with the new method. One paragraph includes the description of one pair of experiments each. Section one reports experiments that are carried out with distractor words related to the picture name. The phonologically related stimuli are begin-related in the first two experiments. The experiments described in section two use phonologically end-related distractors. The next section contains a description of two experiments using distractor words that are related to the target associate, instead of the picture name. While the interfering stimuli are presented visually in the first experiments, auditory presentation is chosen for a replication of the first four experiments, reported in the next two paragraphs. Finally, the phonologically related distractors are mixed up to letter strings without obvious meaning in the next two experiments that are topic of the last paragraph of chapter 5.

While a short discussion of the obtained results is included into the description of each experiment, the conclusions that can be drawn from the combination of all results are presented in chapter 6. By comparing the results of the experimental studies with the assumptions of the models introduced in chapter 3, the recent discussion of the different theories of lexical access is continued. Open questions and possibilities for their clarification are addressed in chapter 6, too.

Chapter 7 concludes this dissertation with a brief summary and an estimation of the relevance of the presented material on the scientific discussion of the processes of lexical access.

2 Experiments and methods

The investigation of speech production is basically founded in two different approaches. The analysis of speech errors led to the first ideas of how speech is encoded in the human brain, based on data that were collected in situations in which speech was used “naturally” and “intuitively”. With the picture-word interference paradigm, a method was developed that enabled the researchers to collect speech data in an experimental way.

The first part of this chapter gives a historical overview of the earliest results of experimental investigation and error analysis. Ideas about speech production derived from the analysis of speech errors by Fromkin (1971) and Garrett (1975 and 1988) are treated in this section, as well as the development of the picture-word interference paradigm, established by Lupker (1979) and Glaser and Düngelhoff (1984) based on the color naming task used by Stroop (1935).

The second part focusses on the enormous variety of distractors that are used as interfering stimuli in picture naming studies. This section is meant to give a short review of several experiments that show how differently the picture-word interference paradigm can be used and of the various effects that can be detected.

In the last section of this chapter the most interesting results of the described experiments are discussed by means of one of the most accepted speech production models. Levelt (1989) introduced a model that contains most of the commonly accepted ideas that were derived from the already conducted experiments and from the results of error analyses.

2.1 The first steps in the investigation of speech production

The first findings on how speech is represented in the human brain and on the processes that are passed before a word can be articulated were already present at the end of the 19th century. Meringer and Mayer (1895) were one of the first investigators who created a major corpus of speech error data. Their collection contained spoken errors of German. The first step in the error analysis was to classify the errors that occurred. The most obvious distinction could be made between meaning-based (e.g. “mouse” instead of “cat”) and form-based (e.g.

“car” instead of “cat”) errors. Furthermore, Meringer and Mayer (1895) differentiated between exchanges (e.g. “mell wade” instead of “well made”), anticipations (e.g. “taddle tennis” instead of “paddle tennis”), perseverations (e.g. “been abay” instead of “been away”) and contaminations, or blends (e.g. “evoid” composed of “avoid” and “evade”; examples see Levelt, 1999).

A more detailed analysis was conducted by Fromkin (1971), who concentrated on the different kinds of segments that can be involved in speech errors. She analysed especially her own corpus containing more than 600 errors. Most often the erroneous segment had the size of a phoneme. Other discrete units were affricates, diphthongs, affixes and whole words. Sometimes errors could even be explained by the replacement of a phonetic feature. Syllables are not counted as discrete units in the speech production process because usually no errors are described where complete syllables are exchanged (q.v. Schade, Berg & Laubenstein, 2003). Nevertheless, they play an important role in the context of phoneme errors. Nooteboom (1969) detected that erroneous phonemes stay in their original syllable position. That means that an onset phoneme will not be embedded into the coda of the erroneous syllable, but into the onset. Furthermore, phonemes can only be changed between syllables of the same structure (e.g. between two syllables of the type CV, but not between CV and CVC[1]).

Fromkin (1971) was able to draw several conclusions concerning the design of the mental lexicon and the different stages involved in the speech production process. The recent models of speech production (e.g. Levelt, 1989) include some assumptions that are made up from these conclusions. Next to complete words, also word parts, word stress and the words’ semantic, syntactic and phonological features seem to be saved in the mental lexicon. Fromkin (1971) assumed that the lexicon contains several lists of different orders. Alphabetical lists ordered according to the orthography and according to phonological features, groups of words sharing the same syntactical features and words arranged in semantic fields are some examples for the different lists in the mental lexicon. The idea of words ordered in semantic fields was derived from the occurrence of blends, errors that are the result of a combination of word parts from different

[1] CV describes a syllable consisting of a consonant and a vowel, while CVC represents a syllable of the kind consonant, vowel and consonant.

words with similar semantic features, e.g. “clarinola” as a combination from “clarinet” and “viola” (example see Fromkin, 1971), or between phrases that have a similar semantic meaning (q.v. Schade, Berg & Laubenstein, 2003). Due to the existence of the “tip-of-the-tongue”-phenomenon[2] Fromkin (1971) stated that there could also be lists of word-endings or a list containing words arranged according to the amount of syllables they consist of, in the mental lexicon. Concerning the processes during speech production, she derived some demands a model of speech production has to deal with. An utterance is encoded in different stages. Beginning with the generation of the conceptual idea a syntactic structure with slots is generated. The slots are first assigned with semantic features, then with different information concerning stress and intonation. Afterwards the slots are filled with the matching words. Right before articulation, the structure is matched to the morpho-phonetic rules.

Although current models do not fit these demands in detail, they at least contain some of Fromkin’s ideas, e.g. that semantic and syntactic information is retrieved from the mental lexicon before the phonetic information.

Another well-known approach in the analysis of errors was provided by Garrett (1975 and 1988), who supported Meringer and Mayer’s (1895) observation of meaning-based and form-based errors. Although mixed errors (errors that are related to the target in meaning and form, e.g. “rat” to “cat”) occur more often than expected by chance (q.v. Dell & Reich, 1981), it was assumed that a lexicon entry consists of two parts: the semantic component, *lemma*, and the phonological part, *word form* (q.v. Kempen & Huijbers, 1983). This observation is widely accepted in the current discussion (q.v. Belke, Eikmeyer & Schade, 2001; Caramazza & Miozzo, 1997; Pechmann & Zerbst, 2004) but see Caramazza (1997) for a different view.

Moreover, Garrett (1975) concentrated on the occurrence of meaning-based and form-based exchanges in a sentence and noticed that form-based errors usually occur between words that have a ‘near-by’ position in the sentence, whereas the distance between the words that take place in a meaning-based error

[2] In a “tip-of-the-tongue”-state the speaker is not able to retrieve a word that is intended to be articulated, but access of different features of this word is possible, e.g. the amount of syllables the word consists of, or the first letter. (q.v. Brown & McNeill, 1966).

can be much greater. It was concluded that meaning-based errors are the result of an erroneous lemma selection, whereas form-based errors occur due to an error in the phonological encoding. The distinction between a semantic-syntactic representation level and a stage of phonological encoding can be found in most of the speech production models (e.g. Levelt, Roelofs, Meyer, 1999; Dell, 1986; Humphreys, Riddoch & Quinlan, 1988).

The first ideas of the processes in speech production were derived from the analysis of speech errors. Collecting errors that occur in a natural dialogue situation surely is a hard and time-consuming way of research, so the investigators tried to find an experimental way that could be used to analyse speech production. In parallel to the analysis of speech errors, a second method was established to investigate speech production processes: the picture-word interference paradigm. This method is still very popular and was developed from the color naming studies conducted by Stroop in 1935.

Stroop presented color names, e.g. “blue”, that were written in black or in another incongruent color (e.g. red), to the participants of the experiment. The participants´ task was to read the presented word. Stroop could not detect significant differences in the reaction times for the words presented in black and the words presented in an incongruent color. So, he changed the task and conducted a second study. Participants were asked to name colors, either the color of a square or the color in which a color name was written (e.g. the word “blue” written in red). The measured reaction times were longer in the case of naming the color in which a word was written. Due to the fact that reaction times were slower in the second experiment than in the first one, Stroop concluded that naming a color is more difficult than reading a word. Thereby he supported Peterson, Launier and Walker (1925) who supposed that words trigger a simple “reading-response” whereas colors cause multiple answers and Cattel (1886) who detected that naming a drawn object takes almost twice as long as naming a written object name.

The experiments conducted by Stroop served as basis for many studies that worked with a variation of this method (q.v. McLeod, 1991). One variety of the Stroop task is the picture-word interference task that was first used by Stephen Lupker (1979). In his studies he presented pictures of common objects simultaneously with an interfering word (so-called: *distractor*). Participants were asked to name the presented object. Their response latencies were measured by means of a voice-key. Lupker concentrated on different semantic relations between the depicted object and the distractor. For example, he presented the picture of a **mouse** together with a word of the same semantic category (e.g. **dog**) or with an associate (e.g. **cheese**). Furthermore, he tested words of a different semantic category (e.g. **hand**), non-words (a chain of meaningless letters), abstract words (e.g. **justice**) and he presented the picture without any interfering stimulus.

Lupker detected that pictures were named more slowly, if a distractor was presented, compared to the condition without interfering stimulus. He concluded that the production of the picture name takes place in a competitive situation in case of presenting a distractor, because the name of the read distractor is already available when the picture name becomes activated. “Thus, by the time the picture name is retrieved, the word’s name will already be available, setting up a competition situation” (Lupker, 1979: 493).

A second observation was that reaction times were more delayed when a word of the same semantic category was presented than in case of another distractor. Lupker explains this effect with the overlap of a lot of semantic features between object name and distractor word in this situation. The competitive situation seems to be enlarged in this case of feature-overlap. Testing words of the same semantic category as distractors became popular in the following studies.

An important change to the method was introduced by Glaser and Düngelhoff (1984). They included different *SOAs* (stimulus onset asynchronies) into their experiments. That means that they did not only present the distractor word and the picture simultaneously, but also with different onset times. Distractors were presented before the picture (SOA -400 ms upto -100 ms), simultaneously with the picture (SOA 0 ms) or after the presentation of the picture had already started (SOA +100 ms upto +400 ms). Glaser and Düngelhoff (1984) tested four distractor conditions: neutral, semantically related (a word that belongs to the same semantic category as the picture name), unrelated (a word of a different semantic category) and the picture name. The results of their study showed a significant interference effect in picture naming for reaction times in the semantically related condition compared to the unrelated condition. This effect was detected especially between SOA -100 ms and +100 ms.

With the introduction of different SOAs the picture-word interference paradigm became a method which enables the researchers to manipulate speech production in order to investigate the processes a word has to undergo before articulation. The picture-word interference paradigm was so far used in many studies, using a high variety of distractors, as described in the next section.

2.2 Different distractors in picture-word interference studies

As described before, the basic form of the picture-word interference paradigm was introduced by Glaser and Düngelhoff (1984). Since then, the paradigm was used in many studies with different modifications. Some of these studies are reported here, to give a short overview of the various possibilities to modify the paradigm and to show how the basic ideas on speech production, which are represented in the next section by means of the *Levelt-Model*, were achieved.

Two modifications of the picture-word interference paradigm were introduced by Schriefers, Meyer and Levelt (1990) that were frequently used in later experiments. First, they used phonologically related distractor words (e.g. picture: **bureau**, desk, distractor: **buurman**, neighbour). As a consequence, they secondly presented the distractor words auditorily, to ensure the activation of the distractor's phonological form, rather than the graphemic representation in case of visual distractor presentation[3]. Additionally, they presented the picture together with a semantically related distractor word (e.g. **kast**, closet) and the word **blanco**. Furthermore, they included one condition with white noise[4] and one condition without interfering stimulus into their experiment. Schriefers, Meyer and Levelt (1990) tested three different SOAs (-150 ms, 0 ms and +150 ms). They detected that response latencies in picture naming were inhibited by the presentation of a semantically related distractor at SOA -150 ms, whereas

[3] The phonological representation will also be activated in case of visual presentation, as shown in many studies (q.v. Levelt, Roelofs & Meyer, 1999; Damian & Martin, 1999). It can be assumed that the phonological activation caused by auditorily presented words is more direct and perhaps stronger than in case of visual presentation.
[4] White noise is a random signal with a flat power spectral density.

phonologically related words facilitated the participant's response at SOAs 0 ms and +150 ms, compared to a distractor of the unrelated condition. Several conclusions were drawn from these results. Due to the fact that semantic and phonological effects occurred at succeeding SOAs, the general notion that entries in the mental lexicon are divided into two parts was supported, as well as the assumption that these parts are accessed in two different stages of the speech production process. These findings are included into the general model of speech production, described in the next section. Additionally, Schriefers, Meyer & Levelt (1990) were able to develop their idea of a *discrete two-stage model* of lexical access (see section 3.1) from these results.

The phonological facilitation effect reported by Schriefers, Meyer & Levelt (1990) was replicated in multiple experiments. The SOA range in which phonological effects occur is different, although these effects are mostly found at positive SOAs (e.g. 0 ms up to +200 ms). The occurrence seems to be dependent on various factors. Damian and Martin (1999) presented their distractors visually and detected phonological facilitation effects at an SOA range from -200 ms up to +100 ms (q.v. Starreveld & LaHeij, 1996), whereas auditory presentation yielded effects at a range from -100 ms up to +200 ms. A detailed investigation on factors which can influence the occurrence or non-occurrence of phonological effects was done by Jescheniak and Schriefers (2001) and Starreveld (2000). They controlled for example if early phonological effects of auditory distractors - Starreveld (2000) reported phonological facilitation effects at SOA -300 ms under certain circumstances - could occur due to strategic behaviour of the participants, or if the absence of semantically related distractors supports early phonological effects. Jescheniak and Schriefers (2001) concluded that the amount of phonological mismatch between distractor word and target word seems to play a role for the occurrence of phonological effects. This finding was supported by Schiller (2004), who tested several sorts of word part distractors. He used syllabic primes that corresponded to the first or the second syllable of the target picture name. Both distractors led to facilitated naming latencies. While he could not obtain effects for end-related word primes, containing a mismatching onset part, facilitating effects for this kind of distractors are reported in some other studies (e.g. Marslen-Wilson & Zwitserlood, 1989; Meyer & Schriefers, 1991).

While the effects caused by phonologically related distractors usually facilitate the response latencies, the effects described for semantically related distractors are not that consistent. Most often (e.g. Schriefers, Meyer & Levelt, 1990; Starreveld & LaHeij, 1995; Damian & Martin, 1999) interfering effects are reported for distractor words that belong to the same semantic category as the target picture name (e.g. picture: **cow**, distractor: **horse**, category: animal). Facilitating effects caused by semantically related distractors were obtained by Alario, Segui and Ferrand (2000) (q.v. LaHeij, Dirkx & Kramer, 1990). They used interfering stimuli, which were associatively linked with the target picture name in the semantic condition (e.g. picture: **dog**, distractor: **bone**).

Effects of distractor words can also differ according to the participants' task. Semantic distractor words that are members of the same category as the picture name (e.g. picture: **apple**, distractor: **banana**) facilitated the reaction times in a categorization task (e.g. Costa, Mahon, Savova & Caramazza, 2003), while they usually inhibit the naming of the picture.

So, not only the distractor words can be chosen to investigate a special detail of speech production – for example the influence of syntactic features is also topic of investigation (e.g. Schriefers, 1993; Schiller & Caramazza, 2003; Pechmann & Zerbst, 2004) – but also the participants' task can differ. Besides picture naming and categorization, a lexical decision task is sometimes used to approach speech processes differently (e.g. Levelt, Schriefers, Vorberg, Meyer, Pechmann & Havinga, 1991).

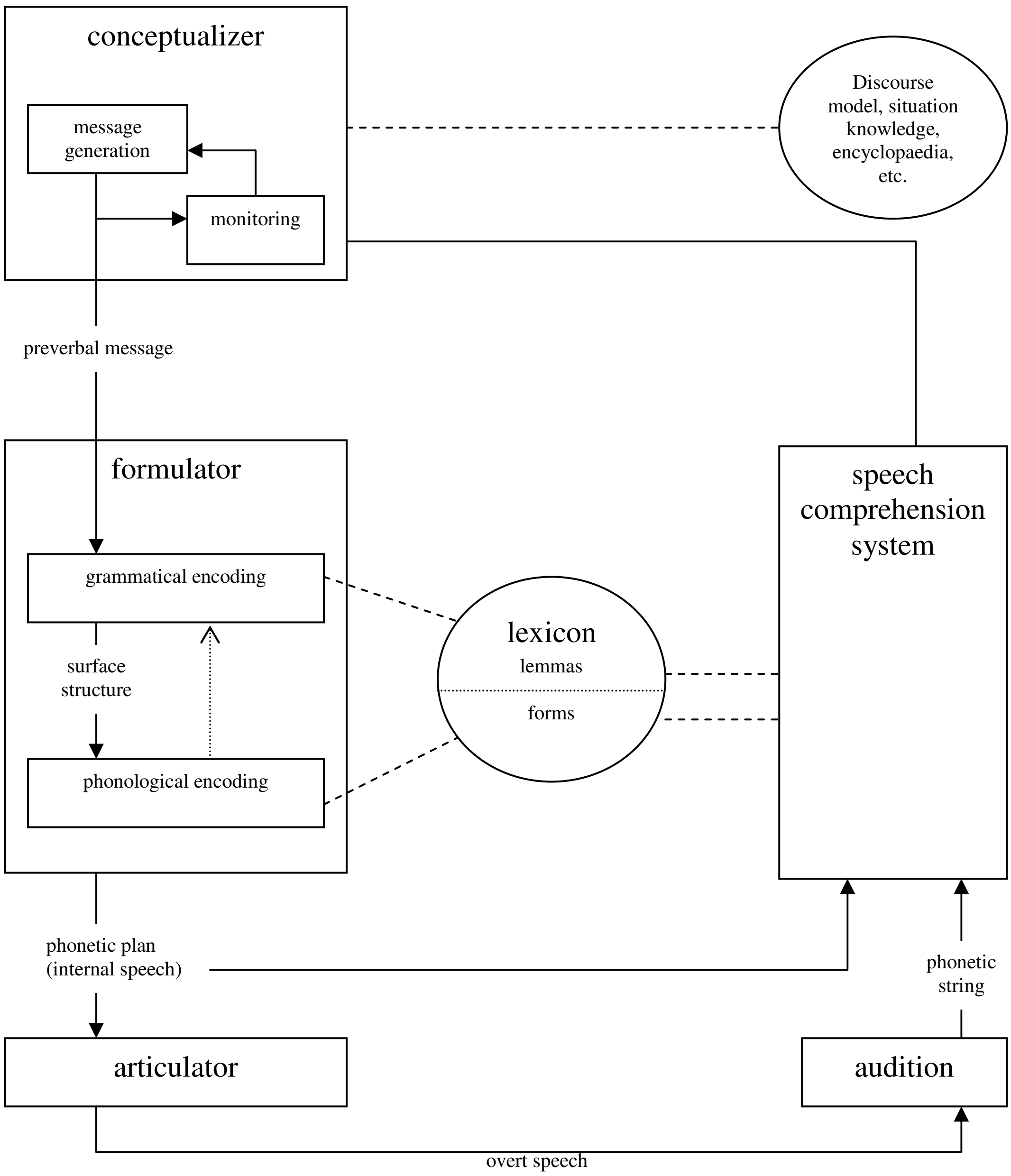
The literature lately reports experiments conducted to investigate the processes of lexical access very often. In these experiments new distractors are used, e.g. pictures of common objects, instead of words (e.g. Morsella & Miozzo, 2002; Navarrete & Costa, 2005), or a new kind of priming technique is used in studies, working with mediated priming (e.g. Cutting & Ferreira, 1999; Peterson & Savoy, 1998; Jescheniak & Schriefers, 1998). Section 4.1 describes these experiments in more detail.

To conclude, the very different studies reported in this paragraph all have contributed to the actual knowledge about speech production. Not all these ideas are commonly accepted, but the most prominent ideas are described by means of the Levelt-Model (Levelt, 1989) in the following section.

2.3 Commonly accepted ideas on speech production – the Levelt-Model

The results of the experiments using the picture-word interference paradigm and the conclusions derived from the error analyses (q.v. pragraph 2.1) led to some assumptions concerning the underlying processes of speech production that are now commonly accepted. Levelt (1989) combined these assumptions in one of the most prominent models of speech production (q.v. Schade, 2004).

Figure 1: Different stages of speech production including sub-processes (rectangular) and knowledge memory (elliptical) (q.v. Levelt, 1989: 9).



According to Levelt (1989), speech production is divided into three main processes as shown in Figure 1.

The first phase describes the information that is intended to be articulated, as conceptual representation. To produce this preverbal, conceptual message, the speaker combines declarative knowledge and procedural knowledge as well as knowledge about the world, which is saved in form of an encyclopaedia, and knowledge about the actual conversational situation.

The preverbal message, conducted at the conceptual level, serves as input for the second phase, which is called *formulator* according to Levelt (1989). This phase is mainly divided into two sub-stages: grammatical and phonological encoding. Both processes access the mental lexicon to retrieve lemmas or word forms, respectively. Due to the results of the different picture-word interference studies (q.v. section 2.1), it is assumed that grammatical encoding precedes phonological encoding. While it is commonly accepted that grammatical encoding starts first, it is less clear if the two stages overlap in time. Lexical access is the process that is especially discussed in the recent literature (e.g. Morsella & Miozzo, 2002; Navarrete & Costa, 2005). Even Levelt actualized his model in this respect several times (q.v. Levelt, 1999 and 2001; Levelt, Roelofs & Meyer, 1999), but sticked to the assumption that the two stages are strictly serial. In more detail, grammatical encoding is finished when the phonological encoding starts. The seriality of the two stages and the way of activation spreading between them are the most critical topics in the discussion. The experimental studies reported in chapter 5 are conducted to investigate lexical access, so different assumptions on these stages are introduced by means of three different models in chapter 3. It is commonly accepted that a lemma matching the intended meaning of the preverbal message with its semantic and syntactic features, is retrieved from the lexicon and can be selected for further production. After grammatical encoding, phonological encoding takes place[5]. The surface structure, derived from the grammatical encoding is now translated into a phonetic plan. Several sub-processes access the mental lexicon in order to retrieve the right word form corresponding to the target lemma. Morphological and phonological features are retrieved with the word

[5] Depending on the underlying model this phase can start before grammatical encoding is finished (q.v. chapter 3).

form, and so the phonetic plan is generated which is transferred into overt speech in the last stage, the articulator.

It is beyond the scope of this dissertation to explain all components of the Levelt-Model (Levelt, 1989) in detail (e.g. monitoring, articulator and audition). The speech comprehension system is not of detailed interest for the experimental studies described in chapter 5, either. Nevertheless, some assumptions of the way distractors can affect speech production are given in a later variation of the Levelt-Model (Levelt, Roelofs & Meyer, 1999), assumptions which are important for the discussion of the results obtained in the experiments. The authors claim that speech production and speech comprehension are not processed in one network, because otherwise bidirectional links between the stages must be assumed. Levelt, Roelofs and Meyer (1999) defend a strictly serial model of speech production, so bidirectional links would contradict their model assumptions. Instead it is assumed that two networks exist for production and perception that are linked only in a certain way. A distractor word can enter the perceptual network in three different ways, no matter if it is presented visually or auditorily. While spoken distractors obviously involve phonological activation, this also holds for written distractors, as was shown in many studies (q.v. Levelt, Roelofs & Meyer, 1999; Damian & Martin, 1999). The first possibility is that the phonological activation of the distractor "directly affects the state of activation of phonologically related morpheme units in the form stratum of the production network" (Levelt et al., 1999: 7). The second way distractors can affect speech production is that active phonological segments can directly impact the corresponding segment nodes in the production network. Third, the distractor activates its corresponding lemma node. The authors state that perception and production network coincide from the lemma level upwards.

Summarizing, the Levelt-Model visualizes the commonly accepted ideas about speech production. It contains a mental lexicon that is divided into lemmas and word forms. The formulator represents lexical access in two stages: grammatical encoding and phonological encoding. The timing of these two stages, which is strictly serial according to Levelt, Roelofs and Meyer (1999), and the way of activation spreading between these stages are the most important topics in the actual discussion (e.g. Morsella & Miozzo, 2002; Navarrete & Costa, 2005).

To resume the discussion, the stages of lexical access are discussed in detail in the following chapter.

3 Models of Language Production and of Associated Processes

While the "overall structure" of the Levelt-Model, as described in chapter 2, is commonly accepted, the process of lexical access is an important topic of the recent discussion.

Chapter 3 deals with three different approaches to lexical access. The discrete two-stage model (Levelt, Roelofs & Meyer, 1999), described in the first paragraph, was in a first version already embedded into the Levelt-Model (Levelt, 1989). Due to new investigation results (e.g. Starreveld & LaHeij, 1995; Starreveld & LaHeij, 1996; Peterson & Savoy, 1998; Jescheniak & Schriefers, 1998), the model was modified several times. Activation is assumed to flow strictly serially between the lemma level and word form encoding in this model. Furthermore, it is assumed that only selected lemmas spread activation to their phonological forms.

The assumptions of cascading models (e.g. Humphreys, Riddoch & Quinlan, 1988), introduced in the second section, are slightly different. Independent of which lemma will be selected for production, all activated lemmas will spread activation to their corresponding word form. The model of Humphreys, Riddoch and Quinlan (1988) differs from the discrete two-stage model (Levelt, Roelofs & Meyer, 1999) also with respect to the activation mechanism underlying the spreading of activation. While the latter approach is based on the "Luce-ratio" (Luce, 1959), Humphreys, Riddoch and Quinlan (1988) developed their model based on the theory of lateral inhibition (q.v. Berg & Schade, 1992; Schade & Berg, 1992), which is explained in the context of the cascading model in section 3.2, too.

Next to the cascading model of lexical access, the interactive feedback model (e.g. Dell, 1986) represents a second variant of spreading-activation models. Paragraph 3.3 gives an overview on this kind of model that differs from the cascading theory in assuming backwards spreading of activation between all levels of speech production.

The experimental studies reported in chapter 5 are based on the assumption that associates (e.g. cow and milk) are connected in the human mind in a specific way. The last paragraph of chapter 3 introduces a mental model

(Kintsch, 1998) which includes a representation of links between associated concepts.

The models introduced in chapter 3 serve as theoretical background for the discussion of the results of the experiments reported in chapter 5.

3.1 The discrete two-stage model

While the overall structure of the Levelt-Model of speech production was presented in section 2.3, the model's assumptions on the stages of lexical access are described in detail in this section.

In the first version of his model, Levelt (1989) distinguished between two kinds of lexical entries. On the one hand, a lemma represents the syntactic and semantic characteristics of a word and on the other hand, morphological and phonological features are retrieved in a separate word form (lexeme) (q.v. Kempern & Huijbers, 1983, for the terminology). Although the mental lexicon is divided into two parts, each lemma refers to its corresponding word form. Experimental investigation has not been far enough to decide if lemma and lexeme are retrieved in one stage or in two independent stages of lexical access, when the first version of the discrete two-stage model was presented. Nevertheless, Levelt (1989) assumed that lemma and lexeme are processed in two independent stages after retrieval.

> "The issue is, of course, not whether lemma and word form information are distinct kinds of information in the lexical entry, nor whether these kinds of information are relevant in subsequent phases of the formulating process (viz. during grammatical and phonological encoding, respectively). Rather, the issue is whether the lexical retrieval stage has to be further partitioned into two subsequent retrieval steps. Let us anticipate the conclusion: We do not know." (Levelt, 1989: 231)

A first hint for a retrieval separated into two stages yielded from the investigation of the "tip-of-the-tongue" phenomenon (e.g. Brown & McNeill, 1966; q.v. Vigliocco, Antonini & Garrett, 1997), but the first experimental evidence was reported by Schriefers, Meyer and Levelt only in 1990. In their picture naming study they obtained semantic interference effects at SOA -150 ms and phonological facilitation effects at SOAs 0 ms and +150 ms. Based on the occurrence of semantic and phonological effects at different SOAs, the discrete two-stage model (Levelt, 1989) was modified with respect to the stages of lexical access (Levelt et al., 1991).

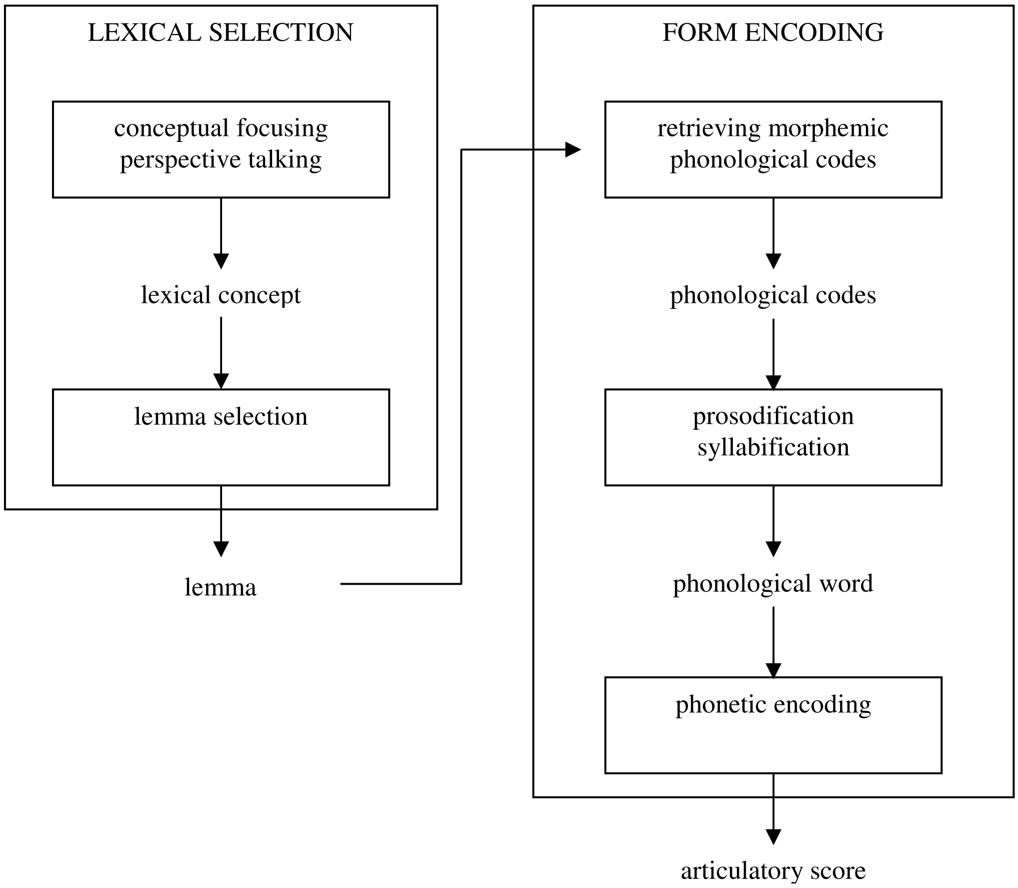
In the first stage of lexical access, an amount of lemmas receive semantically driven activation. The activated lemmas are members of the same semantic category which means that they are meaning-related. The activation is spread from the intended concept to the lemma level. Only one of the lemmas – the target lemma in faultless production – is selected out of all activated lemmas and becomes phonologically encoded in the second stage of lexical access. One characteristic assumption of the discrete two-stage model is that phonological encoding is restricted to the selected target lemma. Activation of the other lemmas will decay automatically after selection of the target candidate (self-inhibition, q.v. paragraph 3.2). The model predicts two phases of activation. In the first phase semantic activation increases until a lemma is selected and falls back to zero afterwards. Phonological activation starts after lemma selection.

A more detailed description of the stages of lexical access is given by Levelt, Roelofs and Meyer in 1999. The intention to produce a meaningful word first activates the corresponding concept node at the conceptual level. The speaker's actual situation prescribes which concept gets activated, for example if the word "bird", "animal" or "eagle" is intended. The conceptual level is represented as a network of concept nodes and links between these nodes. The links represent the semantic relation between the connected nodes. An activated concept spreads a certain amount of activation to semantically related concepts via these links. If the speaker wants to name the picture of a cat for example, the concept CAT (concepts are written in capital letters) will be activated by the speaker's intention. Concepts like e.g. DOG or MOUSE will also receive activation, due to their semantic relation with CAT. In the first stage of lexical access all activated conceptual nodes will spread activation to their corresponding lemmas at the lemma level, for example *cat*, *dog* and *mouse* (lemmas are printed italic) will become activated this way. The first stage of lexical access is completed with the selection of the target lemma. The selection (e.g. of the lemma *cat*) takes place in competition with other activated lemmas (e.g. *dog* and *mouse*). The lemma with the highest activation rate will be selected as target lemma. Calculation of the activation rate of each lemma is based on the "Luce-ratio" (Luce, 1959; q.v. Levelt et al., 1999). According to this rule, the activation rate of a lemma at a given moment in the selection process is determined as the quotient of the activation of this single lemma and the sum of the activation of all lemmas. A high activation rate is correlated with early selection in this account. With the selection of a lemma, its syntactical features will become available for further encoding.

A semantically related distractor word (e.g. **dog**) in a picture naming task presented before or simultaneously with the picture (e.g. **cat**) will usually inhibit the participant's response latency. Lemma level and conceptual network coincide for perception and production processes according to Levelt, Roelofs and Meyer (1999) (q.v. section 2.3), so the distractor will activate *dog* and via bidirectional links also the concept DOG. Semantically related concepts (e.g. CAT and MOUSE) will also receive activation and spread a certain amount to their corresponding lemmas (*cat* and *mouse*), too. Presenting the picture of a cat, the pre-activated concepts will receive more activation and will partly spread it to the lemma level. The lemmas *cat* and *dog* will now be especially activated and a competition in lemma selection is evoked. The activation rates of these two lemmas are approximated, in comparison with the situation without the semantic distractor. So the time needed to detect *cat* as the target lemma is delayed. Due to the delay in lemma selection, the complete response latency will be slower, compared to a situation with an unrelated distractor word.

The stage of phonological encoding follows after selection of the target lemma. First of all, the word form corresponding to the selected lemma is retrieved from the mental lexicon. With accessing the word form, the morphological and phonological structures as well as the metric information become available to the production process. If for example "cat" should be used in the plural form, the morphological segments "cat" and "s" become activated. The morphological segments activate the phonemes that are necessary to utter the word. Phonemes are then concatenated to syllables in the stage of prosodification. Afterwards, context specific information is adjusted to the present representation, in the stage of phonetic encoding, which is the last stage before articulation. Figure 2 visualizes a schematic view on the two stages of lexical access.

Figure 2: Structure of the two stages of lexical access according to Levelt (2001: 13465).



While the links between conceptual and lemma level are bidirectional in the discrete two-stage model, activation between lemma level and word form encoding, as well as activation within phonological encoding can only spread forward. A phonologically related distractor word can have different impacts on the production of the target word. If the word **car** for example is presented simultaneously with or short after the picture of a **cat**, the word form <car> (“<” and “>” represent word forms) will be activated in the perceptual network. Word forms of phonological cohorts (q.v. Marslen-Wilson & Welsh, 1978; Roelofs, Meyer & Levelt, 1996) e.g. <cat> and <cash> will receive activation as well. The activation of <cat> in the perceptual network will now speed up the access to the corresponding word form in the production network. Due to the facilitating effects of end-related phonological distractor words (q.v. Marslen-Wilson & Zwitserlood, 1989; Meyer & Schriefers, 1991; Schiller, 2004), like for example “hat”, it is assumed in the theory of Levelt, Roelofs and Meyer (1999) that a distractor can also activate single phonemes in the perceptual network. A facilitating influence on the retrieval of phonemes that are shared between distractor and picture name, e.g. /a/ and /t/ (phonemes are annotated between “/” and “/”), is assumed for the production of the target word.

Summarizing, the characteristic features of the discrete two-stage model are the distinction of lexical selection and word form encoding. During lexical selection, activation can spread via bidirectional links between conceptual and lemma level. This means that different concepts and lemmas will be activated until the selection of the target lemma. Phonological encoding is realized only for the selected lemma. Activation can only spread to the following level, but not backwards during this second stage of lexical access.

3.2 Cascading models and the theory of lateral inhibition

Cascading models of lexical access (e.g. Humphreys, Riddoch & Quinlan, 1988; Peterson & Savoy, 1998) and interactive feedback models (q.v. section 3.3) belong to the category of spreading-activation models. In contrast to the discrete two-stage model, these models assume that activation is spread from all activated lemmas to their corresponding word forms. As an example for cascading models of lexical access, the theory presented by Humphreys, Riddoch and Quinlan (1988) is described in this paragraph.

Their cascading model is divided into three different levels of representation. Visual representations of common objects are saved at the structural level. The semantic representation level determines the functional and associative features of these objects. An object’s name (phonological representation) is deposited at the level of phonological representation. The three levels are comparable to the stages described in the discrete two-stage model (q.v. section 3.1), e.g. conceptual level, lemma level, and phonological encoding. The difference between these two models is situated in the spreading of activation between the levels. Humphreys, Riddoch and Quinlan (1988) assume that information is transferred continuously between the levels of representation. If activation of one unit at one level has started, the corresponding unit at the following level can receive immediately activation, although the processes at the preceding level of representation are not yet finished. In detail, a word form can become activated before the corresponding lemma has been selected. Different levels of representation can be activated in parallel, which means that early phonological activation is expected according to cascading models of lexical access.

Furthermore, different units can be activated in parallel at the same level of representation. Under this assumption it is possible that more than one word form is activated at the same time at the level of phonological representation, which means another difference to the discrete two-stage model.

To assure the selection of the “right” target unit, Humphreys, Riddoch and Quinlan (1988) included inhibitory connections between the units into their model. Inhibitory links between units at the same level of representation are called lateral inhibition. Lateral inhibition is a mechanism to control the decay of activation, in order to prevent the system from “heat death” (over-activation). Alternative accounts that are used in different models of lexical access are *decay* and *self-inhibition*.

Automatic decay means that each node in the network loses a constant rate of activation (q.v. Berg & Schade, 1992). A linear function, depending on the activation rate of each single node determines the decay. The weakness of this account is that a highly activated node will lose more activation than a node which is not activated up to the same degree. So the differences between the activation rates of the target node and competing nodes become smaller and problems during selection can be the consequence (q.v. Berg & Schade, 1992; Schade & Berg, 1992).

Models using self-inhibition (e.g. Dell, 1986; Levelt et al., 1999) assume that the activation of a selected node is automatically reduced to zero right after selection (q.v. Berg & Schade, 1992). To anticipate that this node can be selected again, immediately after its first selection, it is assumed that the activation of this node stays at the minimum level over a constant time period. This account explains the decay of activation of a selected node, but does not hold for the reduction of activation of co-activated nodes that were not selected.

Instead, the account of lateral inhibition describes inhibitory links between the nodes of one representation level. The rate of inhibition that one node can send to another node is depending on the activation rate of the node and on the characteristic of the connection to the node that should be inhibited. E.g., the activated lemma node *cow* can send a higher inhibition rate to a semantically related node (e.g. *horse*) than to an unrelated node (e.g. *table*). A competition between highly activated nodes will take place because nodes that are activated to a smaller degree can be inhibited more easily. The selection probability of the target lemma will be higher under the assumption of lateral inhibition compared to the situation with decay or self-inhibition, because the target lemma will be a little bit more activated and less inhibited than corresponding nodes. “Whereas decay decreases the difference in the nodes’ activation levels, lateral inhibition acts to increase it” (Schade & Berg, 1992: 444).

Humphreys, Riddoch and Quinlan (1988) did not only include lateral inhibition into their cascading model of lexical access, but also inhibitory links between nodes of different representation levels, as shown in Figure 3[6].

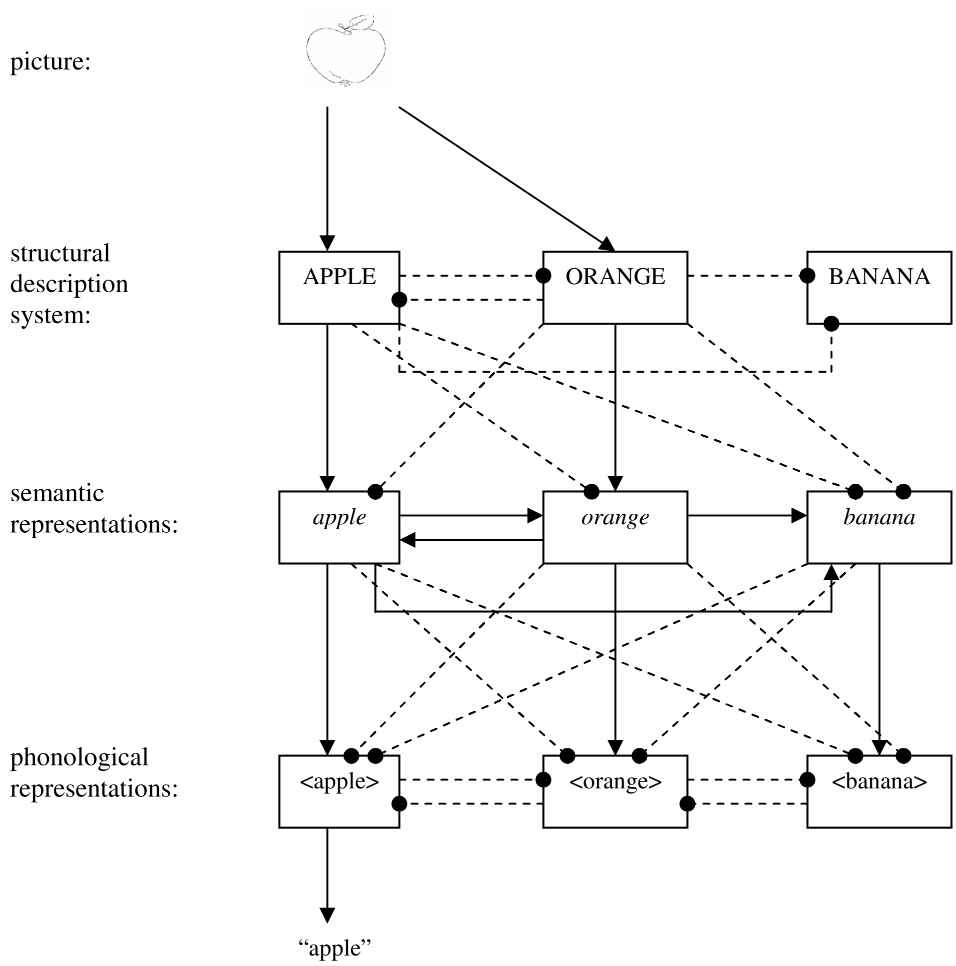
Due to the presentation of the picture of e.g. an apple, the unit APPLE and units of objects that have a similar structure e.g. ORANGE become activated. While the activated units at the structural representation level inhibit each other (e.g. APPLE inhibits ORANGE as well as BANANA), they also spread activation to their corresponding nodes at the semantic representation level, e.g. APPLE will activate *apple* directly. Furthermore, units activated at the structural representation level inhibit competing nodes at the level of semantic representation, e.g. APPLE inhibits *orange*.

At the level of semantic representation, nodes activate each other (e.g. *apple* activates *orange*) and their corresponding units at the following level of phonological representation, while other units at the level of phonological representation are inhibited. *Apple* activates <apple>, and at the same time <orange> is inhibited. Lateral inhibition is assumed for the level of phonological representation, so in faultless production, the target unit will receive the highest

[6] The assumption of inhibitory connections between different levels of representation (e.g. between units at the structural level and units at the semantic level) is redundant as was shown in the TRACE-Model (McClelland & Elman, 1986).

activation rate and the least amount of inhibition and will be articulated in the last step.

Figure 3: Different representations in lexical access (see: Humphreys, Riddoch & Quinlan, 1988: 71).
Activating links are represented by arrows, inhibitory connections are shown as dotted lines.



While the assumption of lateral inhibition is not characteristic for all cascading models of lexical access, the cascading flow of activation between the levels of representation is typically found in this kind of models. In contrast to the discrete two-stage model, cascading models assume parallel activation of different representation levels. Furthermore, the activation of more than one word form at the same time is possible in cascading models, while the two-stage model restricts phonological activation to the target unit. A schematic view on the differences between the models introduced in the first three paragraphs of chapter 3 is given with Figure 4 in the scope of the following section, which focuses on the interactive feedback model.

3.3 The interactive feedback model

Feedback models are based on cascading models, because they also assume spreading of activation between all levels of representation. Moreover, interactive feedback models include bidirectional links between all stages of production. The assumptions of feedback models will be presented in the following, by means of the theory introduced by Dell (1986).

The development of Dell's model (1986) was based on results obtained in the analysis of errors. Consequently, the explanation of mixed errors (q.v. section 2.1) is possible in the interactive feedback model, while a specific monitoring system is necessary to explain this kind of errors in the scope of the discrete two-stage model.

Dell's model (1986) contains different levels of production. Each level processes a specific representation of the utterance, by combining an amount of units. Representations are modified from level to level, by spreading of activation between the levels. Although Dell's theory (1986) only contains activating links and does not assume inhibitory connections, it stays valid under the assumption of inhibition. Characteristic for the feedback model is that all connections are bidirectional: "One of the important assumptions regarding spreading-activation in the theory is that all connections are two way" (Dell, 1986: 288). That means that activation can spread top down to a following production level and also bottom up, back to an earlier level. So processes can influence preceding production levels.

Each of the levels in the interactive feedback model works according to the *slot and filler principle*. A frame with marked slots is constructed that are filled with a matching unit. The unit with the highest activation rate at a given moment in the selection process is matching with a slot. In correct production, this is the target unit, in erroneous production it is the error unit. The interactive feedback model allows estimating the probability of the occurrence of different errors. An error unit with a higher activation rate than other error units will be selected more often in erroneous production and so has a higher probability. It is more probable that mixed errors are produced than other errors, because these units receive activation top down, due to the semantic relatedness with the target unit and bottom up, due to the phonological similarity.

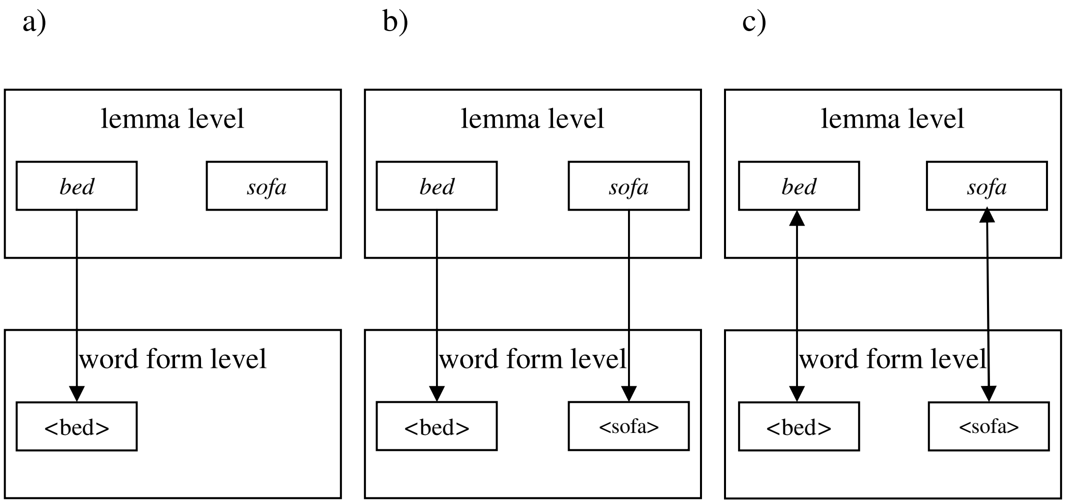
According to Dell (1986), a semantic representation with conceptual units is constructed before the mental lexicon is accessed for the first time (comparable to the conceptual level in the discrete two-stage model). The syntactic level (comparable to the lemma level in the discrete two-stage model) creates a syntactic surface structure of the utterance by retrieving the highly activated word nodes from the mental lexicon. Afterwards, morphological features are added during the stage of morphological encoding (comparable to word form level in the discrete two-stage model). Finally, the demanded phonemes are retrieved at the phonological level.

Presenting the picture of a bed, the interactive feedback model predicts that different semantically related concepts (e.g. BED and SOFA) will become activated. Via the spreading of activation from the conceptual level to the syntactic level, the corresponding lemmas *bed* and *sofa* will receive activation from their concepts. Due to the assumption of activation spreading, all activated lemmas spread activation to their corresponding word forms <bed> and <sofa> as well as in the cascading model. One important difference of the interactive feedback model to the models introduced before is that activation can spread in both directions. While activation is assumed to spread in a bidirectional way between the conceptual level and the lemma level in the discrete two-stage model and the cascading model, too, the bidirectional links between lemmas and word forms and between the stages of phonological encoding are unique for the interactive feedback model.

Figure 4 gives a schematic description of the different model assumptions concerning the spreading of activation between lemma level and word form level.

To conclude, of all activated lemmas, only the target lemma will spread activation to the corresponding word form according to the discrete two-stage model. In the cascading model and the feedback theory, activation will spread from all activated lemmas to the corresponding word forms. While activation can flow from the lemma level to the word form level only in the discrete two-stage model and the cascading model, bidirectional links between all stages are assumed in the interactive feedback model. Processes at the lemma level can be influenced by activation from the word form level in this latter model.

Figure 4: Simplified scheme of activation spreading between lemma level and word form level during the production of the word "bed" to compare the different model assumptions of the discrete two-stage model (a), the cascading model (b) and the interactive feedback model (c).



3.4 Mental representation of knowledge

Investigating speech production by means of associates requires dealing with the mental representation of knowledge. The experimental studies described in chapter 5 are based on the assumption that associates are conceptual representations that are connected in a specific way. To get a detailed view on how this relationship can be represented, the theory of Kintsch (1998) is introduced in this paragraph.

Developing a comprehension theory, Kintsch (1998) had to deal with the mental representation of knowledge. In order to understand a text, the reader has to generate a mental model from the ideas given in the text depending on the knowledge available from former experiences. Although, "a definitive account of mental representations does not yet exist" (Kintsch, 1998: 15) different kinds of mental representations can be classified.

Representations are arranged in a hierarchy, defined by the degree of abstractness and independence from the environment. While the degree of environmental control weakens, the degree of consciousness and intentionality increases from layer to layer. Representations change from sensory in the lower layers to symbolic and arbitrary in the upper layers.

The first layer contains according to Kintsch (1998) direct and perceptual representations. These forms include innate systems, e.g. different types of affordances, abilities, actions, and different biological mechanisms. This first layer is a direct representation of the environment. Modification of these forms of representations is possible by experiences. Perceptual and procedural learning (e.g. how to tie a shoelace) can be seen as a response to environmental affordances.

A layer with episodic representations follows in the hierarchy. Generalized event representations are created from experiences, to guide action and anticipate changes in the environment. These representations are available for recall and reflection processes. Cognition at this layer is analytic and reflective but still environmentally bound. Recollection of particular experiences involving a certain level of consciousness and self-awareness can serve as an example of the modification processes at this stage in the hierarchy. The human mind is able to create linguistic knowledge from this event memory. So this memory is embedded in higher cognition with linguistic and symbolic thought.

The next layer in the hierarchy contains nonverbal imagery and action representations, which are sensory in character but intentionally used, e.g. for communication of emotions (e.g. body language).

The following layer includes narrative, oral representations. They are one form of the linguistic representations, verbally, but not abstract. The structure of the representations at this layer is linear. Information processing is analytic and rule-governed, as e.g. in semantic memory, propositional memory or discourse comprehension. Stories, which allow the listener to learn about the world, are one example of narrative knowledge.

Abstract representations form the final layer of the hierarchy. This kind of representation is required for e.g. categories, logical thought and formal argumentation. Abstract representations are primarily stored in the surrounding world, not in the individual brain. External memory storage for abstract symbols can have many different forms, e.g. written language, maps or calendars.

These different layers are not strictly serial. In the adult brain, the different forms of representations are mixed. This becomes evident, if new representations arise. In these cases the old forms are not removed but remain embedded into the new layer.

After the classification of the different types of mental knowledge representations, Kintsch (1998) introduces several possibilities of scientific representation systems. Due to the fact that all of the introduced systems are insufficient to handle all kinds of knowledge representations, Kintsch (1998) developed a new system as a combination from the systems described in the following, in order to cover as many different kinds of representations as possible.

Feature systems are very popular in psychology, because a small set of features is sufficient for most of the psychological purposes. Originally, feature systems were created in order to find a finite set of semantic features that can be combined to form complex semantic concepts. After several tries to define a finite set that could hold for the description of all concepts, it turned out that it was not possible to cover enough features. Nevertheless, psychology could work with a reduced set of features in many cases and profited from this simple way of representation.

Concepts are represented as nodes in *associative networks*. The concepts are connected via unlabeled associative links of varying strength, based on temporal or causal contiguity. The strength of the associative links for example can be estimated by the frequency of responses in a free association experiment. Some experimental data support the psychological reality of these structures, for example associates sometimes speed up naming latencies in picture naming tasks (e.g. Alario, Segui & Ferrand, 2000; LaHeij, Dirkx & Kramer, 1990). So it seems that associative links play a certain role in lexical access. A weakness of associative networks is that not all knowledge can be represented by unlabeled links.

Furthermore, Kintsch (1998) described *semantic networks*, which are very similar to associative networks. Concepts are represented as nodes as well, but they are connected with labeled links in semantic networks. A kind of hierarchy is built up between the nodes. As a consequence, some semantic features can be passed down to nodes of the next hierarchy level. Such a system needs less memory capacity than would be needed to save all features for each node. Very frequent properties still seem to be stored directly, even if they could be derived through inheritance.

Schemas, *frames* and *scripts* are often used to represent and coordinate concepts that are part of the same event. Against former assumptions that schemas can only be used for rigid structures, it turned out that schemas can be used in a flexible way for generating organizational structures in a particular context.

Kintsch (1998) combined the properties of theses representation systems into a *predicate-argument schema*, a so called proposition network. While for linguistics, especially word production, the use of semantic and associative networks is usually sufficient, the predicate-argument schema is suitable for all kinds of structures of mental representations. A limitation of the proposition network is that higher levels of representation encapsulate lower levels, so propositional representations cannot be separated easily from the layers of representations.

In the proposition network, knowledge is represented in nodes and links. Nodes can be of various kinds, e.g. propositions and schemas, which can all be represented by the predicate argument schema. Links between these nodes are unlabeled and varying in strength. They have the character of an associative network. Concepts in this network do not have a fixed and permanent meaning, because the meaning of a node is determined by its position in the net and the strength with which it is linked to other nodes, e.g. the immediate neighbours and nodes that are not directly linked but via several other nodes. The meaning of a node is constructed newly for each situation and context by activating a certain subset of propositions in the neighbourhood. The context of use, influenced by e.g. goals, experiences and emotional state, determines which nodes linked to a concept are activated. Imagine two situations in which the concept WOOD can be activated. During a walk in the forest, the meaning of WOOD can be determined by the activation of nodes like TREE, PLANT and FIR for example. In the context of energy resources, the meaning of WOOD can depend on the activation of GAS, OIL and COAL. This example shows that meaning, the part of the knowledge net that is activated, is flexible, changeable and temporary on the one hand. On the other hand there is a certain amount of consistency in the meaning of concepts on different occasions, because meaning is always constructed from the same substructure of nodes. In the example, NATURE could be a node that is activated in both situations and SUBWAY could be an example of a node that will not be activated in any context to define the meaning of WOOD. Experimental evidence for this mechanism of meaning construction is reported for example by Barclay, Bransford, Franks, McCarrell and Nitsch (1974) and McKoon and Ratcliff (1988). Barclay et al. (1974) presented words like "piano" to the subjects, either in the context of playing music, or in the context of moving furniture. Afterwards they presented "loud" or "heavy" as retrieval cues, where the first one worked better if "piano" was studied in context of playing music and the latter in case that the subject studied piano in the context of moving furniture.

The remaining question in the description of the knowledge net is how activation is spread via unlabeled links. Links can be of three different kinds: indirect, direct or embedded. Direct links are stronger than indirect ones. Embedded links are the most powerful ones. The strength of links can for example be retrieved in a free association task. According to Kintsch (1998) a spreading-activation mechanism is used to stabilize the network. The activation process depends on iterations. The amount of iterations is variable. Iteration stops at the moment, when the network has reached a stable state. The activation rate ($a_j(t+1)$) of a node j at a certain point in time (t+1) is given by the sum of the product of the activation rate in the earlier iterations and the strength w_{ij} of the link between the two nodes i and j. The activation value is renormalized by division through the maximum activation value in the net as is shown in the following formula (q.v. Kintsch, 1998: 98).

$$a_j(t) = \frac{\sum_{i=1}^{n} a_i(t-1)w_{ij}}{\max a_j(t)}$$

A stable state of the network is achieved, if the growth of the activation rate in the next iteration does not surpass a critical value. Links between nodes can be positive, then they are strengthened during the spreading-activation process, or negative. Nodes that are connected to the target node via negative links will be suppressed during the activation process.

The formula used by Kintsch (1998) differs from the formula used by e.g. Dell (1986: 287):

$$A(j, t_i) = \left[A(j, t_{i-1}) + \sum_{k=1}^{n} p_k A(c_k, t_{i-1}) \right] (1 - q)$$

Both models explain activation as a process of iterations. In Dell's account (1986) the activation rate of a node depends on the nodes that are directly connected ($c_1 \ldots c_n$) with the node j. A decay parameter q is included into the formula. Kintsch (1998) uses the maximum value in the net to renormalize the activation value.

In the propositional network, described in this chapter, new information can be integrated one after another, by connecting ideas of a certain text with the former knowledge in a comprehension process. The integration is run according to certain propositional rules. The result is a mental model that is suitable for the comprehension of a specific text and can also be used as a knowledge representation model in the context of speech production.

4 Investigation of lexical access

Some studies investigating the processes of speech production were reported in section 2.2. In the discussion of the different models of lexical access several experiments are conducted in order to support one of the theories. Recent studies concentrate on the parallel activation of different word forms, because proofing phonological activation of semantic alternatives would serve as experimental evidence against the discrete two-stage model.

Researchers have been very inventive in finding paradigms to test phonological activity of semantic alternatives. Some examples of studies will be given here that support one of the three models under investigation. The second section of this chapter will introduce the associate naming task, a modification of the picture-word interference paradigm, which is used in the experimental studies described in chapter 5.

4.1 Experimental evidence for different models

One of the most prominent studies in favour of discrete lexical access was conducted by Schriefers, Meyer and Levelt in 1990 (q.v. section 2.2). More evidence was found by Levelt et al. (1991). In the latter study, participants were asked to name pictures. In the critical trials an auditory stimulus was presented shortly after the picture onset. The participants had to make a lexical decision concerning this stimulus instead of naming the picture in these trials. The stimulus could be a non-word or a word that was identical to the picture name (e.g. **bureau**, desk). Furthermore, the distractor could be unrelated (e.g. **muts**, cap), semantically related (e.g. **stoel**, chair) or it could be phonologically related to a semantic alternative of the picture name (e.g. **stoep**, pavement). While effects were obtained in the semantic condition, no effects could be detected for the phonological condition. Levelt et al. (1991) argued that semantic alternatives were at least partially activated but not phonologically encoded. So the results of these experiments yielded evidence for the discrete two-stage model of lexical access[7].

Reacting on these conclusions, Dell and O'Sheaghdha (1991 and 1992) proposed that Levelt et al.'s (1991) methodology was not sensitive enough to pick up the phonological activation of 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.

Peterson and Savoy (1998) obtained evidence for the cascading model of lexical access from experiments combining picture naming and word naming. As a variety of the picture-word interference paradigm, they presented pictures of common objects which had two synonym names (e.g. **sofa** and **couch**). Participants were told to use one of the names consistently (dominant name). The influence of this name on target words that were phonologically related to one of the synonymous names was investigated. The experimental design was conducted as follows: participants were asked to name a set of pictures. On half of the trials a word appeared in the middle of the picture. The task in these trials was to read the word aloud. Twenty of these pictures had two synonymous names. The target words that had to be read 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). Phonological effects for both types of phonologically related target words were obtained and the authors concluded that in case of synonyms both phonological representations are activated. At the same time, target words (e.g. bell) phonologically related to semantically related words like **bed** did not yield significant effects. Although Peterson and Savoy (1998) had no control if their participants really used the dominant object's name they were told to use, because they produced a phonologically related word in the critical trials, the authors interpreted their results as supporting the cascading model of lexical access.

[7] In principle, the results of Levelt et al. (1991) should have been counted as evidence for the cascading model of lexical access, because phonological activation is detected at early SOAs. The authors are aware of this discrepancy: "Contrary to the prediction of the two-stage model [...], there is evidence for early phonological activation. And contrary to the backward-spreading connectionist model […], there is no evidence for late semantic activation" (ibid., S. 131).

Jescheniak and Schriefers (1998) replicated the effects reported by Peterson and Savoy (1998) in a comparable study. They changed the methodology to control which of the two synonymous picture names was actually used by the participants. In two experiments, participants had to name pictures in German. They were told to use one name consistently in case that the picture had two ambiguous names (e.g. **Schäfer** – **Hirte**, both meaning shepherd) in the first experiment, while they were free to say one of the two names in the second experiment. Auditory distractor words were presented together with the pictures. Some of these distractors were phonologically related to one of the picture names (e.g. **Schädel**, skull; or **Hirn**, brain). Facilitating effects of both types of distractor words were detected in both experiments. These results support the assumption that in case of synonyms both picture names get phonologically activated and serve as evidence for the cascading model of lexical access.

Reacting on the findings of Peterson and Savoy (1998) and Jescheniak and Schriefers (1998), Levelt et al. (1999) claimed that synonyms mean a too special case of semantic alternatives to serve as general evidence against the discrete two-stage model: "[…] phonological activation has been shown to exist only for synonyms. Any other semantic alternative that is demonstrably *semantically* active has now been repeatedly shown to be phonologically entirely inert" (Levelt, Roelofs & Meyer, 1999: 17). They assumed that under certain circumstances (e.g. in case of synonyms) two lemmas can get selected and phonologically encoded. Evidence against the two-stage model can only be valid if word forms of concepts, that are not as close semantically related as synonyms, are activated in parallel[8].

A different approach to demonstrate that semantically irrelevant stimuli get phonologically encoded was chosen by Morsella and Miozzo (2002). They introduced a picture-picture-interference paradigm. Participants in their study were shown two pictures overlapping each other. One picture was presented in green, the other one in red. The participant's task was to name the green picture as fast and accurately as possible. Picture names were either unrelated (e.g. bed$_{green}$ – hat$_{red}$) or phonologically related (e.g. bed$_{green}$ – bell$_{red}$). Results showed

[8] This is in some contrast to what Levelt (1989, page 213) proposed, namely that there are no "full synonyms" in a language.

significantly faster naming latencies for the related than for the unrelated pairs in English. Morsella and Miozzo (2002) used the same picture pairings in Italian, where the picture names had no phonological relationship and, as expected, did not yield faster naming latencies. The authors argued that their findings can be explained best by cascading models of lexical access, which assume that unselected lexical nodes, e.g. the red distractor picture, activate their phonological representations. Thus, **bell** may activate its phonological representation including the segments, e.g. /b/, /ɛ/ and /l/. When the target **bed** gets phonologically encoded, part of its segments, e.g. /b/ and /ɛ/, were already activated by the distractor and their selection is facilitated leading ultimately to faster production of the target word. Navarrete and Costa (2005) replicated these findings for Spanish with a similar experimental design.

In another variant of the picture-word interference task Cutting and Ferreira (1999) conducted a study with homophones. They presented pictures of objects with a homophone name, e.g. the picture of a ball. A ball can be a sport utility (ball$_{toy}$) or a formal dancing event (ball$_{social\ event}$), i.e. two meanings with maximal phonological overlap. Participants were asked to name the pictures. Words that were semantically related to the non-depicted meaning (e.g. dance) serve as distractor words as well as words semantically related to the depicted meaning (e.g. frisbee) and unrelated words (e.g. hammer). 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. Cutting and Ferreira (1999) argued that the facilitating influence can be ascribed to the word form level and interpreted their results as evidence for the interactive feedback model. The distractor related to the non-depicted meaning (e.g. dance) activates a cohort of meaning related word forms, including ball$_{social\ event}$, which activate their corresponding lexical representations. These lexical representations activate their corresponding word forms. That way, the homophonic word form <ball> receives activation from two sides, i.e. from the selected ball$_{toy}$ and the non-selected ball$_{social\ event}$. So, phonological processing can be affected by semantically processed stimuli even though these stimuli are not semantically similar to the target. Cutting and Ferreira (1999) used an interactive feedback model including lateral inhibition (q.v. section 3.2) at the lemma level for computer simulations and obtained results comparable to the experimental findings.

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$_{\text{toy}}$. So, the findings of Cutting and Ferreira (1999) are also explainable in the scope of the discrete two-stage model.

However, the different studies reported before show that the different theories of lexical access have been an important topic in the recent discussion. Most of the studies yielded effects that can easily be explained based on cascading or interactive feedback models. Although the discrete two-stage model cannot deal with all the effects, it is not conclusively ruled out by the results of the reported experiments, because some effects occurred only in specific contexts (e.g. only for synonyms).

The present study offers a different approach which tries to find evidence for different word forms activated in parallel, as described in the following paragraph.

4.2 The associate naming task

In the actual discussion on the different models of lexical access, the parallel activation of more than one word form is one of the most important topics. The assumptions of the discrete two-stage model (Levelt et al., 1999) rule out that more than one semantic alternative can be phonologically activated at the same time in the speech production process. So researchers tried to find methods to detect phonological activation of more than one word form (see paragraph 4.1), to reduce the discussion on the cascading model (e.g. Humphreys, Riddoch & Quinlan, 1988) and the interactive feedback model (e.g. Dell, 1986).

Based on the experiments with synonyms (e.g. Peterson & Savoy, 1998; Jescheniak & Schriefers, 1998) and homophones (e.g. Cutting & Ferreira, 1999) a sequence of experimental studies using a new type of mediated priming is conducted within the scope of this dissertation. Parallel phonological activation of semantic alternatives is investigated by means of associates. To potentially distinguish between the discrete two-stage model of lexical access (e.g. Levelt et al., 1999) and models assuming activation spreading between the lemma level and word form encoding (e.g. Humphreys, Riddoch & Quinlan, 1988; Dell, 1986), a new task, associate naming, is used in the studies described in the following.

In common picture naming tasks (e.g. Lupker, 1979; Glaser & Düngelhoff, 1984) participants have to name a picture of a common object. In associate naming they are presented with a picture of for example, a **cow** but instead of saying "cow", they are asked to say "milk". While the target word can only be activated via mediated priming from the picture name and not directly, it is assumed that the picture name will at least be activated at the conceptual level due to the presentation of the picture. The meaning of the target word **milk** is determined by related nodes that are activated at the same time (q.v. section 3.4). In case of associate naming, it is assumed that the picture name will be one of the activated nodes that determine the meaning of the target associate. The question of interest is up to which level the picture name will be activated in case that the target associate is produced. Distractor words and different SOAs are used to investigate the encoding of the picture name. The interfering stimuli can be semantically related to the picture name (e.g. **donkey**), phonologically related (e.g. **couch**), unrelated (e.g. **apple**), or neutral. Any relation to the target associate is avoided, so that the distractors are all unrelated or neutral to the target[9].

A general expectation is that reaction times in associate naming should be slower than in common picture naming tasks, because the target associate does not receive direct conceptual activation. Instead the target concept will be activated by mediated priming of the picture's concept (q.v. section 3.4).

All three models under investigation assume that an activated concept node will spread activation to its corresponding lemma automatically and that

[9] Section 5.3 describes two experiments using distractors, which are related to the associate's name. They will be explicitly explained in the description of the experimental method.

activation can spread back from the lemma level to the concept. So, it is expected that the distractor word semantically related to the picture name can influence the reaction time of naming the target associate.

Concerning phonological activation, the models differ in the assumptions of activation spreading. The discrete two-stage model predicts that the word form of the picture name will not get activated, because only the selected target lemma will be phonologically encoded. So effects of the phonologically related distractors are not expected according to this model. In contrast, spreading-activation models assume that all activated lemmas spread activation to their corresponding word forms, no matter if the lemma is selected for further production or not. Effects of distractors that are phonologically related to the picture name are possible in the scope of the cascading and the interactive feedback model.

To investigate the processes at the phonological level as detailed as possible, a great variety of phonological distractors is used in the experiments. Due to the reason that some distractor conditions change from experiment to experiment, detailed descriptions of the expected effects of semantically and phonologically related distractors according to the different model assumptions will be given separately for each of the following experiments. Furthermore, for each associate naming study, a control experiment using the usual picture-word interference paradigm is conducted, because the usage of a new method entails that referring to reference values reported in the literature is difficult.

5 Experimental studies

The new method to investigate the parallel activation of more than one word form was introduced in chapter 4. In chapter 5, six experimental studies are reported that use associate naming to investigate the phonological encoding of the non-target picture name. Each of these experiments is preceded by a common picture-word interference experiment, in order to control the material. The experiments are conducted in Dutch.

The experiments reported in section 5.1 are conducted with distractor words related to the picture name. In the phonological condition, stimuli are begin-related with the picture name, e.g. (picture: **koe**, cow; associate: **melk**, milk; semantically related distractor: **ezel**, donkey; phonologically related distractor: **koek**, cake). The interfering stimuli are presented visually, in the first experiments.

The material used in the experiments, described in the second section of this chapter, changed only with respect to the phonologically related distractors, which share the end segments with the picture name (e.g. **taboe**, taboo). For comparability reasons nothing else was changed in the experimental design compared to the first two experiments.

The next section contains a description of two experiments using distractor words that are related to the target associate, instead of the picture name (e.g. picture: **koe**, cow; associate: **melk**, milk; semantically related distractor: **sap**, juice; phonologically related distractor: **merk**, mark). For the controlling picture naming study, new pictures were selected that correspond to the associate's name.

Paragraphs 5.4 and 5.5 describe a replication of the first four experiments. While the material did not change compared to the earlier studies, a difference was deployed to the experimental design, by auditory presentation of the interfering stimuli.

The final section of chapter 5 contains the description of two experiments using meaningless letter strings as phonological distractors (picture: **varken**, pig; associate: **modder**, mud; semantically related distractor: **hond**, dog; phonologically related distractor: **knerav**).

5.1 Begin-related phonological distractors, presented visually

The two experiments described in this paragraph are conducted to validate, if the associate naming task is qualified to investigate the parallel activation of more than one word form. It is expected that interesting data can be obtained with this method, to contribute to the actual discussion on the models presented in chapter 3, if the mediated priming works in the expected way.

Experiment 1A pretests the influence of the distractor words used in the associate naming task (Experiment 1B) on the encoding of the picture name in a common picture naming task. It is expected to retrieve the usual effects as described in several comparable studies (q.v. section 2.2). In detail, it is expected that semantically related distractors (e.g. **ezel**, donkey) inhibit the response latencies for naming the picture of e.g. a cow (**koe**) at early SOAs (e.g. Glaser & Düngelhoff, 1984), whereas phonologically related stimuli (e.g. **koek**, cake) should speed up naming latencies at least at later SOAs (0 ms up to 150 ms) (e.g. Schriefers, Meyer & Levelt, 1990).

The effects that have to be expected in the associate naming task are more difficult to predict, because there are no comparable effects reported yet. All three models under investigation assume that activation of the target concept is influenced by the presentation of a distractor semantically related to the picture name. The target concept (MELK, milk) is activated via associative links with the concept of the picture name (KOE, cow). Due to the presentation of a semantically related distractor (e.g. **ezel**, donkey), the concept of the picture name will be pre-activated and will also spread a certain amount of activation to the target concept. With the presentation of the picture, all three concepts will become more activated. The corresponding lemmas at the lemma level will receive activation. While this process is assumed to be sped up according to all three models, the assumptions for lemma selection depend on the underlying mechanism. Lateral inhibition predicts that the selection of the target lemma will be faster in case of more highly activated lemmas, while inhibition of the lemma selection could be predicted, if e.g. decay is assumed. Altogether facilitated naming latencies are expected in the semantic condition.

Concerning the phonologically related distractors, predictions are different for the three theories. While the discrete two-stage model predicts that distractors phonologically related to the picture name will not effect the encoding of the target associate, spreading-activation models can handle effects of these distractors. Due to the assumptions of the discrete two-stage model only selected target lemmas (e.g. *melk*, milk) are phonologically encoded, so the picture name (e.g. **koe**, cow) will not receive phonological activation in an associate naming task. This means that distractors phonologically related to the picture name (e.g. **koek**, cake) should not lead to any effect. In contrast, cascading models and feedback models assume phonological activation spread from all activated lemmas to their corresponding word forms. So, the word form of the picture name will get phonological activation and effects of phonological distractors can occur. Facilitation effects are most probable if the feedback theory is assumed. The segments /k/ and /u/ and the word form (<koe>) of the picture name will be primed by the distractor word (e.g. **koek**, cake) and so activation can spread back to the conceptual-semantic level. From there the target concept (e.g. MELK, milk) will receive additional activation, which should speed up the response latencies. The results obtained in the associate naming task are described in Experiment 1B.

<u>Experiment 1A – Picture Naming</u>

Method

Participants. Twenty-four undergraduate students of Maastricht University participated in Experiment 1A. All participants were native speakers of Dutch and had normal or corrected-to-normal vision. They were between 18 and 28 years of age (mean: 21 years). The participants were paid € 5.00 for their participation in the experiment.

Materials. Thirty-two white-on-black line drawings of common objects were selected from the picture database of the Max Planck Institute of Psycholinguistics in Nijmegen. Pictures were chosen if an associate with the picture name could be found in at least one of the association lists for Dutch used here (i.e. De Groot & De Bil, 1987; Lauteslager, Schaap & Schievels, 1986). In the associate naming part of this study (Experiments 1B), the chosen associate was the target word for the picture (e.g. picture: **koe**, cow; target: **melk**, milk). The chosen associates had a mean association rate of 26% to the pictures (range: 9% to 61.3%).

For each picture-associate pair, four distractor words were selected. A semantically related distractor was categorically related to the picture name, e.g. **ezel** (donkey) and a phonologically related distractor was phonologically related to the onset of the picture name, e.g. **koek** (cake). The mean phoneme[10] overlap was 60%. Furthermore, pictures were presented with an unrelated distractor, which did neither have a semantic nor a phonological relationship to the picture name, e.g. **appel** (apple), and together with a row of five X's (**XXXXX**) in the neutral condition. Care was taken that none of the distractors bore any semantic or phonological relationship to the target associate. Distractors were not associatively related to the associate of the picture, either. Distractor words in the semantic, phonological, and unrelated conditions had approximately the same mean word frequencies according to CELEX (Baayen, Piepenbrock & Gulikers, 1995) and were equaled in terms of mean number of letters. A list of the material used in Experiments 1A and 1B can be found in Appendix A.

Distractor words were displayed in white characters (font type and size: Geneva, 30 pts.) on a small black bar, superimposed on the object such that the picture could still be recognized. Pictures appeared in the center of the screen.

Four different SOAs were tested: -150 ms, 0 ms, +150 ms and 300 ms. This means that the distractor could occur preceding the onset of the picture (-150 ms), simultaneously with picture onset (0 ms) or shortly after the picture (+150 ms and +300 ms).

Design. The experiment consisted of three parts. In the first part, each picture appeared on the screen together with its name added below the picture, such that the participants got familiar with the intended picture name. Both remained in view until the participants pressed a button. In the second part, the participants practiced the naming of the pictures. Each picture was presented once in the center of the screen preceded by a fixation point and the participants' task was to name the pictures, e.g. **koe** (cow) in response to the picture of a cow. The experimenter corrected participants in case they did not use the designated name for a given picture. The third part was the proper picture naming experiment. Pictures were now presented together with visual distractor words. Stimuli were

[10] For the segmentation into phonemes, the "DISC"-transcription of the CELEX (Baayen, Piepenbrock & Gulikers, 1995) database was used. Every phoneme is symbolized by one sign in this transcription guideline.

presented in 4 SOA blocks of 128 trials each (32 pictures x 4 distractor conditions). The experimental design included Distractor Type and SOA as within-participants factors, i.e. each picture was paired once with each distractor word (4) in each SOA (4) such that it was shown 16 times to each participant in the course of the experiment. The participants were exposed to 512 trials in total (plus 16 additional "warm-up" trials). In each SOA block, each target occurred four times, once accompanied by each of the four distractors (semantic, phonological, unrelated, and control). SOA blocks were pseudo-randomized for each participant with the constraint that a given picture could not appear in more than two consecutive trials. The sequence in which the participants received the SOA blocks was counter-balanced according to a Latin-square design. A short break was inserted after each SOA block. The experiment lasted approximately half an hour.

Procedure. The participants were tested individually in a dimly lit testing booth. They sat in front of a computer screen at a viewing distance of approximately 60 cm. Participants received verbal and visual instructions before each stage of the experiment. The experimenter scored potential errors in a separate room. The computer screen was a Philips Brilliance 109 monitor. On each trial, a fixation point appeared for 500 ms followed by a blank screen for 200 ms, and by the picture, and the distractor word. Participants were instructed to name the target picture as quickly and as accurately as possible in Dutch. At picture onset, a voice key connected to a microphone was activated to measure the naming latencies. As soon as a response was given and the voice key was triggered, picture and distractor word disappeared from the screen and after a short interval of 200 ms the next trial started. If no response was recorded within two seconds, the next trial started automatically. The software program "Presentation" controlled the presentation of the trial sequences.

Results

One participant made more than 40% errors and was excluded from further analyses. Naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers (4.7% of the data) and not included in the RT analysis. Furthermore, trials including naming errors, lip smacks, or technical failures were excluded from the analyses (9.8% of the data). In total, there were

14.5% errors[11]. The mean naming latencies and error rates are summarized in Table 1. Analyses of variance (4 x 4) were run with Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) as independent variables. Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Table 1: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 1A.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	729 (11.5)	796 (16.4)	751 (13.0)	650 (9.9)
phonologically related	686 (10.5)	717 (9.8)	683 (8.6)	642 (6.5)
unrelated	706 (7.3)	786 (10.7)	744 (8.4)	649 (9.1)
control	652 (8.2)	674 (11.1)	684 (8.0)	638 (7.5)
net semantic effect [a]	–23 (–4.2)	–10 (–5.7)	–7 (–4.6)	–1 (–0.8)
net phonological effect [a]	20 (–3.2)	69 (0.9)	61 (–0.2)	7 (2.6)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

Reaction times. Significant main effects of Distractor Type ($F1(3,66) = 77.63$, $MSE = 1269.27$, $p < .001$; $F2(3,93) = 71.11$, $MSE = 1952.64$, $p < .001$) and of SOA were obtained ($F1(3,66) = 36.05$, $MSE = 4427.70$, $p < .001$; $F2(3,93) = 191.09$, $MSE = 1131.84$, $p < .001$). The interaction between SOA and Distractor Type was also significant in both analyses ($F1(9,198) = 14.39$, $MSE = 831.491$, $p < .001$; $F2(9,279) = 12.76$, $MSE = 1316.20$, $p < .001$).

Analyses of simple effects revealed that the effect of Distractor Type was significant at SOA –150 ms ($F1(3,66) = 28.56$, $MSE = 862.75$, $p < .001$; $F2(3,93) = 25.80$, $MSE = 1371.21$, $p < .001$). The difference between the unrelated and both the semantic and the phonological distractor was tested by means of paired-

[11] The error rate is relatively high, compared to other experiments. This can be explained by the short inter-trial time of 200 ms, leading to errors as consequences of a preceding "voice-key"-error. The inter-trial time was enlarged to 500 ms starting for Experiment 2A and following. Pechmann, Reetz and Zerbst (1989) are reporting general problems with "voice-key"-measures.

samples t-tests. At SOA –150 ms, a semantic interference effect (23 ms) occurred which was significant by participants and marginally significant by items (t1(22) = 3.32, SD = 33.8, p < .01; t2(31) = 2.29, SD = 62.4, p = .05). Also, a significant phonological facilitation effect (20 ms) was obtained (t1(22) = 2.86, SD = 33.8, p < .01; t2(31) = 3.44, SD = 39.1, p < .01) at that SOA.

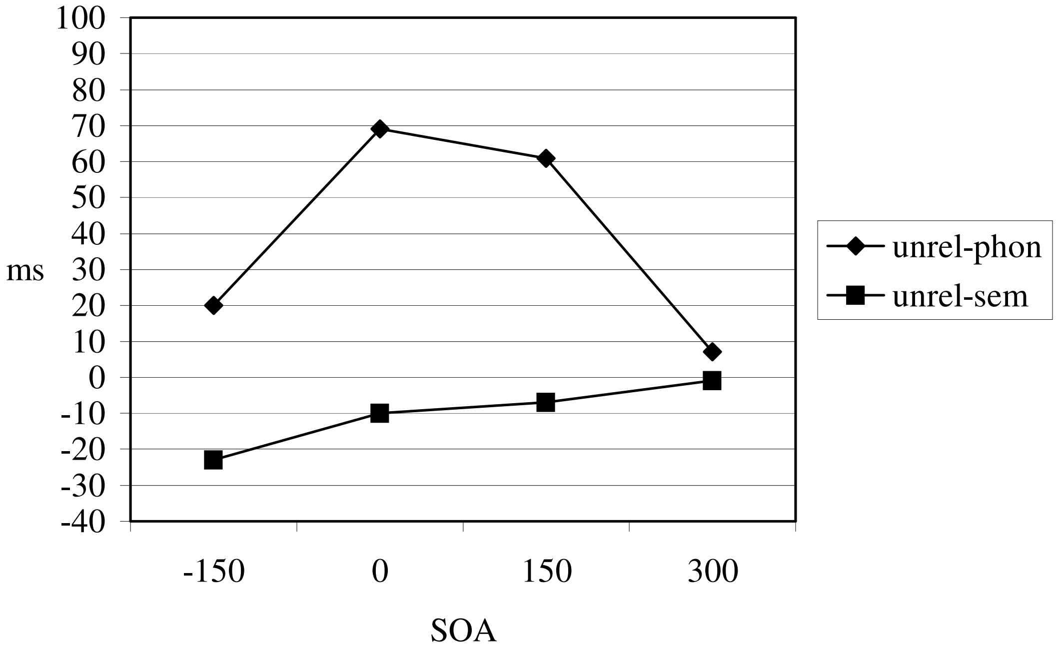
The effect of Distractor Type was also significant at SOA 0 ms (F1(3,66) = 60.75, MSE = 1281.36, p < .001; F2(3,93) = 51.35, MSE = 2136.65, p < .001). The slight semantic interference effects at SOAs 0 ms (10 ms) was not significant (t1(22) = 1.01, SD = 48.4, n.s.; t2(31) = 1.09, SD = 68.1, n.s.), but the phonological facilitation (69 ms) at that SOA was significant in both analyses (t1(22) = 6.84, SD = 48.6, p < .001; t2(31) = 5.48, SD = 70.2, p < .001).

At SOA +150 ms, the effect of Distractor Type was significant as well (F1(3,66) = 24.63, MSE = 1266.05, p < .001; F2(3,93) = 28.17, MSE = 1529.68, p < .001). The semantic interference effect (7 ms) was not significant (both ts < 1.), whereas the phonological facilitation effect (61 ms) was (t1(22) = 5.04, SD = 57.4, p < .001; t2(31) = 6.64, SD = 51.9, p < .001).

At SOA +300 ms the effect of Distractor Type was no longer significant (F1(3,66) = 2.17, MSE = 353.57, n.s.; F2(3,93) = 1.21, MSE = 863.71, n.s.). All effects obtained in Experiment 1A are visualized in Figure 5.

Error rates. A significant effect of Distractor Type was obtained (F1(3,66) = 11.30, MSE = 3.22, p < .001; F2(3,93) = 11.19, MSE = 2.34, p < .001). The effect of SOA was only significant by items but not by participants (F1(3,66) = 1.58, MSE = 15.16, n.s.; F2(3,93) = 7.47, MSE = 2.30, p < .001). The interaction of Distractor Type and SOA was not significant (F1(9,198) = 1.87, MSE = 2.25, p = .06; F2(9,279) = 1.46, MSE = 2.07, n.s.).

Figure 5: Semantic and phonological effects obtained in Experiment 1A.



The analysis of simple effects revealed a significant effect of Distractor Type at SOA –150 ms (F1(3,66) = 3.47, MSE = 2.62, p < .05; F2(3,93) = 3.46, MSE = 1.89, p < .05). Furthermore, paired-samples t-tests revealed that at SOA –150 ms participants made significantly more errors (+4.2%) in the semantically related condition than in the unrelated condition (t1(22) = 3.04, SD = 2.12, p < .01; t2(31) = 2.90, SD = 1.89, p < .01). Although slightly more errors were made in the phonologically related than in the unrelated condition (+3.2%), this effect was not significant (t1(22) = 1.9, SD = 2.5, p = .07; t2(31) = 1.88, SD = 2.2, p = .07).

At SOA 0 ms, the effect of Distractor Type was significant as well (F1(3,66) = 8.30, MSE = 2.55, p < .001; F2(3,93) = 4.93, MSE = 3.08, p < .01). At that SOA, participants made significantly more errors (+5.7%) in the semantically related than in the unrelated condition (t1(22) = 3.67, SD = 2.4, p < .01; t2(31) = 2.59, SD = 2.9, p < .05) while there was no phonological effect (both ts < 1).

The effect of Distractor Type was also significant at SOA +150 ms (F1(3,66) = 6.43, MSE = 2.05, p < .01; F2(3,93) = 4.60, MSE = 2.07, p < .01). At this SOA, again more errors (+4.6%) were made in the semantically related than in the unrelated condition ($t1(22) = 3.63$, $SD = 2.0$, $p < .01$; $t2(31) = 2.98$, $SD = 2.0$, $p < .01$), but no phonological effect occurred (both ts < 1).

Finally, at SOA +300 ms, the effect of Distractor Type was no longer statistically significant ($F1(3,66) = 2.03$, $MSE = 2.74$, n.s.; $F2(3,93) = 2.63$, $MSE = 1.52$, $p = .06$), but there was a tendency towards fewer errors (–2.6%) in the phonologically related than in the unrelated condition ($t1(22) = 1.99$, $SD = 1.99$, $p = .06$; $t2(31) = 2.04$, $SD = 1.64$, $p = .05$), whereas there was no semantic effect at this SOA (both ts < 1).

Discussion

The data obtained in Experiment 1A demonstrated that the chosen distractor words influenced the picture naming latencies in a picture-word interference paradigm in the expected way. At SOA –150 ms a semantic interference effect occurred that is well established in the literature (e.g. Glaser & Düngelhoff, 1984; Schriefers, Meyer & Levelt, 1990). While the semantically related distractor pre-activates the concept of the picture, it inhibits the selection of the target lemma. All models described in chapter 3 can handle this effect, no matter which mechanism is assumed for the lemma selection process (e.g. "Luce-ratio" or lateral inhibition).

Phonological facilitation effects were measured across a wide SOA range (from –150 ms to +150 ms) in Experiment 1A. The phonological effects can be attributed to the influence of phonologically related distractor words to the word form encoding as well as to the stage of phoneme retrieval during the production of the target word. The effect at SOA –150 ms is curious under the assumptions of the discrete two-stage model, because it occurs simultaneously with the semantic interference effect (q.v. Starreveld & La Heij, 1996), while the theory assumes no overlap between these two stages. Phonological facilitation effects with distractors at negative SOAs have been reported in the literature before (e.g. Damian & Martin, 1999 for visual distractors at –200 ms and –100 ms; Jescheniak & Schriefers, 2001 for auditory distractors at –300 ms and –150 ms). Cutting and Ferreira (1999) argued that if "the phonologically related distractor affects picture naming at the same time as a semantically related distractor, then evidence for an overlapping time course of semantic and phonological processing is revealed and cascading is implicated" (p. 321). However, it might be argued that at an even earlier SOA (e.g. –300 ms) only semantic but no phonological effects would be visible and that the semantic interference effect at –150 ms is not fully significant by items and therefore may be spurious.

The outcome of Experiment 1A demonstrated that the set of distractor words can influence the naming of the pictures and produce the expected effects. This is important for Experiment 1B, because this experiment tests whether there is any semantic or phonological activation of the picture name when an associate of that picture is to be named.

Experiment 1B – Associate Naming

Method

Participants. Participants in Experiment 1B were twenty-four undergraduate students of the Maastricht University. All participants were native speakers of Dutch and had normal or corrected-to-normal vision. They were aged between 18 and 34 years (mean: 23 years) and none had participated in Experiment 1A. The participants earned € 7.50 for their participation in the experiment.

Materials. The stimuli were exactly the same as in Experiment 1A.

Design. The design was very similar to Experiment 1A. Experiment 1B consisted of four parts. In the first part the participants were presented with the same pictures as in Experiment 1A and were requested to name them. In the second part, each picture appeared on the screen together with its associate added below the picture. Both remained in view until the participants pressed a button. Participants were asked to learn the associate for each picture. In the third part, the participants practiced naming the associates in response to the pictures. Each picture was presented once in the center of the screen preceded by a fixation point. The participants' task was to name the picture's associate, e.g. **melk** (milk) in response to the picture of a **cow**. The experimenter corrected participants in case they did not use the designated associate in response to a given picture. This part was repeated once including "voice-key" triggering of the next trial, so that the participant could get used to this measurement method. The fourth part was the proper associate naming experiment. This part was again identical to the third part of Experiment 1A except that the participants were asked not to name the picture but to name its associate. The rest of the design was identical to Experiment 1A.

Procedure. The procedure was identical to Experiment 1A.

Results

The data of two participants were excluded from the analysis because they had an error rate higher than 20% and a mean reaction time of more than 1100 ms. Naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the RT analysis (6.2% of the data). Furthermore, trials including naming errors, lip smacks, or technical failures were excluded from the analyses (3.5% of the data). Altogether 9.7% of the data was discarded from the analysis. The mean naming latencies and error rates are summarized in Table 2. Analyses of variance (4 x 4) were run with Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) as independent variables. Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Table 2: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 1B.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	779 (3.0)	815 (3.0)	834 (4.4)	779 (5.1)
phonologically related	781 (2.6)	793 (2.3)	815 (3.7)	765 (3.6)
unrelated	792 (4.0)	833 (3.7)	836 (3.8)	775 (3.8)
control	782 (2.4)	790 (3.7)	794 (4.0)	750 (2.6)
net semantic effect [a]	13 (1.0)	18 (0.7)	2 (–0.6)	–4 (–1.3)
net phonological effect [a]	11 (1.4)	40 (1.4)	21 (0.1)	10 (0.2)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

Reaction times. On average, naming latencies in the associate naming task were about 95 ms longer than in the picture naming task employed in the previous experiment. A significant main effect of Distractor Type ($F1(3,63) = 19.93$, $MSE = 803.02$, $p < .001$; $F2(3,93) = 18.87$, $MSE = 1164.64$, $p < .001$) and SOA ($F1(3,63) = 4.78$, $MSE = 10212.68$, $p < .01$; $F2(3,93) = 55.17$, $MSE = 1218.60$, $p < .001$) was observed. The interaction between Distractor Type and SOA was also significant (F1(9,189) = 4.32, MSE = 466.77, p < .001; F2(9,279) = 2.83, MSE = 1122.54, p < .01).

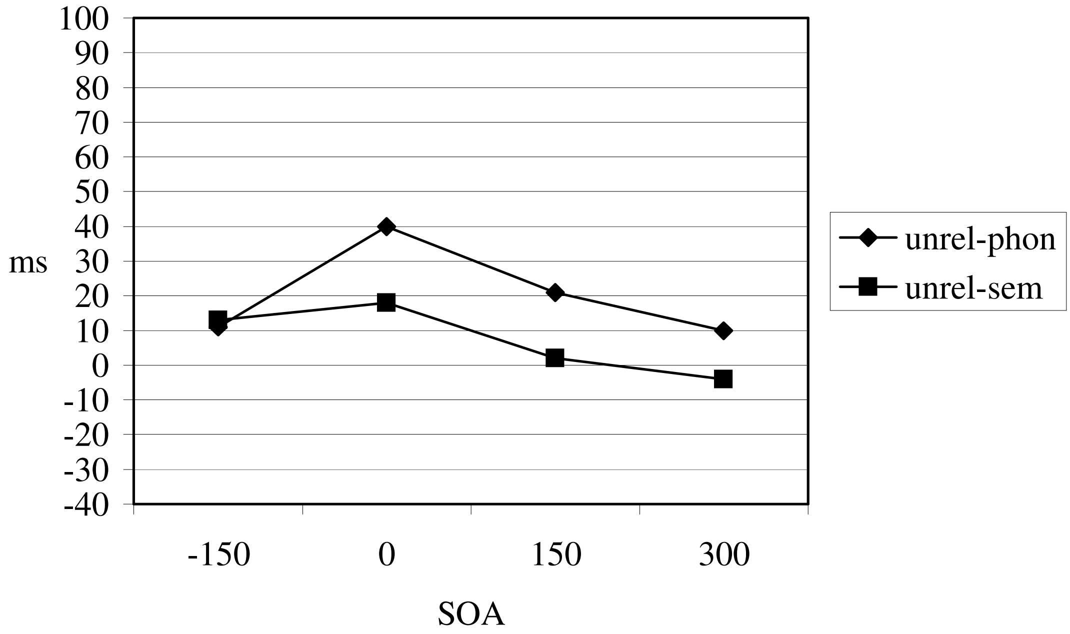
The analysis of simple effects showed that the effect of Distractor Type was not significant at SOA –150 ms (F1(3,63) = 2.02, MSE = 386.31, n.s.; F2(3,93) = 1.19, MSE = 988.29, n.s.). Paired-samples t-tests were conducted to compare the two related distractor conditions with the unrelated distractor condition for all four SOAs. At SOA –150 ms, a slight semantic facilitation effect of 13 ms was observed which was significant by participants and marginally significant in the analysis by items (t1(21) = 2.21, SD = 28.3, p < .05; t2(31) = 1.73, SD = 46.4, p = .09) and a phonological facilitation effect of 12 ms that was marginally significant in the analysis by participants and not significant in the analysis by items (t1(21) = 1.76, SD = 30.6, p = .09; t2(31) = 1.42, SD = 43.4, p = n.s.).

A significant effect of Distractor Type was obtained for SOA 0 ms (F1(3,63) = 12.49, MSE = 724.58, p < .001; F2(3,93) = 11.01, MSE = 1209.40, p < .001). At SOA 0 ms, the semantic facilitation effect increased to 18 ms and remained significant in the analysis by participants and marginally significant in the item analysis (t1(21) = 2.27, SD = 38.1, p < .05; t2(31) = 1.93, SD = 56.6, p = .06). Furthermore, at the same SOA, the phonological facilitation increased to a fully significant 40 ms effect (t1(21) = 5.57, SD = 34.1, p < .001; t2(31) = 3.97, SD = 58.1, p < .001).

At SOA +150 ms, the effect of Distractor Type was significant as well (F1(3,63) = 11.41, MSE = 738.92, p < .001; F2(3,93) = 7.96, MSE = 1352.87, p < .001). Although no semantic effect was apparent at this SOA (t1(21) = 0.36, SD = 36.2, n.s.; t2(31) = 0.32, SD = 49.4, n.s.), a significant phonological facilitation effect of 21 ms was obtained (t1(21) = 3.42, SD = 29.6, p < .005; t2(31) = 2.11, SD = 53.6, p < .05).

Finally, at SOA +300 ms the effect of Distractor Type was again significant (F1(3,63) = 10.74, MSE = 353.50, p < .001; F2(3,93) = 6.36, MSE = 981.71, p < .01), but neither was there a semantic effect at this SOA (t1(21) = 0.75, SD = 25.3, n.s.; t2(31) = 0.52, SD = 49.8, n.s.), nor was the 10 ms phonological effect significant (t1(21) = 1.90, SD = 25.8, p = .07; t2(31) = 1.06, SD = 47.6, n.s.). Results of Experiment 1B are visualized in Figure 6.

Figure 6: Semantic and phonological effects obtained in Experiment 1B.



Error rates. Neither the effect of Distractor Type (F1(3,63) = 1.20, MSE = 1.49, n.s.; F2(3,93) = 1.86, MSE = 0.66, n.s.), not the effect of SOA (F1(3,63) = 1.07, MSE = 1.89, n.s.; F2(3,93) = 1.52, MSE = 0.92, n.s.) nor the interaction of Distractor Type and SOA (both Fs < 1) were significant.

Discussion

A general result of Experiment 1B is that the reaction times in associate naming are slower than in picture naming. Compared to Experiment 1A, response latencies were around 95 ms slower. This effect can be attributed to the paradigm. The target associates receive no direct activation, but are activated via links to the concept of the picture name (q.v. section 3.4). So, slower reaction times in associate naming were expected.

The results of Experiment 1B are interesting in many respects. First, signs of semantic facilitation were found at early SOAs (–150 ms and 0 ms), although not fully significant by items. This was predicted by all three models, discrete, cascading and feedback theories of lexical access. When the distractor word (e.g. **ezel**, donkey) that is semantically related to the picture (e.g. **koe**, cow) enters the psycholinguistic processing system, presumably it activates its corresponding lexical node, which spreads activation to its concept (e.g. EZEL, donkey). From there activation spreads to all its category members including KOE (cow). Due to the assumption that perception and production network coincide for the lemma level and the conceptual level the conceptual node KOE receives activation from two sides, i.e. the picture and the distractor word. As a consequence, the associatively linked node MELK (milk) can be activated faster and naming latencies for the associate **melk** will be reduced. In lemma selection, the situation is enlarged from two highly activated lemmas in picture naming, to three in associate naming.

According to the "Luce-ratio" *ezel* (donkey) and *koe* (cow) are no strong competitors for *melk (milk)*, because they are no members of the same semantic category. In picture naming the two competing lemmas are member of the same semantic category, so lemma selection is delayed, while it is not in associate naming.

The facilitation effect is also explainable by means of the theory of lateral inhibition (q.v. Berg & Schade, 1992; Schade & Berg, 1992). The activated lemma nodes *koe* and *ezel* will inhibit each other more than the target lemma *melk*, due to a closer semantic relationship. So the selection of the target lemma will be faster than in the unrelated condition. However, the facilitation effect is only visible at early SOAs, since at later SOAs the conceptual node of the associate will already be activated by the concept of the picture and a relatively late activation from the distractor will not have an effect.

Another possibility for the semantic facilitation effects could be that the semantically related distractors had relatively high associative connections with the target associates. This could be because the picture had strong associative links with the targets and the semantic distractors are from the same semantic category as the pictures. Therefore they might have an associative link with the targets as well. After a check it turned out that one of the 32 semantic distractors was strongly associatively related to the response: **gitaar** (guitar) being the semantically related distractor for the picture of a **harp** (harp) was highly associatively related (32%) to the target associate **muziek** (music). The overall mean percentage of associative relatedness between semantically related distractor words and the targets reached 2.3% (incl. guitar – music) which is much lower than the average associative relatedness between the pictures and the targets of

26% (see Materials section of Experiment 1A)[12]. Nevertheless, the statistical analyses were carried out once again, without the semantic distractor **gitaar** but the results did not change with respect to significance.

Second, robust phonological priming effects were obtained. This is interesting because the participants' responses (e.g. **melk**; milk) and the distractor words (e.g. **koek**; cake) were never phonologically related. The phonological relation exists between the distractor and the picture name (e.g. **koe**; cow). According to the discrete two-stage model of lexical access (Levelt, Roelofs & Meyer, 1999), the picture **cow** activates its concept (and via activation spreading also its lemma) because the associate can only be activated indirectly via the picture's concept. Since the picture name itself is not produced, there is no reason to select it and to activate its phonological representation according to the discrete two-stage model. Apparently, however, this is what happens, and this is predicted by cascaded models and feedback theories of lexical access. When participants are presented with a picture (e.g. **koe**; cow) to cue the response of an associate (e.g. **melk**; milk), activation does not stop at the lemma level but spreads all the way down to the phonological form of the word.

Feedback models (e.g. Dell, 1986) can explain the facilitating phonological effect. Since a phonologically related distractor like **koek** (/kuk/) largely overlaps with the picture name **koe** (/ku/) in terms of segments, these segments become also activated by the phonologically related distractor word as well as the word form. When activation spreads back to earlier encoding levels (e.g. lemma level), the phonologically related condition will have an advantage as compared to the unrelated condition. The conceptual node of KOE receives activation from two sides, i.e. top down from the concept and bottom up from the phonological representations, leading to faster naming latencies of the associate.

However, there might be an alternative account. From the comprehension literature it is known that words (and non-words) can activate sets of words in the perceptual network that are form-related, so-called *phonological cohorts* (e.g. Zwitserlood, 1989). According to Levelt et al.'s (1999) theory, this phonological

[12] Associative links between semantically related distractors and picture names were also controlled by means of the association lists for Dutch (e.g. De Groot, & De Bil, 1987; Lauteslager, Schaap, & Schievels, 1986). The mean relation was 2.3%, which is as weak as the associative relation between distractor words and target associates. Phonologically related distractors were not associatively connected with the target associates.

cohort of word forms activates its corresponding lexical nodes, which are shared between the perceptual and production networks. Therefore, if the phonological distractor **koek** (cake) activates the word form <koe> (cow) in the perceptual network, this word form can activate its corresponding lemma *koe* and from there activation can flow to the concept KOE (cow), and thus facilitating the activation of the associate MELK (milk) relative to an unrelated condition (see also Roelofs et al., 1996). This alternative account would be compatible with the discrete two-stage model of lexical access (e.g. Levelt, Roelofs & Meyer, 1999). This alternative account only works in case that picture name (e.g. **koe**; cow) and phonological distractor (e.g. **koek**; cake) are onset-related, i.e. they have segmental overlap at the word beginning. Levelt et al. (1999) state that an end-related distractor such as **summer** will hardly activate the word **hammer** in its perceptual cohort, but rather words like **sum** and **summit**. Therefore, in Experiments 2A and 2B phonologically related distractors are used, which share overlapping segments at the end of words, not at the beginning (e.g. picture: **koe** /ku/, cow; distractor: **taboe** /tabu/, taboo). If the phonological facilitation effect in associate naming can be replicated with these distractors, more evidence for the interactive feedback model and against the discrete two-stage model would be reported.

5.2 End-related phonological distractors, presented visually

The two experiments reported in the following were conducted with end-related phonological distractor words to investigate the processes at the phonological encoding stages in more detail. While the phonological facilitation effects described in Experiments 1A and 1B could also be ascribed to the lemma level, assuming cohort-effects (q.v. Roelofs et al., 1996) end-related distractors (e.g. **taboe**, taboo; picture: **koe**, cow) will not be able to activate a phonological cohort. If phonological effects can be obtained in Experiment 2A and 2B, they can be attributed to the phonological encoding stages.

Experiment 2A is a picture-word interference experiment similar to Experiment 1A to validate the materials that will be used in Experiment 2B. The only change concerning the material was that the phonologically related distractors shared overlapping end segments with the picture name in Experiment 2A. Due to the fact that the semantically related distractors remained the same as in the previous experiments, it is predicted to replicate the semantic inhibition effects described in Experiment 1A. Concerning the phonologically related distractors facilitating effects are expected in the picture naming task, according to several occurrences in the literature (q.v. Meyer & Schriefers, 1991).

The results of Experiment 2B will show if the effects obtained in the associate naming experiment 1B are consistent. If so, it is expected to retrieve semantic facilitation effects again in Experiment 2B, because the material was changed only with respect to the phonological distractors. More important is the way in which the phonologically end-related stimuli will work. If phonological effects can be found, the discrete two-stage model will not be able to explain these effects without difficulties, because phonological activation of the picture name is implied in this situation. Spreading-activation models can handle phonological effects caused by end-related distractors.

Experiment 2A – Picture Naming

Method

Participants. Twenty-four undergraduate students of Maastricht University participated in Experiment 2A. All participants were native speakers of Dutch and had normal or corrected-to-normal vision. They were between 18 and 29 years of age (mean: 20 years) and had not participated in earlier experiments of this study. Participants were paid € 5.00 for their participation in the experiment.

Materials. The materials used in Experiment 2A were identical to those used in Experiment 1A except for one distractor condition, i.e. the phonological condition. The phonological distractors in Experiment 2A were selected such that the picture name (e.g. **koe** /ku/; cow) and the distractor (e.g. **taboe** /tabu/; taboo) segmentally overlap at the end. The mean segmental overlap in number of phonemes (DISC representation in CELEX) of phonological distractors and picture names increased from 60% in Experiment 1A to 64% in Experiment 2A. The whole list of pictures and distractor words used in Experiment 2A can be found in Appendix B.

Design and Procedure. The design and procedure in Experiment 2A were identical to Experiment 1A, except that the inter-trial-interval was increased from

200 ms to 500 ms to forestall some of the voice-key errors that occurred in the first experiments as consequence of a too short interval.

Results

Naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the analysis (4.7% of the data). Furthermore, some data included naming errors or voice key failures (4.8% of the data) were excluded. Altogether, 9.5% of the data were not included in the analyses. The mean naming latencies and error rates are summarized in Table 3. Analyses of variance (4 x 4) were run with Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) as independent variables. Separate analyses were carried out with participants (F_1) and items (F_2) as random variables.

Table 3: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 2A.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	726 (4.3)	784 (7.8)	701 (6.9)	644 (4.0)
phonologically related	660 (4.0)	701 (4.7)	664 (4.2)	638 (3.6)
unrelated	704 (6.4)	759 (3.8)	711 (6.5)	644 (3.8)
control	659 (4.7)	678 (3.9)	673 (4.9)	642 (3.3)
net semantic effect [a]	–22 (2.1)	–25 (–4.0)	10 (–0.4)	0 (–0.2)
net phonological effect [a]	44 (2.4)	58 (–0.9)	47 (2.3)	6 (0.2)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

Reaction times. A significant main effect of Distractor Type ($F1(3,69) = 97.80$, $MSE = 670.90$, $p < .001$; $F2(3,93) = 81.77$, $MSE = 1100.65$, $p < .001$) and of SOA ($F1(3,69) = 39.32$, $MSE = 3146.74$, $p < .001$; $F2(3,93) = 169.28$, $MSE = 1017.71$, $p < .001$) was obtained. The interaction between Distractor Type and SOA was also significant ($F1(9,207) = 18.81$, $MSE = 557.24$, $p < .001$; $F2(9,279) = 20.90$, $MSE = 739.61$, $p < .001$).

Analyses of simple effects revealed a significant effect of Distractor Type at SOA –150 ms ($F1(3,69) = 33.36$, $MSE = 807.97$, $p < .001$; $F2(3,93) = 29.76$, $MSE = 1245.79$, $p < .001$). Again, paired-samples t-tests were conducted on the differences between the unrelated condition and the phonologically related distractor condition, as well as on the differences between the unrelated and the semantic condition. At SOA –150 ms, a significant semantic interference effect of 22 ms occurred ($t1(23) = 2.64$, $SD = 40.9$, $p < .05$; $t2(31) = 2.54$; $SD = 54.1$, $p < .05$) and a significant phonological facilitation effect of 44 ms was obtained ($t1(23) = 9.6$, $SD = 22.7$, $p < .001$; $t2(31) = 6.51$, $SD = 39.3$, $p < .001$).

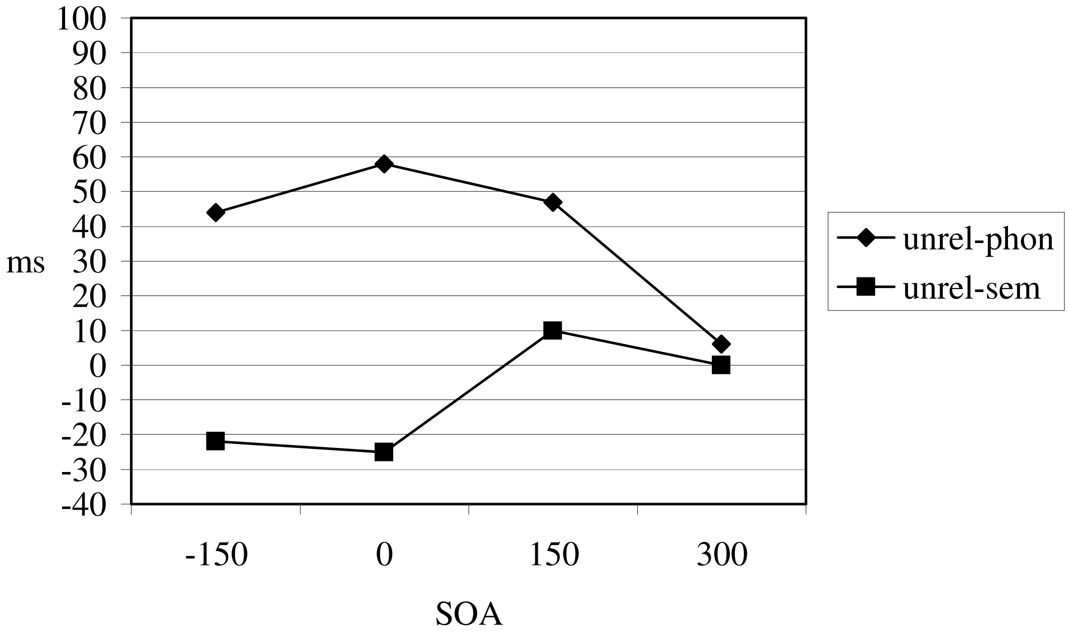
At SOA 0 ms, the effect of Distractor Type was also significant ($F1(3,69) = 98.83$, $MSE = 586.81$, $p < .001$; $F2(3,93) = 79.71$, $MSE = 1048.10$, $p < .001$). At that SOA, semantic interference was 25 ms ($t1(23) = 4.35$, $SD = 28.1$, $p < .001$; $t2(31) = 4.39$, $SD = 38.0$, $p < .001$), while at the same SOA phonological facilitation increased to 58 ms ($t1(23) = 9.9$, $SD = 28.4$, $p < .001$; $t2(31) = 6.43$, $SD = 51.0$, $p < .001$).

The effect of Distractor Type was also significant at SOA +150 ms ($F1(3,69) = 18.01$, $MSE = 661.02$, $p < .001$; $F2(3,93) = 23.40$, $MSE = 667.00$, $p < .001$). At SOA +150 ms, the semantic effect was reduced to non-significant 10 ms ($t1(23) = 1.35$, $SD = 38.4$, n.s.; $t2(31) = 1.61$, $SD = 41.4$, n.s.), while the phonological facilitation was still 47 ms ($t1(23) = 6.11$, $SD = 37.5$, $p < .001$; $t2(31) = 6.22$, $SD = 42.8$, $p < .001$).

Finally, at SOA +300 ms, the effect of Distractor Type was no longer significant (both $Fs < 1$). The effects obtained in Experiment 2A are depicted in Figure 7.

Error rates. A significant effect of Distractor Type was obtained ($F1(3,69) = 4.68$, $MSE = 1.28$, $p < .01$; $F2(3,93) = 4.70$, $MSE = 0.96$, $p< .01$). The effect of SOA was significant in the analysis by items but not by participants ($F1(3,69) = 2.03$, $MSE = 3.24$, n.s.; $F2(3,93) = 3.55$, $MSE = 1.39$, $p < .05$). The interaction of Distractor Type and SOA was significant ($F1(9,207) = 2.81$, $MSE = 1.17$, $p < .01$; $F2(9,279) = 2.58$, $MSE = 0.96$, $p < .01$).

Figure 7: Semantic and phonological effects obtained in Experiment 2A.



Analyses of simple effects demonstrated that the effect of Distractor Type at SOA –150 ms was only significant by items but not by participants ($F1(3,69) = 1.94$, $MSE = 1.41$, n.s.; $F2(3,93) = 2.76$, $MSE = 0.74$, $p < .05$). Paired-samples t-tests showed that slightly fewer errors (–2.1%) were made in the semantically related than in the unrelated condition. This effect was only significant by items, not by participants ($t1(23) = 1.72$, $SD = 1.90$, n.s.; $t2(31) = 2.49$, $SD = 114$, $p < .05$). In the phonologically related condition, participants made significantly fewer errors (–2.4%) than in the unrelated condition ($t1(23) = 2.23$, $SD = 1.7$, $p < .05$; $t2(31) = 2.33$, $SD = 1.4$, $p < .05$).

At SOA 0 ms, there was a significant effect of Distractor Type ($F1(3,69) = 6.99$, $MSE = 1.25$, $p < .001$; $F2(3,93) = 5.18$, $MSE = 1.27$, $p < .01$). At this SOA, participants made significantly more errors (+4.0%) in the semantically related than in the unrelated condition ($t1(23) = 3.51$, $SD = 1.81$, $p < .01$; $t2(31) = 2.98$, $SD = 1.84$, $p < .01$), whereas there was no phonological effect ($t1(23) = 1.07$, $SD = 1.33$, n.s.; $t2(31) = 1.02$, $SD = 1.21$, n.s.).

Distractor Type was also significant at SOA +150 ms ($F1(3,69) = 3.69$, $MSE = 1.11$, $p < .05$; $F2(3,93) = 2.78$, $MSE = 1.10$, $p < .05$). While there was no semantic effect at this SOA (both ts < 1), participants made 2.3% fewer errors in the phonologically related than in the unrelated condition ($t1(23) = 2.39$, $SD = 1.5$ $p < .05$; $t2(31) = 2.81$, $SD = 1.1$, $p < .01$).

Finally, at SOA +300 ms there was no effect of Distractor Type (both $Fs < 1$).

Discussion

As expected, the semantic interference effect found in Experiment 1A was replicated. In Experiment 2A, semantic interference was obtained also at SOA 0 ms, whereas in Experiment 1A it was only found at SOA –150 ms. This finding supports the assumption that the semantically related distractors were chosen carefully and work in the expected way.

Interestingly, robust phonological facilitation from end-related phonological distractors occurred across a wide range of SOAs (from –150 ms to +150 ms), demonstrating that end-related form overlap also facilitates the naming of pictures (q.v. Meyer & Schriefers, 1991). Curiously, semantic interference and phonological facilitation largely overlapped in time (–150 ms to 0 ms). This outcome contradicts the assumptions of the discrete two-stage model that semantic and phonological activation occur strictly serial (e.g. Schriefers et al., 1990). In contrast, cascading models and feedback theories predict phases of parallel semantic and phonological activation, due to the assumption of activation spreading (e.g. Cutting & Ferreira, 1999).

In general the results showed that the end-related stimuli have influence on the phonological activation of the picture name, because cohort effects can be ruled out for end-related distractors, so the material is valid for a test in an associate naming task.

Experiment 2B – Associate Naming

Method

Participants. Twenty-four undergraduate students of Maastricht University, aged between 18 and 28 years (mean: 21 years), participated in Experiment 2B. All participants were native speakers of Dutch and had normal or corrected-to-normal vision. They did not participate in the earlier experiments. Participants were paid € 7.50 for their participation in the experiment.

Materials. The materials used in Experiment 2B were exactly the same as in Experiment 2A. With the help of the association norms for Dutch (i.e. De Groot

& De Bil, 1987; Lautslager et al., 1986) it was controlled that the phonologically related distractors were not associatively related to the target words, i.e. the associates.

Design and *Procedure*. Design and procedure of Experiment 2B were identical to Experiment 1B, except that the inter-trial interval was set from 200 ms to 500 ms (q.v. Experiment 2A).

Results

Three participants were excluded from the analyses due to very high error rates. Naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the analysis (8.7% of the data) as well as data included naming errors or voice key failures (4.3% of the data). Altogether, 13.0% of the data were not included in the analyses. The mean naming latencies and error rates are summarized in Table 4. Analyses of variance (4 x 4) were run with Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) as independent variables. Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Table 4: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 2B.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	819 (4.8)	853 (5.4)	878 (5.1)	831 (3.7)
phonologically related	817 (3.0)	839 (3.9)	876 (4.3)	820 (4.6)
unrelated	832 (3.3)	861 (5.5)	877 (4.9)	821 (4.6)
control	826 (2.4)	839 (5.4)	832 (3.6)	799 (3.7)
net semantic effect [a]	13 (–1.5)	8 (0.1)	–1 (–0.2)	–10 (0.9)
net phonological effect [a]	15 (0.3)	22 (1.6)	1 (0.6)	1 (0.0)

[a] The net effects are computed by subtracting the unrelated condition from the semantically related or phonologically related condition, respectively.

Reaction times. Significant main effects of Distractor Type (F1(3,60) = 9.82, MSE = 973.68, p < .001; F2(3,93) = 11.55, MSE = 1312.80, p < .001) and

SOA were obtained ($F1(3,60) = 4.92$, $MSE = 8436.77$, $p < .01$; $F2(3,93) = 54.75$, $MSE = 1107.89$, $p < .001$). The interaction between Distractor Type and SOA was also significant ($F1(9,180) = 3.74$, $MSE = 728.98$, $p < .001$; $F2(9,279) = 3.25$, $MSE = 1236.34$, $p < .01$).

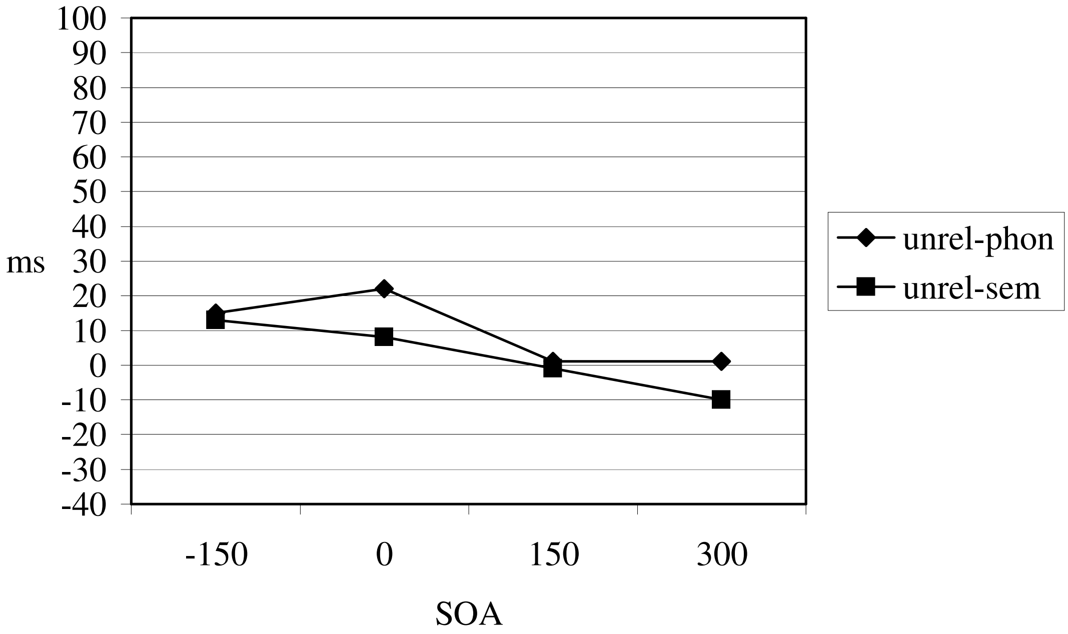
Analyses of simple effects showed that Distractor Type was only marginally significant in the analysis by items but not by participants at SOA –150 ms ($F1(3,60) = 1.56$, $MSE = 659.14$, n.s.; $F2(3,93) = 2.59$, $MSE = 858.21$, $p = .06$). Paired-samples t-tests at SOA –150 ms revealed a semantic facilitation effect of 13 ms that was marginally significant ($t1(20) = 1.9$, $SD = 30.7$, $p = .07$; $t2(31) = 1.99$, $SD = 47.3$, $p = .06$) and a marginally significant phonological facilitation effect of 15 ms ($t1(20) = 1.93$, $SD = 37.0$, $p = .07$; $t2(31) = 2.93$, $SD = 35.4$, $p < .01$).

A significant effect of Distractor Type was also obtained at SOA 0 ms ($F1(3,60) = 3.50$, $MSE = 679.12$, $p < .05$; $F2(3,93) = 2.76$, $MSE = 1307.62$, $p < .05$). At this SOA, there was a significant phonological facilitation effect of 22 ms ($t1(20) = 2.49$, $SD = 39.1$, $p < .05$; $t2(31) = 2.34$, $SD = 53.0$, $p < .05$), while no semantic facilitation was detected ($t1(20) < 1$; $t2(31) = 1.03$, $SD = 53.1$, n.s.).

At SOAs +150 ms and +300 ms, the effect of Distractor Type was significant as well ($F1(3,60) = 11.35$, $MSE = 908.21$, $p < .001$; $F2(3,93) = 10.67$, $MSE = 1391.75$, $p < .001$ and $F1(3,60) = 4.40$, $MSE = 914.16$, $p< .01$; $F2(3,93) = 4.46$, $MSE = 1464.23$, $p< .01$, respectively), but neither phonological nor semantic effects were obtained at these SOAs. (SOA +150 ms phon.: ($t1(20) < 1$; $t2(31) < 1$), sem.: ($t1(20) < 1$; $t2(31) < 1$). SOA +300 ms phon.: ($t1(20) < 1$; $t2(31) < 1$), sem.: ($t1(20) = 1.03$, $SD = 45.4$, n.s.; $t2(31) = 1.07$, $SD = 56.2$, n.s.)). The phonological and semantic effects are illustrated in Figure 8.

Error rates. The effect of Distractor Type was not significant ($F1(3,60) = 1.44$, $MSE = 1.33$, n.s.; $F2(3,93) = 1.63$, $MSE = 0.77$, n.s.) and the effect of SOA was only significant in the analysis by items but not by participants ($F1(3,60) = 1.81$, $MSE = 2.32$, n.s.; $F2(3,93) = 3.11$, $MSE = 0.88$, $p < .05$). The interaction of Distractor Type and SOA was not significant ($F1(9,180) = 1.03$, $MSE = 1.01$, n.s.; $F2 < 1$).

Figure 8: Semantic and phonological effects obtained in Experiment 2B.



Discussion

The results of Experiment 2B are important for several reasons. A marginal semantic facilitation effect was obtained at SOA -150 ms. This effect supports the findings of Experiment 1B with a different set of participants. While the semantic effect is explainable by all three models under consideration, the phonological effects obtained in Experiment 2B help to distinguish between the models. In Experiment 2B phonological facilitation was detected at SOA -150 ms and SOA 0 ms. The phonologically related distractors were end-related (e.g. **taboe** /tab**u**/, taboo) to the picture names (e.g. **koe** /k**u**/, cow) that were never overtly produced during the experiment. It is difficult to imagine that the phonological distractors activate a perceptual cohort including the picture name. Nevertheless, slight priming for the word form of the picture caused by end-related distractors is possible, because distractor and picture usually share nucleus and coda at the syllabic level. Most probably the facilitation effect can be ascribed to the segmental level.

According to the interactive feedback model, the facilitating phonological effect for naming an associate can be easily explained. When activation of the picture name cascades down from the conceptual via lemma and word form level to the segmental level, overlapping segments between picture name and phonological distractor were already activated by the presentation of the distractor. That way, the concept of the picture name receives additional activation via feedback from the segmental level via word form and lemma level to the concept node such that the conceptual link to the associate can be activated earlier and the associate can be named faster than in the unrelated condition.

While cascading models of lexical access also assume that the non target picture name will be activated at the phonological level, the data obtained in Experiment 2B pose a problem to discrete accounts of lexical access. The discrete two-stage model can only hold for these effects, if it assumes that even the end-related distractors were able to activate a perceptual cohort including the picture name. The reason why this possibility cannot be completely excluded is that there were pairs of picture names and phonological distractors that overlapped in all but the initial segment, e.g. **akker** (field) – **rakker** (rascal). Thus, it may be possible that due to this large overlap these phonological distractors were nevertheless able to activate the picture name in the perceptual system, due to visual misperception of the distractor (**kamer**, for instance, is visually extremely similar to **hamer**). In order to test this potential alternative explanation, Experiment 2B was replicated with auditory distractors by means of Experiment 5B. Auditory distractors enter the perceptual system strictly sequentially. Therefore, they reduce the possibility of perceptual cohort activation of the picture name due to, for instance, misperception of the onset.

Moreover, it could be argued that the way close semantic associates are activated is not via conceptual links, but rather via word form to word form association. For instance, the way participants produce the word **melk** (milk) when seeing a picture of a **koe** (cow), is by encoding the picture down to the phonological level. Due to the fact that **koe** and **melk** co-occur very often, **melk** is activated and produced. In this scenario, a phonological facilitation effect would be predicted because the phonologically related distractor word **koek** (cake) might activate the picture name due to word form to word form links from the perceptual to the production network (q.v. Levelt et al., 1999). That way, the word form <koe> receives both top down activation from the picture and bottom up activation from the perception-to-production links on the word form level, and hence **melk** could ultimately be produced faster than in the presence of the unrelated condition word **appel** (apple). A problem of this account is that the associate **melk** (milk) will not be activated at the conceptual level, such that the production system does not know if the correct target is encoded and not another associate to the picture name as **boer** (farmer). To rule out this possibility, distractors related to the associate are used in Experiments 3A and 3B. If a semantic effect for **sap** (juice) is found in the associate naming task, this would be evidence for activation of the associate at the conceptual level and at the lemma level.

5.3 Distractors related to the target associates

Experiment 1B and 2B demonstrated that distractor words related to the non-target picture name can influence the naming latencies of an associate. Experiments 3A and 3B are conducted to investigate if distractor words related to the target associates and unrelated to the non-target picture names have effects in an associate naming task.

Experiment 3A includes a picture naming task to control part of the material used in the associate naming study reported in Experiment 3B in a paradigm for which reference values are available (e.g. Lupker, 1979; Glaser & Düngelhoff, 1984; Levelt, et al., 1991).

To conduct a picture naming task, new pictures had to be selected with the former associates as picture names. While a picture of a **stork** (ooievaar) was presented in Experiments 1B and 2B to provoke the expected associative target response **baby** (baby), the picture of a **baby** was shown in Experiment 3A (e.g. picture: **baby**, baby; semantically related distractor: **kleuter**, pre-school-child; phonologically related distractor: **beek**, brook). The stimulus material had to be reduced to a set of twenty pictures, because for twelve associate names (e.g. **lucht**, air) no adequate pictures could be found in the database. By reducing the number of pictures, the number of trials per participant was reduced, too (48 trials per SOA less than in the experiments before). Due to this reason it was possible to include a fifth condition into the experimental set up. A set of end-related distractor words was composed and used as a second phonological condition, besides the begin-related distractor words. (e.g. picture: **baby**, baby; semantically related distractor: **kleuter**, pre-school-child; begin-related distractor: **beek**, brook;

end-related distractor: **fobie**, phobia). The reason to include this fifth condition is to use the chance to test begin-related and end-related distractor words within one experiment, so the effects of these conditions can be compared much better than between experiments (e.g. Experiment 1A and Experiment 2A).

Semantic inhibition effects are expected to occur at early SOAs (-150 ms and 0 ms) in Experiment 3A according to well-known reference experiments (e.g. Glaser & Düngelhoff, 1984; Schriefers et al., 1990). The begin-related distractor words are expected to facilitate naming latencies as well as the end-related distractor words. Due to effects described in earlier studies (e.g. Marslen-Wilson & Zwitserlood, 1989; Meyer & Schriefers, 1991; Schiller 2004) it can be expected that the begin-related distractor words will cause stronger effects than end-related distractors. Phonological effects are expected to occur at an SOA range from 0 ms to +150 ms, which can be easily handled by all models under consideration. Phonological effects at early SOAs, however, would support spreading-activation models (q.v. Levelt et al., 1991; Starreveld, 2000).

To stick to the number of trials used in the earlier associate naming tasks and to keep the comparability of the experiments, the end-related distractor condition used in Experiment 3A was not included into the material of Experiment 3B. It is expected that the presentation of a distractor word that is phonologically similar to the target word should speed up the phonological encoding of the target word. The presentation of the distractor (e.g. **merk**, mark) with the picture of a cow should facilitate the phonological encoding of the target associate (e.g. **melk**, milk), because of the phonological overlap of the first segments (q.v. Schiller, 2004). The models discussed in this dissertation don't make different predictions concerning this effect. According to the different model predictions only the time course of the expected phonological effects can differ. Where discrete models predict phonological effects in later SOAs (e.g. 0 ms – +150 ms) (q.v. Schriefers, Meyer & Levelt, 1990), models assuming bi-directional activation between the lemma level and phonological encoding can also handle phonological effects appearing at earlier SOAs. The same holds for cascading models, due to the assumption, that phonological activation can occur before the semantic encoding is finished.

The effects of semantically related distractor words are not so easy to predict. Based on the effects semantic distractors have in usual picture-word interference tasks, inhibition effects are expected to occur at early SOAs in Experiment 3B (q.v. Glaser & Düngelhoff, 1984; Schriefers, Meyer, & Levelt, 1990). A word sharing its semantic category with the target word (e.g. distractor word: **sap**, juice; target word: **melk**, milk) usually increases the naming latencies at early SOAs (e.g. -150 ms – 0 ms), due to competition effects in lemma selection. In the case of associate naming the effects caused by semantically related distractors at the conceptual level, might be of special importance. In this kind of task, the target concept is activated only indirectly by the presentation of a non-target picture, and not directly as in a picture naming task. A semantic distractor causes pre-activation of categorically related concepts, including the target concept, which can speed up the participant's response at early SOAs. It is also possible to obtain no measurable semantic effects, because semantically related distractor words can cause two effects in different directions annulling each other. They can speed up the activation of the target's concept and at the same time delay the lemma selection process, due to the competition effects between the distractor's and the target's lexical representation.

Experiment 3A – Picture Naming

Method

Participants. The participants in Experiment 3A were twenty-four undergraduate students of Maastricht University, all native speakers of Dutch, who had not participated in one of the experiments described before. The participants were aged between 18 and 28 years with an average age of 21 years. All participants had normal or corrected-to-normal vision. They were paid € 5.00 for their participation in the experiment.

Materials. As described above, some changes were made concerning the stimuli compared to the previous experiments. For the picture naming task in Experiment 3A new pictures had to be selected from the picture database of the Max Planck Institute of Psycholinguistics in Nijmegen. So, the associative targets in the earlier experiments became picture names in this experiment. The material was reduced to twenty pictures, because for twelve associates it was impossible to find adequate pictures.

New distractor words were chosen in the three already known categories, related to the new picture names. In an additional fifth condition an end-related distractor word was selected for every picture. In total, one picture was presented together with five different distractors (e.g. picture: **paard**, horse; semantically related distractor: **ezel**, donkey; begin-related distractor: **paal**, post; end-related distractor: **zwaard**, sword; unrelated distractor: **laars**, boot; neutral distractor: **XXXXX**). The material used in Experiment 3A is listed in Appendix C.

Design. The experimental design was the same as in Experiment 1A and 2A. Due to the changes in the material, participants had to do 120 trials (24 pictures x 5 distractor conditions, including 4 warm-up pictures) per SOA.

Procedure. The procedure was identical to Experiment 2A.

Results

All naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the RT analysis (4.8% of the data), as well as trials including naming errors, lip smacks, or technical failures (4.7% of the data). Altogether 9.5% of the data were not included in the analysis. Table 5 shows the summarized mean naming latencies and error rates. Distractor Type (semantic, begin-related, end-related, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) served as independent variables in the analyses of variance (5 x 4). Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Reaction times. Significant main effects of Distractor Type ($F1(4,92) = 43.03$, $MSE = 1154.19$, $p < .001$; $F2(4,76) = 23.14$, $MSE = 1971.21$, $p < .001$) and SOA ($F1(3,69) = 27.72$, $MSE = 2881.26$, $p < .001$; $F2(3,57) = 76.77$, $MSE = 893.72$, $p < .001$) were obtained in the analyses. The interaction between Distractor Type and SOA was also significant in the analysis by participants and in the analysis by items ($F1(12,276) = 12.95$, $MSE = 732.70$, $p < .001$; $F2(12,228) = 8.95$, $MSE = 987.72$, $p < .001$).

Table 5: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 3A.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	687 (5.2)	757 (6.7)	701 (7.1)	630 (4.6)
begin-related	653 (4.0)	672 (4.2)	644 (4.0)	641 (4.8)
unrelated	672 (5.0)	733 (4.4)	700 (6.5)	636 (4.4)
control	652 (4.0)	663 (5.0)	644 (4.2)	631 (3.3)
end-related	645 (4.2)	662 (5.4)	644 (4.2)	634 (3.3)
net semantic effect [a]	-15 (-0.2)	-24 (-2.3)	-1 (–0.6)	6 (-0.2)
net phon. effect (begin)[a]	19 (1.0)	61 (0.2)	56 (2.5)	-5 (-0.4)
net phon. effect (end)[a]	27 (0.8)	71 (-1.0)	56 (2.3)	2 (1.1)

[a] The net effects are computed by subtracting the semantically related, begin-related or the end-related condition from the unrelated condition, respectively.

In the analyses of simple effects a significant effect of Distractor Type was obtained at SOA –150 ms ($F1(4,92) = 8.09$, $MSE = 898.50$, $p < .001$; $F2(4,76) = 5.05$, $MSE = 1201.60$, $p < .01$). For the begin-related, the end-related and the semantically related distractor condition paired-samples t-tests were conducted in comparison with the unrelated distractor condition for all four SOAs. At SOA –150 ms, a trend to semantic inhibition of 15 ms was observed which was neither significant in the analysis by participants nor in the analysis by items ($t1(23) = 1.44$, $SD = 51.9$, n.s.; $t2(19) = 1.04$, $SD = 50.9$, n.s.). In the begin-related condition a facilitation effect of 19 ms was obtained which was significant in both analyses ($t1(23) = 2.37$, $SD = 39.6$, $p < .05$.; $t2(19) = 2.17$, $SD = 41.1$, $p < .05$). A significant facilitation effect of 27 ms was obtained in the end-related condition ($t1(23) = 3.62$, $SD = 36.5$, $p < .01$; $t2(19) = 2.60$, $SD = 51.4$, $p < .05$).

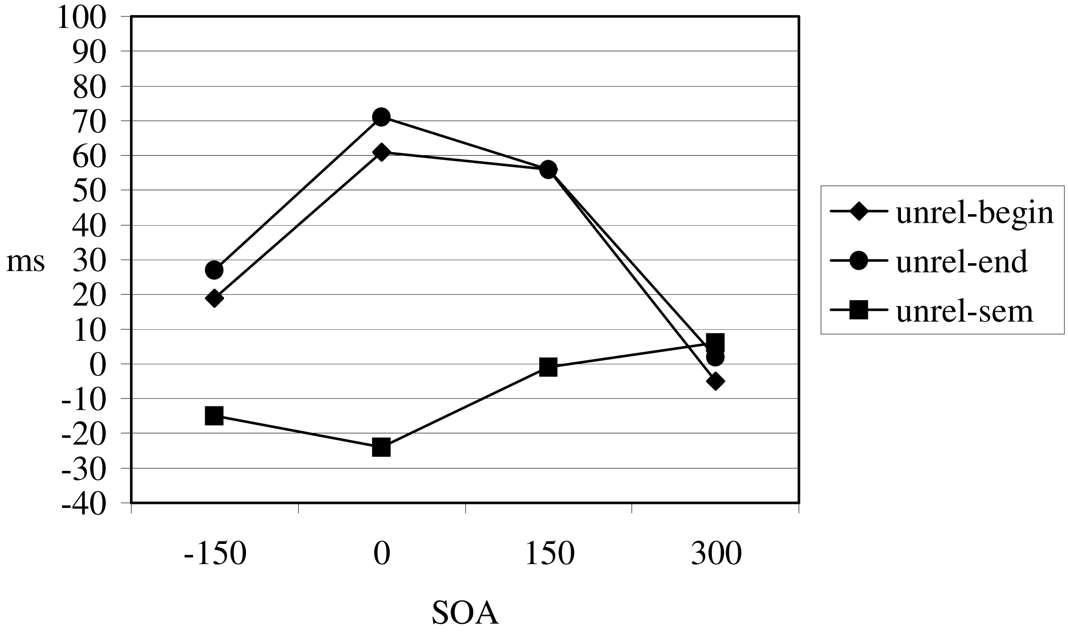
At SOA 0 ms a significant effect of Distractor Type was obtained ($F1(4,92) = 47.09$, $MSE = 1008.25$, $p < .001$.; $F2(4,76) = 24.34$, $MSE = 1748.69$, $p < .001$). The semantic inhibition effect increased to 24 ms at SOA 0 ms and reached significance in both analyses ($t1(23) = 2.74$, $SD = 42.3$, $p < .05$; $t2(19) = 2.62$, $SD = 49.5$, $p < .05$). The phonological facilitation effects reached their maximum at SOA 0 ms and were significant in both conditions. Naming latencies in the begin-related condition were 61 ms faster than naming latencies in the unrelated condition ($t1(23) = 7.55$, $SD = 39.4$, $p < .001$; $t2(19) = 4.24$, $SD = 63.4$, $p < .001$). In the end-related condition reaction times were even 71 ms faster then in the unrelated condition ($t1(23) = 9.00$, $SD = 38.9$, $p < .001$; $t2(19) = 5.67$, $SD = 57.2$, $p < .001$).

A significant effect of Distractor Type was obtained at SOA +150 ms ($F1(4,92) = 26.70$, $MSE = 859.33$, $p < .001$; $F2(4,76) = 19.47$, $MSE = 1184.40$, $p < .001$). The semantic effect decreased to 1 ms at this SOA (both $ts < 1$), but the phonological facilitation effects stayed significant for the begin-related condition (56 ms) ($t1(23) = 6.96$, $SD = 39.3$, $p < .001$; $t2(19) = 5.77$, $SD = 44.1$, $p < .001$) and for the end-related condition (56 ms) ($t1(23) = 5.46$, $SD = 49.8$, $p < .001$; $t2(19) = 4.35$, $SD = 60.1$, $p < .001$).

At SOA +300 ms the effect of Distractor Type was not significant (both $Fs < 1$). Neither in the semantic condition, nor in one of the phonologically related conditions could any effect be obtained (all $ts < 1$). The effects obtained in Experiment 3A are visualized in Figure 9.

Error rates. The error analyses did not show any significant effect. The effect of Distractor Type ($F1(4,92) = 2.08$, $MSE = 1.06$, n.s.; $F2(4,76) = 1.92$, $MSE = 1.37$, n.s.) was not significant. The effect of SOA ($F1 < 1$; $F2(3,57) = 1.86$, $MSE = .87$, n.s.) and the interaction of Distractor Type and SOA (both $Fs < 1$) were also not significant.

Figure 9: Effects of the semantically, the begin- and the end-related condition obtained in Experiment 3A.



Discussion

In Experiment 3A the semantically related distractor words caused a slight inhibition effect at SOA –150 ms and a significant inhibition effect at SOA 0 ms. This kind of influence was expected to occur in a picture naming task (e.g. Lupker, 1979; Glaser & Düngelhoff, 1984; Schriefers et al., 1990).

The begin-related and end-related distractor words caused significant facilitation effects at an SOA range from –150 ms to +150 ms. By testing these two conditions together in one experiment, it is shown that the end-related distractor words are as effective as the begin-related distractor words. At SOA –150 ms and 0 ms their effect is even stronger than the effect caused by the begin-related words. This strong facilitating effect caused by the end-related distractor words can depend on the amount of phonological overlap the distractors have with the picture names (q.v. Schiller, 2004). The mean segmental overlap in number of phonemes (DISC representation in CELEX) was 63% for the begin-related distractor words and the picture names and 65% for the end-related distractor words and the picture names.

The occurrence of the phonological effects at SOA –150 ms cannot be handled without difficulties by serial models of lexical access (but see Levelt, Roelofs & Meyer, 1999), whereas it can be easily explained by cascading models and interactive feedback theories.

To summarize, the data collected in Experiment 3A offer useful reference values for the material that is used in an associate naming task in Experiment 3B.

Experiment 3B – Associate Naming

Method

Participants. Twenty-four undergraduate students of Maastricht University participated in Experiment 3B. None of them had participated in one of the earlier experiments. All participants were native speakers of Dutch and had normal or corrected-to-normal vision. They were between 18 and 24 years of age (mean: 20 years). The participants received € 7.50 for their participation in the experiment.

Materials. The picture material was the same as in the earlier associate naming tasks. Different to the material used in Experiments 1B and 2B, distractor words related to the target associates were chosen in Experiment 3B (e.g. picture: *koe*, cow; target word: **melk**, milk; semantically related distractor: **sap**, juice; phonologically related distractor: **merk**, mark). For a complete list of the distractor words used in the present experiment see Appendix D.

Design. The experimental design was the same as in Experiments 1B and 2B.

Procedure. The procedure was identical to Experiment 2B.

Results

The data of one participant with a mean reaction time of more than 1200 ms were excluded from the analysis. Naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the RT analysis (5.4% of the data), as well as trials including naming errors, lip smacks, or technical failures (7.5% of the data). Altogether 12.9% of the data were not included in the analysis. Table 6 shows the summarized mean naming latencies and error rates. Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) served as independent variables in the analyses of variance (4 x 4). Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Table 6: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 3B.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	830 (9.6)	826 (7.5)	870 (8.2)	813 (7.2)
phonologically related	853 (8.3)	847 (6.9)	842 (7.5)	782 (8.2)
unrelated	857 (9.4)	838 (5.4)	873 (7.3)	808 (7.3)
control	814 (8.8)	822 (6.3)	816 (6.9)	785 (5.8)
net semantic effect [a]	27 (-0.2)	12 (-2.1)	3 (–0.9)	–5 (0.1)
net phonological effect [a]	4 (1.1)	-9 (-1.5)	31 (-0.2)	26 (-0.9)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

Reaction times. A significant main effect of Distractor Type ($F1(3,66) = 22.86$, $MSE = 882.07$, $p < .001$; $F2(3,93) = 11.30$, $MSE = 2424.76$, $p < .001$) and SOA ($F1(3,66) = 4.48$, $MSE = 10902.00$, $p < .01$; $F2(3,93) = 51.18$, $MSE = 1264.85$, $p < .001$) was observed. The interaction between Distractor Type and SOA was also significant ($F1(9,198) = 5.89$, $MSE = 817.92$, $p < .001$; $F2(9,279) = 6.57$, $MSE = 1132.83$, $p < .001$).

The analysis of simple effects showed that the effect of Distractor Type was significant at SOA –150 ms ($F1(3,66) = 8.86$, $MSE = 1044.31$, $p < .001$; $F2(3,93) = 10.26$, $MSE = 1295.54$, $p < .001$). Paired-samples t-tests were conducted to compare the two related distractor conditions with the unrelated distractor condition for all four SOAs. At SOA –150 ms, a semantic facilitation effect of 27 ms was observed which was significant by participants and in the analysis by items ($t1(22) = 3.17$, $SD = 40.5$, $p < .01$; $t2(31) = 2.93$, $SD = 54.6$, $p < .01$). No phonological effect (4 ms) was obtained at this SOA (both $ts < 1$).

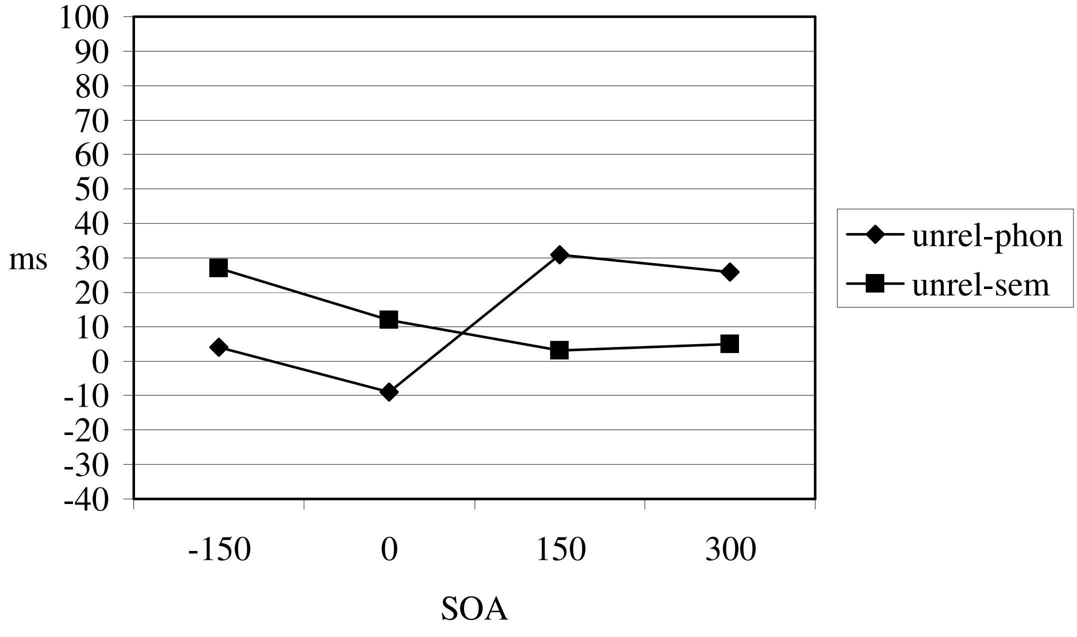
The effect of Distractor Type obtained for SOA 0 ms was significant ($F1(3,66) = 3.22$, $MSE = 928.76$,$p < .05$; $F2(3,93) = 2.73$, $MSE = 1633.63$,$p < .05$). At SOA 0 ms, the semantic facilitation effect decreased to 12 ms and was not significant in both analyses ($t1(22) = 1.50$, $SD = 37.4$, n.s.; $t2(31) = 1.23$, $SD = 60.7$, n.s.). A slight phonological inhibition trend of 9 ms was observed, which was not significant in the analysis by participants or in the analysis by items ($t1(22) = 1.13$, $SD = 38.4$, n. s.; $t2(31) < 1$).

A significant effect of Distractor Type was obtained at SOA +150 ms ($F1(3,66) = 36.85$, $MSE = 448.91$, $p < .001$; $F2(3,93) = 14.00$, $MSE = 1634.72$, $p < .001$). Although the semantic effect decreased to 3 ms at this SOA (both ts < 1), a significant phonological facilitation effect of 31 ms was obtained ($t1(22) = 4.71$, $SD = 32.2$, $p < .001$; $t2(31) = 2.75$, $SD = 65.5$, $p < .05$).

Finally, at SOA +300 ms the effect of Distractor Type was again significant ($F1(3,66) = 6.38$, $MSE = 913.85$, $p < .01$; $F2(3,93) = 7.21$, $MSE = 1259.36$, $p < .001$). No semantic effect was obtained at this SOA (both ts < 1), whereas the phonological facilitation effect (26 ms) stayed significant ($t1(22) = 3.19$, $SD = 39.8$, $p < .01$; $t2(31) = 3.16$, $SD = 51.2$, $p < .01$). The results of Experiment 3B are visualized in Figure 10.

Error rates. Neither the effect of Distractor Type ($F1(3,66) = 1.11$, $MSE = 1.99$, n.s.; $F2(3,93) = 1.04$, $MSE = 2.93$, n.s.), nor the effect of SOA ($F1(3,66) = 0.99$, $MSE = 11.34$, n.s.; $F2(3,93) = 2.25$, $MSE = 2.38$, n.s.) nor the interaction of Distractor Type and SOA (both Fs < 1) were significant.

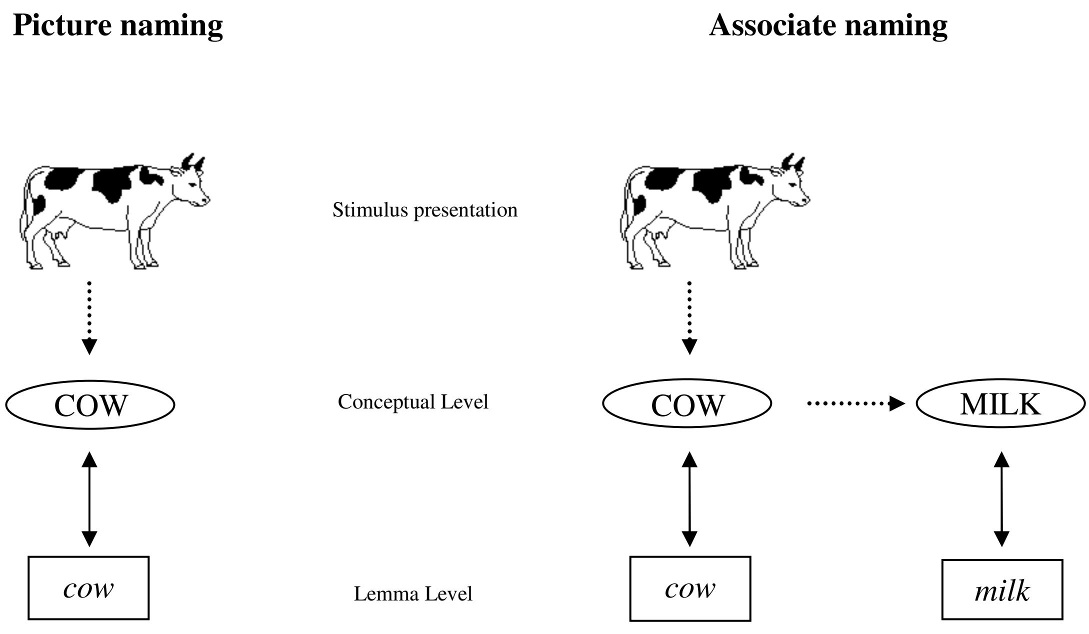
Figure 10: Semantic and phonological effects obtained in Experiment 3B.



Discussion

Response latencies in Experiment 3B confirm again that naming an associate takes more time than naming a picture, because the target word is activated indirectly at the conceptual level. Different to picture naming tasks, the target concept is not activated visually by the presentation of the target in the shape of a picture, but indirectly via cognitive connections that are activated by the presentation of another picture (e.g. MELK, milk; is activated via the picture of a cow, which activates the concept KOE, cow). Consequentially the response latencies in an associate naming task are delayed (approx. 100 ms) in comparison with the response latencies in a picture naming task (q.v. differences in the mean reaction times of Experiment 1A compared with 1B and 2A compared with 2B). Figure 11 illustrates the differences in the activation of the target concept in picture naming and associate naming.

Figure 11: Schematic illustration of the activation flow between picture presentation and lemma selection.
The direction of activation is depicted by arrows. Dotted arrows mean activation of the target concept, which is direct in picture naming (one arrow) and indirect in case of associate naming (two arrows). The amount of activation is not depicted in this figure.



Furthermore, the data obtained in Experiment 3B demonstrate that distractor words related to the target associate influence the response latencies in an associate naming task. At SOA -150 ms a significant semantic facilitation effect was obtained. By comparing Experiment 3A and 3B, it can be concluded, that the effects of semantically related distractor words differ with the task they are used in. While they lead to inhibition effects in a picture naming task, they facilitate the response latencies in an associate naming task.

Presenting a semantic distractor word before the presentation of the picture, pre-activates the concept of the distractor (e.g. SAP, juice), which spreads activation to a set of categorically related items at the conceptual level. The target concept, as a member of the set of categorically related items (e.g. MELK, milk, as a member of the set of soft drinks activated by juice) has already received some activation before the picture is presented and spreads further activation, so the response latency is sped up in this case.

All theories discussed in this manuscript can handle this effect, but they also predict inhibition effects of semantically related distractors at the stage of lemma selection. In Experiment 3B no semantic inhibition effects are obtained. One reason for this might be that the activation rate of the distractor lemma has already decreased when the target lemma is selected, so that these two lemmas are not in strong competition during lemma selection. The activation rate of the distractor lemma could decay during the additional time it takes to activate the target concept via an indirect way. Another possibility is that the facilitation effect of the semantic distractor at the conceptual level is much stronger than the inhibitory effect at the lemma level so that the difference between these effects leads to a significant facilitation effect at SOA -150 ms.

The phonological facilitation effects at SOA +150 ms and +300 ms were expected and can be easily explained in all theories. The fact that no phonological effects could be observed at early SOAs seems to contradict the assumptions of cascading and feedback models at first sight, but that is not the case. Due to the indirect activation at the conceptual level it is assumed that the associate's representations are activated with little delay compared to the representations of the picture name. The delay should be smaller than 100 ms, which is the difference between the mean reaction times in picture naming and associate naming. Investigating the parallel activation of more than one word form it must be assured that the activation-times of the picture's word form and the associate's word form are overlapping. Based on the results of Experiment 1B, 2B and 3B it can be stated that these two word forms are activated in parallel at SOA +150 ms. To get more information on the time window in which these two word forms are activated it is necessary to conduct another experiment with smaller time steps between the SOAs.

Finally, the results of Experiment 3B affirm the results of the first experiments and give some more information on the special characteristics of an associate naming task.

5.4 Begin-related phonological distractors, presented auditorily

In the investigation of effects in associate naming studies the most prominent effects are expected to occur at the level of phonological encoding. To get a more detailed view on the processes at the level of phonological encoding, it was decided to change the modality of distractor words and present the interfering stimuli auditorily in Experiments 4A to 5B.

The distractor words are presented auditorily to ensure the generation of a phonological representation (e.g. Schriefers, Meyer & Levelt, 1990). While visually presented distractor words might activate a graphemic representation rather than a phonological one, auditorily presented interfering stimuli seem to impact the phonological representations, word form and segments, immediately (e.g. Damian & Martin, 1999; Levelt, Roelofs & Meyer, 1999).

According to Damian and Martin (1999) the effects of auditorily presented distractor words may appear across a different SOA range compared to interfering stimuli presented visually. This difference can be explained by the different presentation duration of the distractor words. While auditory stimuli have limited presentation duration, the visually presented distractors are accessible until the participant's response is measured. Due to this effect auditory distractor words usually cause phonological facilitation effects at later SOAs (0 ms to 200 ms) and semantic interference at early SOAs (-200 ms to 0 ms) (e.g. Damian & Martin, 1999; Schriefers, Meyer & Levelt, 1990). The visual presentation of distractors can lead to earlier phonological facilitation effects (SOA -200 ms to +100 ms) and later semantic interference effects (SOA 0 ms to +200 ms), because the distractor word can be recognized earlier and is accessible for a longer period than a spoken one (e.g. Damian & Martin, 1999). Contrary to this explanation, early phonological facilitation effects are obtained in several studies using auditorily presented distractor words (e.g. Starreveld, 2000; Jecheniak & Schriefers, 2001). Several factors may be responsible for the occurrence or non-occurrence of early phonological facilitation. While Jescheniak and Schriefers (2001) were able to exclude a strategic behavior as reason for early effects, Starreveld (2000) showed that the absence of the effect does not depend on the preparation procedure before the start of the experiment. Two other factors are still discussed to inhibit early phonological effects in picture naming studies with auditorily presented distractor words. Starreveld (2000) argues that semantically related distractors could cause this lack of early phonological facilitation, because in many studies where semantically and phonologically related distractor words were used together, no early phonological effects could be reported. This dependency cannot be easily explained with existing models, but another logical influence seems to consist in the amount of phonological mismatch between the phonologically related distractors and the picture names to be pronounced (e.g. Schiller, 2004). While Starreveld (2000) reports phonological facilitation at SOA -300 ms for word part distractors but not for word distractors, Jescheniak and Schriefers (2001) obtained effects for word distractors. The difference is founded in the amount of mismatching segments concerning phonological distractor and picture name. In the study of Starreveld (2000) the word distractors shared an average of 2.06 segments with the picture names in comparison to a mean word length of 7.42 segments, while 2.19 was the mean of shared segments in the study of Jescheniak and Schriefers (2001) compared to a mean word length of 4.28. This is a difference of about 23%. (Jescheniak & Schriefers: 49% mismatch, Starreveld: 72% mismatch). In Experiment 4A (as well as in Experiment 1A) the number of shared segments (phonemes according to the DISC representation in CELEX) between phonologically related distractor and picture name is 2.56 compared to a mean distractor length of 4.44. This means a relatively slight mismatch of 1.88 (42%), so that early phonological effects are expected to occur. This expectation is supported by the SOA range tested in experiment 4A. The earliest SOA tested is -150 ms (compared with -300 ms tested by Jescheniak & Schriefers and Starreveld). Due to this reasons it is expected to obtain phonological facilitation effects at SOA -150 ms in Experiment 4A.

In Experiment 4A effects comparable to the effects obtained in Experiment 1A are expected to occur, due to the use of the same material. The phonologically related distractors should cause facilitation effects. Due to the immediate activation of the target's phonological representation caused by the auditory presentation of the distractor words, these effects might be even stronger than the effects obtained with the visually presented distractors in Experiment 1A. For the semantically related distractors interference effects are expected to occur at early SOAs (e.g. Damian & Martin, 1999). Experiment 4A is conducted to ensure that the distractor words also affect the naming latencies in a picture naming task if they are presented auditorily. Additionally, effects in Experiment 4A might serve as reference values for Experiment 4B.

Reviewing the results of Experiments 1B and 2B semantic facilitation effects are expected to occur at early SOAs (-150 ms and 0 ms) in the associate naming task in Experiment 4B. Phonologically related distractors should facilitate the naming of an associate at later SOAs (0 ms and +150 ms).

<u>Experiment 4A – Picture Naming</u>

Method

Participants. Participants in Experiment 4A were twenty-four undergraduate students of Maastricht University. All participants were native speakers of Dutch, who had not participated in any of the experiments described before. They were aged between 17 and 36 years with an average age of 22 years. All participants had normal or corrected-to-normal vision. They earned € 5.00 for their participation in Experiment 4A.

Materials. Pictures and distractor words used in Experiment 4A were the same as the material used in Experiment 1A (see Appendix A). Due to the auditory presentation of the distractor words in Experiment 4A, white noise was presented as interfering stimulus in the control condition. The duration of the noise was the same as the mean duration of the distractor words in the remaining conditions.

Design. The experimental design was the same as in the previous picture naming experiments (e.g. Experiments 1A and 2A).

Procedure. The procedure was identical to Experiment 2A. Different to the previous experiments the distractor words were presented auditorily in

Experiment 4A. The distractor words were spoken by a female native speaker of Dutch. They were digitized with a sampling frequency of 44100 Hz and presented via Sony Dynamic Stereo Headphones (MDR-V600).

Results

All naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the RT analysis (5.2% of the data). Trials including naming errors, lip smacks, or technical failures (7.4% of the data) were also excluded from the RT analysis. Altogether 12.6% of the data were excluded from the analysis. Table 7 shows the summarized mean naming latencies and error rates. Distractor Type (semantically related, phonologically related, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) served as independent variables in the analyses of variance (4 x 4). Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Table 7: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 4A.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	718 (11.1)	732 (8.6)	672 (9.4)	662 (6.9)
phonologically related	645 (7.6)	639 (5.1)	613 (5.5)	636 (6.5)
unrelated	715 (7.8)	726 (7.8)	705 (9.8)	673 (6.5)
control	641 (7.0)	661 (5.3)	649 (7.0)	651 (7.0)
net semantic effect [a]	-3 (-3.3)	-6 (-0.8)	33 (0.4)	11 (-0.4)
net phonological effect [a]	70 (0.2)	87 (2.7)	92 (4.3)	37 (0.0)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

Reaction times. Significant main effects of Distractor Type (F1(3,69) = 71.47, MSE = 1603.05, p < .001; F2(3,93) = 87.69, MSE = 1715.45, p < .001) and SOA (F1(3,69) = 5.70, MSE = 4411.62, p < .005; F2(3,93) = 36.12, MSE = 1009.00, p < .001) were obtained in the analyses. The interaction between

Distractor Type and SOA was also significant in the analysis by participants and in the analysis by items (F1(9,207) = 9.55, MSE = 752.98, p < .001; F2(9,279) = 10.20, MSE = 905.71, p < .001).

In the analyses of simple effects a significant effect of Distractor Type was obtained at SOA –150 ms (F1(3,69) = 43.91, MSE = 980,27, p < .001; F2(3,93) = 49.59, MSE = 1119.42, p < .001). For the phonologically related distractor condition and the semantically related distractor condition paired-samples t-tests were conducted in comparison with the unrelated distractor condition for all four SOAs. At SOA –150 ms, a trend to semantic inhibition of 3 ms was observed which was neither significant in the analysis by participants nor in the analysis by items (both ts < 1). A facilitation effect of 70 ms was obtained for the phonologically related condition. This effect was significant in both analyses (t1(23) = 7.23, SD = 47.3, p < .001.; t2(31) = 8.01, SD = 48.6, p < .001).

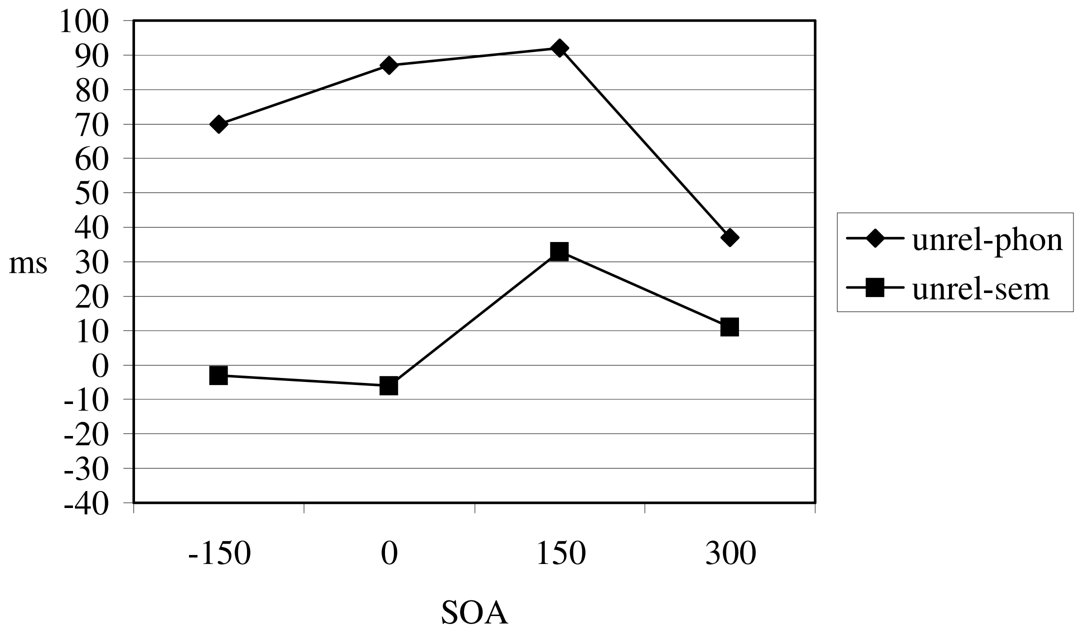
At SOA 0 ms a significant effect of Distractor Type was obtained (F1(3,69) = 34.75, MSE = 1476.66, p < .001.; F2(3,93) = 45.19, MSE = 1522.33, p < .001). The semantic inhibition trend increased to 6 ms at SOA 0 ms but stayed not significant in both analyses (both ts < 1). The phonological facilitation effect increased at SOA 0 ms to 87 ms and was significant in the analysis by participants and in the analysis by items (t1(23) = 7.69, SD = 55.1, p < .001; t2(31) = 9.73, SD = 49.6, p < .001).

A significant effect of Distractor Type was obtained at SOA +150 ms (F1(3,69) = 62.12, MSE = 574.89, p < .001; F2(3,93) = 45.99, MSE = 988.30, p < .001). A semantic facilitation effect of 33 ms was observed at this SOA which was significant in both analyses (t1(23) = 4.18, SD = 38.5, p < .001; t2(31) = 3.86, SD = 46.7, p < .005). The phonological facilitation effect reached 92 ms at SOA +150 ms and was significant in both analyses (t1(23) = 11.60, SD = 38.7, p < .001; t2(31) = 10.98, SD = 46.0, p < .001).

At SOA +300 ms the effect of Distractor Type was significant in the analysis by participants (F1(3,69) = 7.30, MSE = 830.16, p < .001) and in the analysis by items (F2(3,93) = 10.46, MSE = 802.52, p < .001). The semantic facilitation effect decreased to non-significant 11 ms (t1(23) = 1.14, SD = 47.9, n.s.; t2(31) = 1.44, SD = 48.1, n.s.) The phonological facilitation effect (37 ms) stayed significant at SOA +300 ms in the analysis by participants (t1(23) = 3.87, SD = 47.1, p < .005) and in the analysis by items (t2(31) = 6.30, SD = 34.2, p < .001). The effects obtained in Experiment 4A are visualized in Figure 12.

Error rates. A significant effect of Distractor Type was obtained in the analysis by participants and in the analysis by items (F1(3,69) = 8.54, MSE = 1.93, p < .001; F2(3,93) = 7.43, MSE = 1.66, p < .001). The effect of SOA was not significant in the analysis by participants (F1(3,69) = 1.25, MSE = 5.52, n.s.) and significant in the analysis by items (F2(3,93) = 3.03, MSE = 1.71, p < .05). The interaction of Distractor Type and SOA was not significant in both analyses (F1(9,207) = 1.32, MSE = 2.44, n.s.; F2(9,279) = 1.31, MSE = 1.84, n.s.).

Figure 12: Semantic and phonological effects obtained in Experiment 4A.



In the analysis of simple effects the effect of Distractor Type obtained at SOA -150 ms was significant in the analysis by participants (F1(3,69) = 4.34, MSE = 1.90, p < .01) and marginally significant in the analysis by items (F2(3,93) = 2.31, MSE = 2.67, p = .08). Paired-samples t-tests revealed that participants made more errors in the semantically related condition than in the unrelated condition (+3.3%). This effect was significant in the analysis by participants and marginally significant in the analysis by items (t1(23) = 2.99, SD = 1.7, p < .01; t2(31) =

1.81, SD = 2.4, p = .08). Slightly fewer errors occurred in the phonologically related condition than in the unrelated condition (-0.2%) (both ts < 1).

At SOA 0 ms a significant effect of Distractor Type occurred in the simple analyses (F1(3,69) = 4.38, MSE = 1.74, p < .01; F2(3,93) = 3.79, MSE = 1.51, p < .05). In the semantically related condition the error rate was not significantly higher (+0.8%) than in the unrelated condition (both ts < 1). In the phonologically condition slightly fewer errors were made than in the unrelated condition (-2.7%). The phonological effect was significant in both analyses (t1(23) = 2.18, SD = 2.0, p < .05; t2(31) = 2.32, SD = 1.6, p < .05).

The effect of Distractor Type was significant at SOA +150 ms (F1(3,69) = 3.01, MSE = 3.36, p < .05; F2(3,93) = 5.06, MSE = 1.50, p < .005). Non-significant +0.4% more errors were made in the semantically related condition than in the unrelated condition (both ts < 1). Participants made significantly fewer errors (-4.3%) in the phonological condition than in the unrelated condition (t1(23) = 2.82, SD = 2.4, p < .05; t2(31) = 3.00, SD = 1.9, p < .01).

At SOA +300 ms the effect of Distractor Type was not significant (both Fs < 1).

Discussion

In Experiment 4A interesting effects of the semantically and the phonologically related distractor words are obtained.

As expected the phonologically related distractors led to strong facilitation effects across a wide SOA range (-150 ms to +300 ms). The immediate activation of the target's phonological representation (e.g. **koe**, cow) by auditorily presented distractors (e.g. **koek**, cake) enlarges the phonological effects. At SOA +150 ms the largest effect is measured (about 90 ms), which means a stronger impact on the participants' response latencies than in Experiment 1A (about 70 ms at SOA 0 ms), where the distractor words were presented visually. As expected (e.g. Damian & Martin, 1999) the auditory presentation of phonological distractor words influences the reaction times at later SOAs. In Experiment 4A significant phonological facilitation effects were obtained at SOA +300 ms, whereas no phonological effects were obtained at SOA +300 ms in the earlier experiments with visual distractor word presentation. Additionally, the peak of the phonological effect moved from SOA 0 ms, in Experiment 1A, to SOA +150 ms in Experiment 4A. Furthermore, the phonological facilitation effect at SOA -150 ms was enlarged by the auditory presentation of the distractor words. These results, similar to Jescheniak & Schriefers' theory (2001), support the idea that the amount of non-matching segments between distractor and picture name has an influence on phonological effects at early SOAs. The percentage of mismatching segments (42%) was relatively small in Experiment 4A, so that early phonological facilitation effects occurred. The idea that semantic distractor words used in the same experiment could avoid the occurrence of early phonological effects (e.g. Starreveld, 2000) is not supported by the effects obtained in Experiment 4A.

While the phonological effects obtained in Experiment 4A fit the data collected in the earlier experiments and can easily be compared to the effects described in the reference literature, the effects caused by the semantically related distractor words seem to be an exception. As in Experiments 1A and 2A semantic inhibition was expected to occur at early SOAs in Experiment 4A, instead semantic facilitation was obtained at SOA +150 ms. In comparison to Experiment 1A the only difference was the distractor presentation modality. The reason for that particular change was based on the fact that the distractor's impact on the target's phonological representation is stronger in case of auditory presentation. Assuming that the impact on the conceptual level and the lemma level does not differ for auditory and visual distractor presentation, the effects of the semantically related distractors seem to be founded at the level of phonological encoding. Semantic inhibition effects at early SOAs are usually explained by competition effects between the target lemma (e.g. *koe*, cow) and distractor's lemma (e.g. *ezel*, donkey). This competitive effect is strong enough to compensate the priming effect caused by semantically related distractors at the conceptual level through categorical pre-activation. Assuming semantic priming at the level of word form encoding, the semantic effects in Experiment 4A can be explained as follows. At the early SOAs (-150 ms and 0 ms) the competition effect at the lemma level and the priming effects at the conceptual level and at the level of word form encoding cancel each other, so there is no measurable semantic effect. At SOA +150 ms the conceptual-semantic encoding has already started or is perhaps even finished, so the semantically related distractor has only influence on the level of word form encoding. The response latency is sped up in this situation. This model also fits the data of the earlier experiments, because the semantic priming at the level of word form encoding is assumed to be much weaker for visually presented distractor words, so that the competition effect at the lemma level is not canceled by the priming effects.

This explanation for the semantic effects is carefully tested in the following experiments. In Experiment 4A important data were collected for the interpretation of effects occurring in an associate naming task conducted with the same material, as done in Experiment 4B. The prediction of the semantic effects for Experiment 4B becomes difficult facing the semantic effects obtained in Experiment 4A. The impact of the semantically related distractors (e.g. **ezel**, donkey) on the activation of the target word (e.g. **melk**, milk; picture: **koe**, cow) in Experiment 4B is hardly predictable, if semantic priming effects at the level of word form encoding are assumed. Facilitation effects can occur at early SOAs if the picture presentation causes a higher amount of categorical pre-activation for the target concept than the amount of inhibition at the word form level that is primed by the auditorily presented distractor. Inhibitory effects could be explained if the priming effect for the picture's word form is stronger than the facilitating effects at the earlier levels of production. The last possibility is that no measurable semantic effects can be detected, in case that the contrary effects at the conceptual-semantic level and the level of phonological encoding cancel each other.

Predictions for the phonological effects in Experiment 4B are not easy, too, taking the results of Experiment 4A into account. Phonological facilitation covers the whole SOA range in this experiment. The extraordinary activation of the picture's phonological representation through the auditory presentation of the distractors might cause two different effects while naming an associate. On the one hand, the response latencies can be sped up in an interactive feedback model, where activation spreads back to the lemma of the picture name and the concept of the picture and from there to the concept of the associate. This would be the predicted effect according to the results of Experiments 1B and 2B. On the other hand, reaction times can be delayed, due to inhibitory effects at the phonological level. This means that the phonological representation of the picture receives such an extraordinary amount of activation that it takes longer to get enough activation for the associate's phonological form. It is possible, that no phonological effect will be detectable in Experiment 4B, if both effects compensate each other.

Experiment 4B – Associate Naming

Method

Participants. Twenty-four undergraduate students of Maastricht University participated in Experiment 4B. None of them had participated in one of the earlier experiments. All participants were native speakers of Dutch and had normal or corrected-to-normal vision. They were between 18 and 26 years of age (average: 21 years). Participants were paid € 7.50 for their participation in Experiment 4B.

Materials. Pictures, distractor words and the target associates used in Experiment 4B were the same as in Experiment 1B (see Appendix A). White noise served as interfering stimulus in the control condition of Experiment 4B (see Experiment 4A).

Design. The experimental design was the same as in the previous associate naming experiments.

Procedure. The procedure was identical to Experiment 4A.

Results

The data of one participant were excluded from the analysis, due to a mean reaction time of more than 1000 ms. All naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the RT analysis (5.5% of the data). Trials including naming errors, lip smacks, or technical failures (6.5% of the data) were discarded from the analysis as well. Altogether 12% of the data were excluded from the analysis. Table 8 visualizes the summarized mean naming latencies and error rates. Analyses of variance (4 x 4) were run with Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) as independent variables. Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Reaction times. In the analyses of variance a significant main effect of Distractor Type ($F1(3,66) = 18.14$, $MSE = 907.46$, $p < .001$; $F2(3,93) = 12.72$, $MSE = 1673.09$, $p < .001$) and SOA ($F1(3,66) = 4.93$, $MSE = 7325.33$, $p < .005$; $F2(3,93) = 44.26$, $MSE = 1005.64$, $p < .001$) was observed. The interaction between Distractor Type and SOA was not significant in the analysis by participants ($F1(9,198) = 1.65$, $MSE = 818.17$, n.s.) and significant in the analysis by items ($F2(9,279) = 2.04$, $MSE = 950.96$, $p < .05$).

In the analysis of simple effects the effect of Distractor Type was significant at SOA –150 ms (F1(3,66) = 4.32, MSE = 674.75, p < .01; F2(3,93) = 4.39, MSE = 848.26, p < .01). Paired-samples t-tests were conducted for all four SOAs to compare the semantically related distractor condition and the phonologically related condition with the unrelated distractor condition. At SOA –150 ms, a slight trend to semantic facilitation of 4 ms was observed which was not significant by participants and in the analysis by items (both ts < 1). A phonological inhibition effect (16 ms) was obtained at this SOA which was marginally significant in the analysis by participants (t1(22) = 1.92, SD = 39.0, p = .07) and significant in the analysis by items (t2(31) = 2.10, SD = 43.8, p < .05).

Table 8: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 4B.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	776 (8.2)	812 (6.3)	826 (5.7)	775 (8.3)
phonologically related	796 (6.0)	820 (7.3)	839 (7.9)	790 (7.9)
unrelated	780 (7.1)	815 (5.3)	816 (7.1)	778 (6.9)
control	769 (4.8)	790 (3.9)	786 (6.3)	770 (6.0)
net semantic effect [a]	4 (-1.1)	3 (-1.0)	-10 (1.4)	3 (-1.4)
net phonological effect [a]	-16 (1.1)	-5 (-2.0)	-23 (-0.8)	-12 (-1.0)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

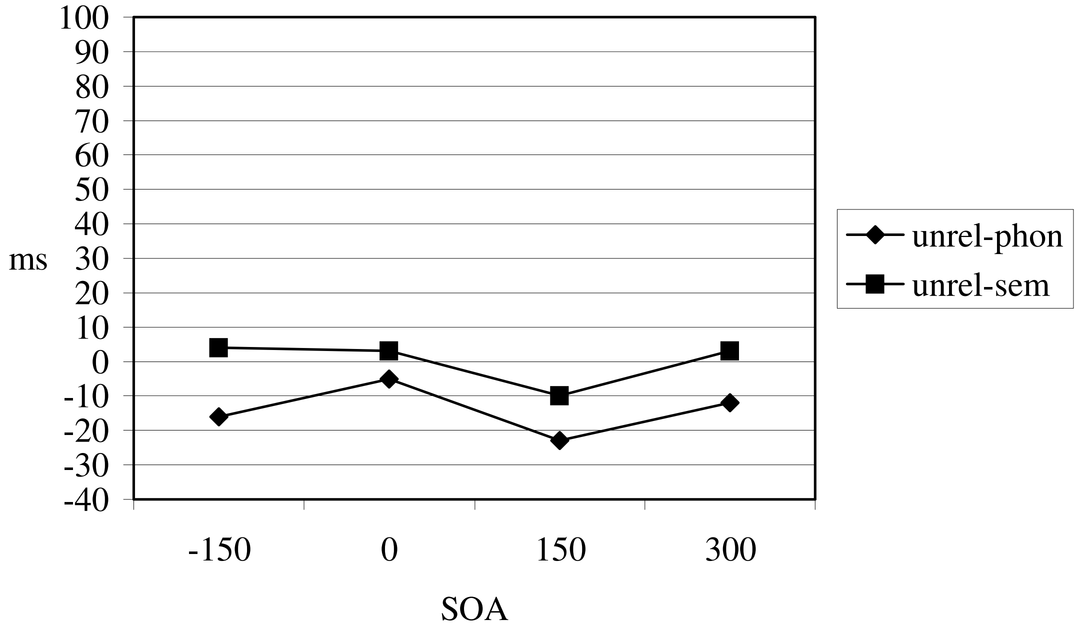
The effect of Distractor Type obtained for SOA 0 ms was significant (F1(3,66) = 4.74, MSE = 879.73, p < .01; F2(3,93) = 3.66, MSE = 1284.33,p < .05). At SOA 0 ms, the semantic facilitation trend decreased to 3 ms and was not significant in both analyses (both ts < 1). The phonological inhibition effect decreased to a trend of 5 ms, which was not significant in the analysis by participants or in the analysis by items (both ts < 1).

A significant effect of Distractor Type was obtained at SOA +150 ms (F1(3,66) = 11.57, MSE = 1011.60, p < .001; F2(3,93) = 13.67, MSE = 1174.50, p

< .001). A semantic inhibition effect of 10 ms was obtained at this SOA, which was not significant in both analyses (t1(22) = 1.23, SD = 39.1, n.s.; t2(31) = 1.47, SD = 41.7, n.s.). The phonological inhibition effect (23 ms) reached significance at SOA +150 ms in both analyses (t1(22) = 2.84, SD = 39.8, $p < .05$; t2(31) = 2.58, SD = 47.7, $p < .05$).

Finally, at SOA +300 ms no significant effect of Distractor Type was observed (F1(3,66) = 2.17, MSE = 795.89, n.s.; F2(3,93) = 2.13, MSE = 1218.89, n.s.). No semantic effect (3 ms) was obtained at this SOA (both ts < 1). The phonological inhibition trend decreased to 12 ms at SOA +300 ms and was not significant in both analyses (t1(22) = 1.43, SD = 40.8, n.s.; t2(31) = 1.26, SD = 63.2, n.s.). Figure 13 visualizes the results of Experiment 4B.

Figure 13: Semantic and phonological effects obtained in Experiment 4B.



Error rates. The effect of Distractor Type obtained in the error analyses was significant over participants (F1(3,66) = 5.22, MSE = 1.54, $p < .005$) and in the analysis by items (F2(3,93) = 3.45, MSE = 1.67, $p < .05$). The effect of SOA was not significant in both analyses (F1(3,66) = 1.31, MSE = 3.02, n.s.; F2(3,93) = 1.53, MSE = 1.86, n.s.). The interaction of Distractor Type and SOA was not significant (F1(9,198) = 1.32, MSE = 1.63, n.s.; F2(9,279) = 1.03, MSE = 1.51, n.s.).

In the analysis of simple effects a significant effect of Distractor Type was obtained at SOA -150 ms (F1(3,66) = 3.48, MSE = 1.44, p < .05; F2(3,93) = 2.96, MSE = 1.22, p < .05). Paired-samples t-tests revealed that participants made slightly fewer errors in the phonologically related condition than in the unrelated condition (-1.1%) (t1(22) = 1.36, SD = 1.2, n.s.; t2 < 1). In the semantically related condition slightly more errors occurred than in the unrelated condition (+1.1%) (both ts < 1).

At SOA 0 ms the effect of Distractor Type was marginally significant in the analysis by participants (F1(3,66) = 2.43, MSE = 2.01, p = .07) and not significant in the analysis by items (F2(3,93) = 1.54, MSE = 2.28, n.s.). In the phonologically condition slightly more errors occurred than in the unrelated condition (+2.0%). Neither the phonological effect (t1(22) + 1.37, SD = 2.3, n.s.; t2(31) = 1.26, SD = 2.1, n.s.), nor the semantic effect of +1.0% (both ts < 1) was significant.

The effect of Distractor Type was also not significant at SOA +150 ms (F1(3,66) = 1.32, MSE = 1.62, n.s.; F2(3,93) = 1.19, MSE = 1.29, n.s.). No phonological effect occurred at this SOA (both ts <1), whereas participants made slightly fewer errors in the semantically related condition than in the unrelated condition (-1.4%) (t1(22) = 1.27, SD = 1.6, n.s.; t2(31) = 1.28, SD = 1.4, n.s.).

At SOA +300 ms the effect of Distractor Type was not significant (F1(3,66) = 1.82, MSE = 1.38, n.s.; F2(3,93) = 1.27, MSE = 1.42, n.s.). In the phonologically related condition participants made 1% more errors than in the unrelated condition (t1(22) = 1.16, SD = 1.3, n.s.; t2 < 1). Although 1.4% more errors were made in the semantically related condition than in the unrelated condition, this effect did not reach significance (t1(22) = 1.21, SD = 1.7, n.s.; t2(31) = 1.01, SD = 1.7, n.s.).

Discussion

Semantically related distractors did not yield any significant effect in Experiment 4B, but a remarkable trend to inhibition was detected at SOA +150 ms. The facilitation effects at SOA –150 ms and 0 ms obtained in Experiments 1B and 2B could not be replicated. Experiment 4B reflects the assumptions made in Experiment 4A.

Semantic priming (caused by the distractor: e.g. **ezel**, donkey) for the picture's word form (e.g. <koe>, cow) seems to inhibit the encoding of the target's word form (e.g. <melk>, milk). This effect is strong enough to compensate the distractor's facilitating impact on the activation of the target at the conceptual-semantic level at SOA –150 ms and 0 ms. In the discussion of Experiments 1B and 2B it is assumed that the semantically related distractor (e.g. **ezel**, donkey) pre-activates the concept of the picture (e.g. KOE, cow) via categorical links. The target's concept (e.g. MELK, milk) is then pre-activated by the link to the concept of the picture. Additionally, the competitive situation at the stage of lemma selection is reduced in associate naming. At SOA +150 ms the inhibitory effects at the level of word form encoding dominate. One possibility for the explanation of this effect would be to assume inhibitory connections at the level of word form encoding between picture name and associate, but this is not very likely. More probable is that the picture's word form spreads back activation via bidirectional links to the lemma level. Lemma selection is perhaps not yet finished due to the activation delay in the process of associate naming, compared to picture naming. So the selection of the target lemma could be inhibited, because the picture's lemma is much more activated than during visual presentation of the distractor. In summary, the semantic inhibition trend cannot be explained sufficiently based on the data collected so far.

The assumption that the highly activated word form of the picture inhibits the activation of the target's word form is supported by the phonological inhibition effects obtained at SOAs –150 ms and +150 ms. Auditory presentation of the phonologically related distractor words (e.g. **koek**, cake) causes strong activation of the picture's word form (e.g. <koe>, cow) and segments, so that activation can spread back to the lemma level. Furthermore, it is assumed that phonologically related cohorts including <koe> are activated in the perceptual network and spread activation to their corresponding lemmas and concepts (e.g. Zwitserlood, 1989; Roelofs, Meyer & Levelt, 1996; Levelt, Roelofs & Meyer, 1999). As a consequence, all representations of the picture name are highly activated, so that the speech production system might have problems to focus on the associate as target word. Especially at the stage of lemma selection and perhaps at the stage of word form encoding strong interference seems to occur due to the extremely strong activated picture's representations.

The results of Experiments 4A and 4B did not replicate the results of Experiment 1A and 1B, so it is necessary to replicate Experiment 2A and 2B with auditorily presented distractor words, too. If the replication offers comparable results to Experiments 4A and 4B, these results can be ascribed to the modality of the distractor presentation. In this case, the new findings and assumptions concerning associate naming made in Experiment 4B would be supported.

5.5 End-related phonological distractors, presented auditorily

To confirm the effects obtained in Experiments 4A and 4B, two further experiments (5A and 5B) were conducted. End-related phonological distractor words are presented auditorily in Experiments 5A and 5B, to get more information about the processes at the stage of phonological encoding. That way, the sequence of the first four Experiments (1A to 2B), using visual presentation of the distractor words, is replicated with the auditory presentation of the interfering stimuli. The auditory presentation of distractor words is used to ensure that the distractor's phonological representation gets activated (e.g. Schriefers, Meyer & Levelt, 1990). The theory of phonological cohort effects at the lemma level (e.g. Zwitserlood, 1989; Roelofs, Meyer & Levelt, 1996; Levelt, Roelofs & Meyer, 1999) predicts, that phonologically begin-related distractor words, sharing the initial segments with the target word, can impact the target encoding at the lemma level via a cohort of lemmas sharing the initial segments (q.v. discussion of Experiment 1B). Phonologically end-related distractor words are used in Experiment 5A to rule out this theory as explanation for phonological facilitation effects obtained in the associate naming studies. End-related words cannot activate cohorts of lemmas sharing the initial segments, so phonological effects caused by this kind of distractors have to be ascribed to the stage of phonological encoding, in detail, word form encoding and especially to the segmental level.

Reviewing the results of Experiment 2A and the effects described by Meyer and Schriefers (1991) phonological facilitation effects are expected to occur in the picture naming experiment 5A. Meyer and Schriefers detected facilitation effects of end-related distractors at SOAs 0 ms and +150 ms. Assuming that the SOA range and the strength of phonological effects can depend on the amount of phonological mismatch between the distractor and the picture name (e.g. Jescheniak and Schriefers, 2001; Schiller, 2004) even in case of end-related distractors, it can be expected to obtain phonological facilitation effects even at SOA -150 ms in Experiment 5A. The amount of phonological mismatch is 36% in Experiment 5A (mean of 2.78 shared segments – phonemes according to the DISC representation in CELEX – compared with a mean word length of 4.31) is even less than in Experiment 4A (42%) where phonological facilitation effects were obtained at all SOAs tested. However, this difference does not mean that stronger phonological facilitation effects are expected in Experiment 5A than in Experiment 4A, because the mismatch of the distractors in Experiment 5A is word-initial compared with word-final mismatch in Experiment 4A.

Concerning the semantic distractors, multiple predictions are possible for Experiment 5A. According to the effects described in the literature (e.g. Schriefers, Meyer & Levelt, 1990; Damian & Martin, 1999) inhibitory effects are expected to occur at early SOAs in experiments using semantically related distractor words, presented auditorily. Early inhibitory effects would also affirm the results of Experiment 1A and 2A. In Experiment 4A semantic facilitation was reported at SOA +150 ms. This unusual effect is hard to explain. As a first idea of explanation it was ascribed to semantic priming at the level of word form encoding in the discussion of Experiment 4A. A replication of these semantic effects in Experiment 5A would support this theory and rule out that the effect in Experiment 4A was an artifact of the collected data.

SOA +150 ms seems to be an interesting SOA in experiments dealing with auditory presentation of the distractor words, as can be seen in the results of Experiments 4A and 4B. In Experiments 5A and 5B this SOA will be focused on.

Experiment 5B replicates Experiment 2B with auditorily presented distractor words. As already mentioned before it is assumed that the impact of auditorily presented words on the phonological representation of the picture name is more directly than during visual presentation. (e.g. Levelt, Roelofs & Meyer, 1999; Damian & Martin, 1999).

It is difficult to predict the effects that are expected to occur in Experiment 5B. In Experiment 4B phonological inhibition effects were obtained in an associate naming study, while in all other associate naming studies phonological facilitation effects were reported. In Experiment 4B it was assumed that the phonological representation of the picture gets such an overwhelming amount of activation via the begin-related and auditorily presented distractor word, that the encoding of the target associate takes place in a competitive situation. For Experiment 5B it can be expected that the activation of the picture name is not that strong, because the phonological overlap with the distractor word is end-related. Phonological inhibition seems unlikely for Experiment 5B. Instead facilitating effects would replicate the effects that occurred in Experiment 2B and would also be in line with the effects reported in Experiment 1B. Due to the end-overlap and the serial way of distractor recognition it is expected that phonological effects will occur at early SOAs, because at later SOAs the recognition of the distractors' critical segments will perhaps be finished too late to cause effects.

Prediction of the effects the semantically related distractor words will cause in Experiment 5B is even more difficult. In the associate naming studies using visual presentation of the distractor words (Experiments 1B and 2B) the semantically related distractors facilitated the naming of the associate. In contrast, in Experiment 4B no significant semantic effects could be detected, but a trend to inhibition occurred at SOA +150 ms. Interestingly, a change took place, from semantic inhibition effects (Experiments 1A and 2A) in the picture naming tasks where the distractors were visually presented, to semantic facilitation effects in the picture naming study using auditory presentation (Experiment 4A). The semantic inhibition trend in Experiment 4B was not significant, so it is unclear if semantic effects will be detectable at all in Experiment 5B. If there is any detectable semantic effect it is expected that this would be of interfering nature rather than facilitating, based on the effects obtained in the earlier studies with auditory distractor words. Additionally, it is expected that any semantic impact should become visible at SOA +150 ms, because this is the SOA where the semantic effects could be detected in the other experiments with auditory distractor words, too.

<u>Experiment 5A – Picture Naming</u>

Method

Participants. Twenty-four undergraduate students of Maastricht University took part in Experiment 5A. The participants were aged between 17 and 25 years with an average age of 20 years. They were native speakers of Dutch and had not participated in any of the experiments described before. All participants had normal or corrected-to-normal vision. € 5.00 were paid for the participation in Experiment 5A.

Materials. Pictures and distractor words used in Experiment 5A were the same as the material used in Experiment 2A (see Appendix B). In Experiment 5A the distractor words were presented auditorily. White noise was presented as interfering stimulus in the control condition. The duration of the noise was the same as the mean duration of the distractor words.

Design. The experimental design was the same as in the previous picture naming experiments (e.g. Experiments 1A and 2A).

Procedure. The procedure was identical to Experiment 4A.

Results

Outliers – naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition (4.7% of the data) – and errors – trials including naming errors, lip smacks, or technical failures (7.0% of the data) – were excluded from the RT analysis. Altogether 11.7% of the data were excluded from the analysis. The summarized mean naming latencies and error rates are visualized in Table 9. Distractor Type (semantically related, phonologically related, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) served as independent variables in the analyses of variance (4 x 4). Separate analyses were carried out with participants (F1) and items (F2) as random variables.

Reaction times. Significant main effects of Distractor Type ($F1(3,69) = 53.48$, $MSE = 649.97$, $p < .001$; $F2(3,93) = 48.32$, $MSE = 933.00$, $p < .001$) and SOA ($F1(3,69) = 8.52$, $MSE = 2820.35$, $p < .001$; $F2(3,93) = 57.64$, $MSE = 528.80$, $p < .001$) were obtained in the analyses. The interaction between Distractor Type and SOA was also significant in the analysis by participants and in the analysis by items ($F1(9,207) = 35.44$, $MSE = 330.33$, $p < .001$; $F2(9,279) = 29.68$, $MSE = 524.78$, $p < .001$).

In the analyses of simple effects a significant effect of Distractor Type was obtained at SOA –150 ms ($F1(3,69) = 80.32$, $MSE = 487.37$, $p < .001$; $F2(3,93) = 58.98$, $MSE = 882.18$, $p < .001$). For the phonologically related distractor condition and the semantically related distractor condition paired-samples t-tests were conducted in comparison with the unrelated distractor condition for all four

SOAs. At SOA –150 ms, a trend to semantic inhibition of 10 ms was observed which was neither significant in the analysis by participants (t1(23) = 1.69, SD = 29.2, n.s.) nor in the analysis by items (t2(31) = 1.20, SD = 50.5, n.s.). A significant facilitation effect of 66 ms was obtained for the phonologically related condition in both analyses (t1(23) = 14.72, SD = 21.7, p < .001.; t2(31) = 9.57, SD = 38.7, p < .001).

Table 9: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 5A.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	685 (7.3)	681 (9.1)	623 (7.2)	609 (8.1)
phonologically related	609 (5.6)	625 (4.9)	630 (6.4)	629 (6.3)
Unrelated	675 (7.4)	669 (7.2)	648 (9.4)	611 (6.9)
Control	611 (6.0)	619 (6.4)	612 (7.6)	608 (5.9)
net semantic effect [a]	-10 (0.1)	-12 (-1.9)	25 (2.2)	2 (-1.2)
net phonological effect [a]	66 (1.8)	44 (2.3)	18 (3.0)	-18 (0.6)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

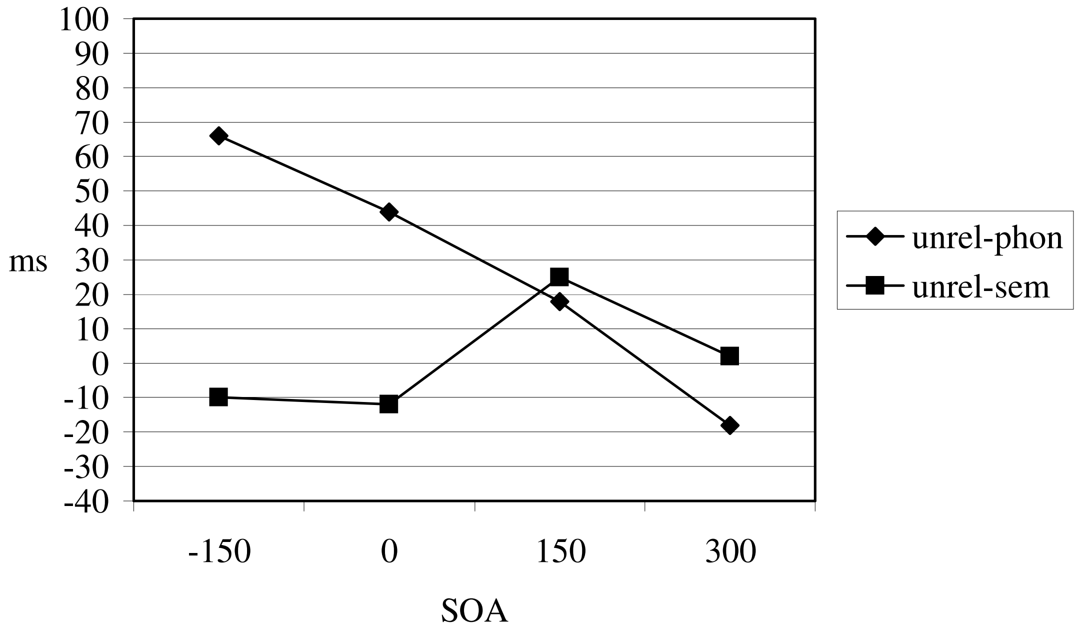
A significant effect of Distractor Type was obtained at SOA 0 ms (F1(3,69) = 47.10, MSE = 490.00, p < .001.; F2(3,93) = 40.52, MSE = 756.19, p < .001). The semantic inhibition trend increased to 12 ms at SOA 0 ms and was significant in the analysis by participants (t1(23) = 2.20, SD = 25.9, p < .05) and not significant in the analysis by items (t2(31) = 1.44, SD = 47.0, n.s.). The phonological facilitation effect decreased at SOA 0 ms to 44 ms but stayed significant in both analyses (t1(23) = 8.07, SD = 26.8, p < .001; t2(31) = 8.31, SD = 30.3, p < .001).

The effect of Distractor Type was significant at SOA +150 ms (F1(3,69) = 13.61, MSE = 384.85, p < .001; F2(3,93) = 12.47, MSE = 481.88, p < .001). A semantic facilitation effect of 25 ms was observed at this SOA which was significant in both analyses (t1(23) = 5.26, SD = 22.5, p < .001; t2(31) = 4.25, SD = 30.8, p < .001). The phonological facilitation effect decreased to 18 ms at SOA

+150 ms and was significant in both analyses (t1(23) = 3.43, SD = 25.7, p < .005; t2(31) = 2.67, SD = 36.4, p < .05).

At SOA +300 ms the effect of Distractor Type was significant in the analysis by participants (F1(3,69) = 8.65, MSE = 278.74, p < .001) and in the analysis by items (F2(3,93) = 8.07, MSE = 387.08, p < .001). No semantic effect was obtained at SOA +300 ms (both ts < 1), whereas a significant phonological inhibition effect (18 ms) was obtained (t1(23) = 3.92, SD = 22.9, p < .005; t2(31) = 3.45, SD = 31.1, p < .005). Figure 14 shows the semantic and phonological effects obtained in Experiment 5A.

Figure 14: Semantic and phonological effects obtained in Experiment 5A.



Error rates. A significant effect of Distractor Type was obtained in the analysis by participants and in the analysis by items (F1(3,69) = 4.24, MSE = 2.40, p < .01; F2(3,93) = 4.67, MSE = 1.63, p < .005). The effect of SOA was not significant (both Fs < 1) The interaction of Distractor Type and SOA was not significant in the analysis by participants and in the analysis by items, too (F1 < 1; F2(9,279) = 1.15, MSE = 1.22, n.s.).

In the analysis of simple effects the effect of Distractor Type obtained at SOA -150 ms was not significant (F1(3,69) = 1.10, MSE = 1.87, n.s.; F2(3,93) = 1.40, MSE = 1.11, n.s.). Paired-samples t-tests revealed that participants made slightly fewer errors (-0.1%) in the semantically related condition than in the unrelated condition (both ts < 1). In the phonologically related condition fewer errors (-1.8%) occurred than in the unrelated condition. This effect was not significant in the analysis by participants (t1(23) = 1.45, SD = 2.0, n.s.) and marginally significant in the analysis by items (t2(31) = 1.91, SD = 1.3, p = .07).

At SOA 0 ms a significant effect of Distractor Type occurred in the simple analyses (F1(3,69) = 4.09, MSE = 1.82, p < .05; F2(3,93) = 4.63, MSE = 1.20, p < .01). In the semantically related condition the error rate was not significantly higher (+1.9%) than in the unrelated condition (t1(23) = 1.42, SD = 2.2, n.s.; t2(31) = 1.41, SD = 1.9, n.s.). In the phonologically condition fewer errors were made than in the unrelated condition (-2.3%). The phonological effect was marginally significant in the analysis by participants (t1(23) = 1.75, SD = 2.0, p = .09) and significant in the analysis by items (t2(31) = 2.32, SD = 1.3, p < .05).

The effect of Distractor Type was not significant at SOA +150 ms (F1(3,69) = 1.89, MSE = 2.10, n.s.; F2(3,93) = 1.78, MSE = 1.67, n.s.). In the semantically related condition –2.2% fewer errors were made than in the unrelated condition. This effect was not significant in the analysis by participants (t1(23) = 1.53, SD = 2.3, n.s.) and marginally significant in the analysis by items (t2(31) = 1.87, SD = 1.6, p = .07). Participants made fewer errors (-3.0%) in the phonological condition than in the unrelated condition. This effect was significant in the analysis by participants (t1(23) = 2.75, SD = 1.7, p < .05) and marginally significant in the analysis by items (t2(31) = 1.98, SD = 2.1, p = .06).

At SOA +300 ms the effect of Distractor Type was not significant (F1(3,69) = 1.01, MSE = 2.29, n.s.; F2(3,93) = 1.33, MSE = 1.30, n.s.). In the semantically related condition +1.2% more errors were made than in the unrelated condition (both ts < 1). In the phonologically related condition participants made slightly fewer errors (-0.6%) than in the unrelated condition (both ts < 1).

Discussion

The results of Experiment 5A confirm the effects obtained in Experiments 4A and 2A.

Phonologically end-related distractor words, presented auditorily, facilitated the naming of the picture at SOA -150 ms, SOA 0 ms and SOA +150 ms, in Experiment 5A. Phonological facilitation effects were expected to occur in Experiment 5A due to several reasons. First, the same distractors led to facilitation effects presented visually in Experiment 2A (q.v. Schriefers, Meyer & Levelt, 1990). Furthermore, acoustic distractor words have a more immediate impact on phonological representations, compared to visually presented stimuli (cf., Levelt, Roelofs & Meyer, 1999; Damian & Martin, 1999). According to Damian and Martin (1999) it was expected to obtain phonological effects at later SOAs in an experiment using auditory presentation of the distractor words, but early effects were found at SOA -150 ms in Experiment 5A instead. These early effects can be explained with the amount of phonological mismatch between distractor word and picture name. (e.g. Jescheniak & Schriefers, 2001; Schiller, 2004). Surprisingly, a phonological inhibition effect is obtained in Experiment 5A at SOA +300 ms. This effect is regarded as an artifact of these special data and not as a consistent experimental effect, because there were no comparable effects detected in any of the previous picture naming experiments. Experiment 4B was the only experiment in which phonological inhibition effects occurred, but these were more or less detectable across the whole range of SOAs. There was no previous experiment where significant phonological facilitation and inhibition effects could be detected within the same experiment.

Concerning the phonologically related distractor words the expected facilitation effects can be reported in Experiment 5A. These effects are caused by end-related distractor words and so the cohort theory (e.g. Zwitserlood, 1989; Roelofs, Meyer & Levelt, 1996; Levelt, Roelofs & Meyer, 1999) can be excluded as explanation for the phonological effects. This means that the phonological effects are clearly located at the levels of phonological encoding and not at the lemma level.

Concentrating on the semantically related distractors, surprising effects can be found in Experiment 5A again. At SOA -150 ms and 0 ms a trend to semantic inhibition was obtained in Experiment 5A. Although this effect was not fully significant, it reflects the effects reported in many recent studies (e.g. Schriefers, Meyer & Levelt, 1990; Damian & Martin 1999). At SOA +150 ms however the semantically related distractor words led to facilitation in the reaction times. Although this effect can hardly be proved by literature, it is not taken as an artifact because it perfectly replicates the semantic facilitation effect at the same SOA in Experiment 4A. It seems that the data show an authentic effect that has to be carefully explained. In the discussion of Experiment 4A the assumption was made that semantically related distractors, presented auditorily, can impact the processes at the level of word form encoding (q.v. Starreveld & La Heij, 1996) and so a first possibility to explain the semantic effects was shown. Within the scope of this assumption, the effects in Experiment 5A are explainable, too. At SOA +150 ms the conceptual-semantic encoding of the picture name has already started or is even finished, so that only the semantic priming at the word form level leads to facilitating effects. Whereas the competition effects at the level of lemma selection led to a trend of inhibition in the first two SOAs, where the level of conceptual-semantic encoding was not yet finished, at the moment when the distractor is recognized.

In the literature other assumptions are made to explain differences between effects in experiments with auditory and with visual presentation of the distractor words. Damian and Martin (1999) assume that the difference in the duration of the distractor presentation can be responsible for some differences (e.g. the SOA – range across which the effects can be obtained). At first sight the mean presentation duration of the semantically related distractors in Experiment 5A (and 4A) is very long (737 ms) compared to the mean reaction times in the semantic condition of Experiment 2A (714 ms). So the difference between the presentation times does not seem to be critical, because the auditory presentation duration is not shorter than the visual presentation duration. Furthermore, Damian and Martin (1999) are discussing different SOA ranges and not opposite effects (facilitation vs. inhibition), so this argument seems to be irrelevant for the effects obtained in Experiment 5A. However, there is a big difference in the way of recognition of the distractors. Auditorily presented distractors can only be recognized in a serial way, from the beginning of the word up to the end, while all parts of the word are available during the whole time of presentation in case of visual presentation. So it is possible that different effects can be caused, but this seems to be more critical for effects caused by phonologically related distractors. A theory dealing with activation decay could also lead to an acceptable explanation, but more experiments would be necessary to further investigate the reasons for the semantic effects. Here, the assumption of semantic priming at the level of word form encoding is chosen as explanation, because it holds for all the results in the previous experiments, too. It seems to be the most likely explanation at this point of investigation. The semantic effects are not focused on in this study, so it would go too far to conduct more experiments to further investigate the differences between visually and auditorily presented semantic distractor words.

Overall, Experiment 5A has yielded comparable effects to those reported in Experiment 2A, so it can be concluded that the distractors will show their usual influence in the associate naming task in Experiment 5B.

Experiment 5B – Associate Naming

Method

Participants. Twenty-four undergraduate students of Maastricht University, who had not participated in any of the earlier experiments, participated in Experiment 5B. They were aged between 18 and 26 years (mean: 21 years). The participants received € 7.50 for their participation in the experiment. All participants were native speakers of Dutch and had normal or corrected-to-normal vision.

Materials. Pictures, distractor words and the target associates used in Experiment 5B were the same as in Experiment 2B (see Appendix B). Due to the auditory presentation of the distractor words, white noise served as interfering stimulus in the control condition of Experiment 5B (see Experiment 5A).

Design. The experimental design was the same as in the previous associate naming experiments.

Procedure. The procedure was identical to Experiment 5A.

Results

14.3% of the data were excluded from the analysis, divided in outliers (all naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition; 5.5% of the data) and trials including naming errors, lip smacks, or technical failures (8.8% of the data). The mean naming latencies and error rates obtained in Experiment 5B are summarized in Table 10. Analyses of variance (4 x 4) were run with Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) as independent variables. Participants (F_1) and items (F_2) served as random variables in separate analyses.

Table 10: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 5B.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	807 (7.7)	814 (7.9)	833 (7.8)	768 (10.4)
Phonologically related	778 (8.1)	795 (9.9)	816 (9.6)	777 (9.9)
Unrelated	807 (7.4)	816 (7.9)	820 (8.2)	783 (7.6)
Control	769 (9.9)	777 (10.3)	785 (8.9)	754 (9.5)
net semantic effect [a]	0 (-0.3)	2 (0)	-13 (0.4)	15 (-2.8)
net phonological effect [a]	29 (-0.7)	21 (-2.0)	4 (-1.4)	6 (-2.3)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

Reaction times. In the analyses of variance a significant main effect of Distractor Type (F1(3,69) = 25.15, MSE = 1040.11, p < .001; F2(3,93) = 23.82, MSE = 1323.70, p < .001) was obtained. The effect of SOA was not significant in the analysis with participants (F1(3,69) = 2.07, MSE = 15434.96, n.s.) and significant in the analysis with items (F2(3,93) = 39.47, MSE = 944.39, p < .001). The interaction between Distractor Type and SOA was significant in the analysis with participants (F1(9,207) = 2.80, MSE = 617.53, p < .005) and not significant in the analysis with items (F2(9,279) = 1.56, MSE = 1062.82, n.s.).

The effect of Distractor Type was significant in the analysis of simple effects at SOA –150 ms (F1(3,69) = 15.99, MSE = 601.45, p < .001; F2(3,93) = 11.89, MSE = 1106.59, p < .001). For all four SOAs, paired-samples t-tests were conducted to compare the unrelated distractor condition with the semantically related distractor condition and the phonologically related distractor condition. The semantically related distractor condition did not differ from the unrelated condition at SOA –150 ms. Reaction times were as fast in both conditions (both ts < 1). Distractors of the phonologically related condition caused significant facilitation effects (29 ms) at this SOA (t1(23) = 4.38, SD = 32.6, p < .001; t2(31) = 4.13, SD = 37.8, p < .001).

At SOA 0 ms the effect of Distractor Type ms was significant as well (F1(3,69) = 9.52, MSE = 845.72, p < .001; F2(3,93) = 7.22, MSE = 1034.00, p < .001). At SOA 0 ms, a slight trend to semantic facilitation of 2 ms was obtained, which was not significant in both analyses (both ts < 1). The phonological facilitation effect decreased to 21 ms, but stayed significant in the analysis by participants (t1(23) = 2.34, SD = 43.7, p < .05) and in the analysis by items (t2(31) = 2.14, SD = 45.6, p < .05).

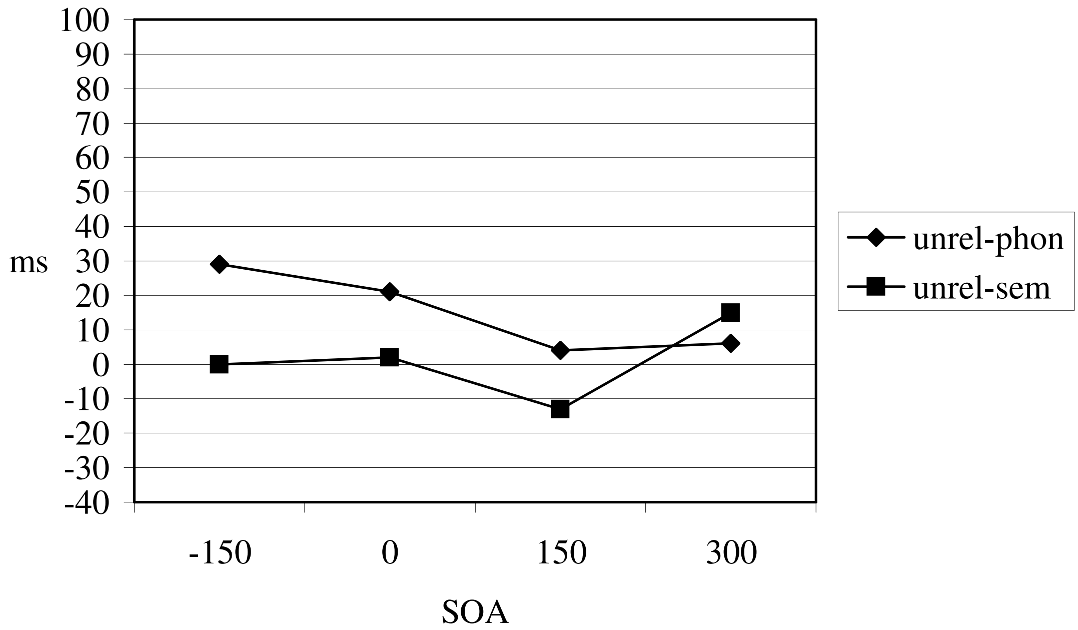
A significant effect of Distractor Type was obtained at SOA +150 ms (F1(3,69) = 10.83, MSE = 916.59, p < .001; F2(3,93) = 9.31, MSE = 1198.21, p < .001). A trend to semantic inhibition of 13 ms was obtained at this SOA, which was not significant in both analyses (t1(23) = 1.38, SD = 45.3, n.s.; t2 < 1). The phonological facilitation effect decreased (4 ms) and did not reach significance at SOA +150 ms in both analyses (t1 < 1; t2(31) = 1.04, SD = 49.0, n.s.).

Finally, at SOA +300 ms the effect of Distractor Type was also significant in both analyses (F1(3,69) = 7.08, MSE = 528.93, p < .001; F2(3,93) = 4.03, MSE = 1173.35, p < .05). A semantic facilitation effect (15 ms) was obtained at this SOA, which was significant in the analysis by participants (t1(23) = 2.99, SD = 25.0, p < .01) and not significant in the analysis by items (t2(31) = 1.54, SD = 50.5, n.s.). The phonologically related distractors led to a facilitation effect of 6 ms at SOA +300 ms. This effect was not significant in one of the analyses (t1 < 1; t2(31) = 1.19, SD = 49.4, n.s.). Figure 15 shows the effects obtained in Experiment 5B.

Error rates. The effect of Distractor Type obtained in the error analyses was marginally significant in the analysis with participants (F1(3,69) = 2.51, MSE = 2.85, p = .07) and significant in the analysis with items (F2(3,93) = 2.83, MSE = 1.89, p < .05). The effect of SOA and the effect of the interaction of Distractor Type and SOA were not significant in both analyses (all Fs < 1).

In the analysis of simple effects the effect of Distractor Type obtained at SOA -150 ms was not significant in one of the analyses (F1(3,69) = 1.18, MSE = 2.61, n.s.; F2(3,93) = 1.35, MSE = 1.70, n.s.). Paired-samples t-tests revealed that participants made slightly more errors in the semantically related condition (+0.3%) (both ts <1) and in the phonologically related condition (+0.7%) (both ts <1) than in the unrelated condition at SOA -150 ms.

Figure 15: Semantic and phonological effects obtained in Experiment 5B.



At SOA 0 ms no significant effect of Distractor Type occurred in the simple analyses (F1(3,69) = 1.65, MSE = 2.34, n.s.; F2(3,93) = 1.56, MSE = 1.85, n.s.). In the semantically related condition as many errors as in the unrelated condition were made (both ts < 1). In the phonologically condition slightly more errors occurred than in the unrelated condition (+2.0%). The phonological effect was not significant (t1(23) = 1.39, SD = 2.2, n.s.; t2(31) = 1.38, SD = 1.9, n.s.).

The effect of Distractor Type was also not significant at SOA +150 ms (both Fs < 1). While fewer errors were made in the semantically related condition than in the unrelated condition (-0.4%), slightly more errors (+1.4%) were made in the phonologically related condition than in the unrelated condition. Both effects were not significant (all ts <1).

At SOA +300 ms the effect of Distractor Type was not significant (F1(3,69) = 1.57, MSE = 2.45, n.s.; F2(3,93) = 1.54, MSE = 1.87, n.s.). In the semantically related condition participants made more errors than in the unrelated condition (+2.8%). This effect was marginally significant in the analysis by participants (t1(23) = 1.89, SD = 2.4, p = .07) and significant in the analysis by items (t2(31) = 2.18, SD = 1.8, p < .05). Participants made 2.3% more errors in the phonologically related condition than in the unrelated condition. This effect was not significant in both analyses (t1(23) = 1.72, SD = 2.1, n.s.; t2(31) = 1.79, SD = 1.8, n.s.).

Discussion

The data obtained in Experiment 5B fit the results of the former experiments. Phonological facilitation effects were detected at the early SOAs (-150 ms and 0 ms). It was expected to obtain phonological effects early in Experiment 5B, because the distractors were presented auditorily (q.v. Jescheniak & Schriefers, 2001). That means that they are recognized in a serial way. The distractors were end-related, so that the "critical" segments are recognized relatively late and that early presentation of the distractor word is necessary to obtain an impact on the production process. In contrast to Experiment 4B facilitating phonological effects are reported in Experiment 5B. These findings fit the results of the previous experiments and support the theory that the inhibitory effects obtained in Experiment 4B form an exception because the picture's phonological representation and lemma are much more activated than in all other cases. So, there might be a kind of competition between the target associate and the picture name at the level of phonological encoding and especially during lemma selection. Experiment 5B supports the idea of an interactive feedback model for the explanation of the collected data. The phonological distractor word (e.g. **taboe**, taboo) activates the phonological representation of the picture name (e.g. **koe**, cow). Assuming that there are no associative connections between different word forms, it seems that backflow of activation to the picture's lemma is the only possibility to facilitate the encoding of the target associate (e.g. **melk**, milk).

The role of the semantically related distractor words is difficult to explain for Experiment 5B. At SOAs -150 ms and 0 ms no significant semantic effects could be detected. This observation is in agreement with the results of the earlier experiments with auditory presentation of the distractor words. While significant facilitation effects were reported at SOA +150 ms for the picture naming experiments (Experiments 4A and 5A), no significant effects were found in the associate naming tasks (Experiments 4B and 5B), but a trend to semantic inhibition at this SOA could be detected in both experiments. Additionally, a semantic facilitation effect at SOA +300 ms was reported in Experiment 5B that was significant in the analysis by participants and not significant in the analysis by items. Although this effect is significant in the analysis by participants, it is seen as an artifact of the data. First, because there was no semantic effect detected at SOA +300 ms in any of the earlier experiments and second, because the error rate in the semantic condition is very high at SOA +300 ms. So, the only effect that has to be explained is once more (q.v. Experiment 4B) the inhibitory trend at SOA +150 ms.

As argued in the discussion of Experiment 4B there is more than one explanation for this trend, so more investigation has to be done to localize this effect correctly. In general it is assumed that the inhibition of the target encoding is caused by a facilitating effect for the activation of the picture's representation. Remembering the discussions of Experiment 4B and 5A the most probable explanation for the effects in Experiment 5B is that the auditory presentation of the distractors leads to priming effects for the picture name at the level of word form encoding. It is not clear, how the encoding of the target associate is inhibited. The most probable explanation seems to be that lemma selection is not yet completed. So, feedback of activation spread from the word form of the picture (e.g. <koe>, cow) to the corresponding lemma inhibits the selection of the target lemma (e.g. *melk*, milk). A second possibility would be to assume inhibitory links at the level of word form encoding between picture name and associate, but this is not probable due to the results obtained in the earlier experiments.

In general, the phonological effects obtained in Experiment 5B closely replicate the effects obtained in the experiments with visual distractor presentation and also support the explanation of the inhibitory effects in Experiment 4B. The semantic effects also fit the line with the auditory experiments. As in Experiments 4A and 4B, in Experiment 5B a semantic inhibition trend occurred, which is contrary to the facilitation trend at the same SOA in the respective picture naming study.

5.6 Phonological non-word distractors, presented visually

Different stages and processes of phonological encoding were subject of many recent studies. Researchers tested phonological primes of different kinds in picture naming studies. Most often words that share the onset segments (phonemes or graphemes) with the picture name that has to be encoded, are chosen as phonological distractor words (e.g. Schriefers, Meyer & Levelt, 1990; Damian & Martin, 1999; Starreveld, 2000). Facilitating effects of this kind of distractors are usually ascribed to priming at the level of phonological encoding, especially at the word form level. In order to exclude that the effects are measured due to activation of phonological cohorts at the lemma level and to investigate the priming effects of segments, researchers tested distractors that share another part with the target word (e.g. end segments) in many studies (e.g. Marslen-Wilson & Zwitserlood, 1989; Meyer & Schriefers, 1991; Schiller, 2004). Usually, in these studies phonological effects are reported, at least if the phonological similarity between distractor and picture name is strong enough.

In Experiment 6A another kind of phonological distractor is used. The phonological distractors are non-words (that means a sequence of letters that does not form an existing word in Dutch), which are built by mixing up the letters of the picture name (e.g. picture name: **varken**, pig; phonological distractor: **knerav**). These distractors are expected to affect the segmental level of phonological encoding only, because a lemma and a word form should not exist for them. Lupker (1982) used non-words that shared some letters (nucleus and coda) with the picture to be named as phonological distractors and detected a facilitation effect of 53 ms compared to non-words that did not share a remarkable amount of letters with the picture name.

It is expected to obtain phonological facilitation effects in Experiment 6A. During or before the phonological encoding of the target word the target segments (phonemes) get a certain amount of activation via the reception of the distractor. Phonological effects across a wide SOA range are possible, because the distractors are presented visually and stay present until the articulation of the target word starts.

The prediction of the effects caused by the semantically related distractors in Experiment 6A can be derived from the picture naming studies described before (e.g. Experiments 1A and 2A) and from the effects reported in the literature (e.g. Schriefers, Meyer & Levelt, 1990; Damian & Martin, 1999). It is expected to obtain semantic inhibition effects at least at one of the earlier SOAs (-150 ms or 0 ms).

Experiment 6A is conducted to ensure that the non-words used as phonological distractors affect the naming latencies in a picture naming task. If so, they can be used in an associate naming task to investigate the activation of the segments of the picture name during the encoding of an associate.

In Experiment 6B an associate naming task is conducted with the material used in Experiment 6A. Through the presentation of phonological non-words, which are related to the picture name, it is expected to collect more information on how far the picture name is activated during the encoding of a target associate.

Based on the effects obtained in the earlier associate naming studies (especially Experiments 1B and 2B, where the distractors were presented visually) it can be expected that phonological facilitation effects occur in Experiment 6B. The phonological distractors should speed up the activation of the picture name at the segmental level and activation will spread back to the level of word form encoding and to the lemma level. The associate can be activated faster than during the presentation of an unrelated distractor word because activation will flow from the picture's lemma via the conceptual representation to the related associate's concept.

It is also possible that phonological effects will not be detectable in Experiment 6B. In this case it seems likely that the picture name is not activated up to the segmental level during an associate naming task, or that the picture's segments are activated, but due to the lack of an activated distractor word form the word form of the picture will not get enough activation to spread it back to the lemma level via feedback links. So the associate's concept will not receive an extra amount of activation.

The third variant of phonological inhibition effects is not very probable, because these effects were only detected in case of begin-related, auditorily presented phonological distractor words, which means a very high activation rate for the representations of the picture name at the phonological encoding levels, especially at the word form level.

Concerning the semantically related distractor words, it is expected to obtain facilitating effects in Experiment 6B. This expectation is based on the semantic facilitation effects that are described in the earlier associate naming studies (e.g. Experiment 2B).

Experiment 6A – Picture Naming

Method

Participants. Participants in Experiment 6A were twenty-four undergraduate students of Maastricht University. All participants were native speakers of Dutch, who had not participated in any of the experiments described before. They were aged between 18 and 27 years with an average age of 20 years. All participants had normal or corrected-to-normal vision. They earned € 5.00 for their participation in Experiment 6A.

Materials. In Experiment 6A the phonological distractors were created by mixing the letters of the picture names to a new order. Creating the phonological distractors, it was controlled that they did not start with the same segment as the picture name and two letters that build one phoneme stayed in their correct order (e.g. oe /u/), so that the created sequence of letters is not meaningful and the non-word is pronounceable. The distractors used in the other conditions (semantically related, unrelated, control) and the pictures did not differ from the material used in former experiments (e.g. Experiment 1A and 2A). For a complete list of the material used in Experiment 6A see Appendix E.

Design. The experimental design was the same as in the previous picture naming experiments (e.g. Experiments 1A and 2A).

Procedure. The procedure was identical to Experiment 1A for the first four participants. Afterwards the experimental hardware was replaced. The following participants saw the pictures presented on a Samsung Sync Master 940 BF computer screen. The rest of the procedure remained as described in the experiments before (e.g. Experiment 1A) also for the remaining 20 participants.

Results

Naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition were counted as outliers and excluded from the RT analysis (4.7% of the data). Trials including naming errors, lip smacks, or technical failures (5.9% of the data) were also excluded from the RT analysis. Altogether 10.6% of the data were excluded from further analysis. Table 11 shows the summarized mean naming latencies and error rates. Distractor Type (semantically related, phonologically related, unrelated or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) served as independent variables in the analyses of variance (4 x 4).

Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Reaction times. Significant main effects of Distractor Type ($F1(3,66) = 100.38$, $MSE = 846.04$, $p < .001$; $F2(3,93) = 97.16$, $MSE = 1228.65$, $p < .001$) and SOA ($F1(3,66) = 22.81$, $MSE = 6265.16$, $p < .001$; $F2(3,93) = 180.14$, $MSE = 1112.85$, $p < .001$) were obtained in the analyses. The interaction between Distractor Type and SOA was also significant in the analysis by participants and in the analysis by items ($F1(9,198) = 21.50$, $MSE = 724.97$, $p < .001$; $F2(9,279) = 23.81$, $MSE = 911.84$, $p < .001$).

Table 11: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 6A.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	752 (6.9)	838 (8.3)	750 (6.9)	672 (7.3)
phonologically related	684 (4.4)	738 (4.6)	707 (5.6)	677 (5.6)
unrelated	741 (5.2)	806 (6.1)	751 (6.0)	680 (5.0)
control	685 (6.0)	704 (4.6)	706 (4.6)	674 (6.8)
net semantic effect [a]	-11 (-1.7)	-32 (-2.2)	1 (-0.9)	8 (-2.3)
net phonological effect [a]	57 (0.8)	68 (1.5)	44 (0.4)	3 (-0.6)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

A significant effect of Distractor Type was obtained at SOA –150 ms in the analyses of simple effects ($F1(3,66) = 36.06$, $MSE = 835.10$, $p < .001$; $F2(3,93) = 33.22$, $MSE = 1279.93$, $p < .001$). To compare the phonologically related distractor condition and the semantically related distractor condition with the unrelated distractor condition, paired-samples t-tests were conducted for all four SOAs. At SOA –150 ms, a trend to semantic inhibition of 11 ms was observed which was neither significant in the analysis by participants ($t1(22) = 1.20$, SD =

42.7, n.s.) nor in the analysis by items (t2(31) = 1.13, SD = 43.9, n.s.). For the phonologically related condition a facilitation effect of 57 ms was obtained. This effect was significant in the analysis by participants (t1(22) = 7.13, SD = 38.6, p < .001) as well as in the analysis by items (t2(31) = 7.10, SD = 47.2, p < .001).

At SOA 0 ms a significant effect of Distractor Type was obtained (F1(3,66) = 108.90, MSE = 791.16, p < .001.; F2(3,93) = 93.52, MSE = 1293.72, p < .001). The semantic inhibition effect increased to 32 ms at SOA 0 ms and reached full significance in both analyses (t1(22) = 5.40, SD = 28.2, p < .001; t2(31) = 3.63, SD = 51.4, p < .005). The phonological facilitation effect increased to 68 ms and was significant in both analyses at SOA 0 ms (t1(22) = 7.38, SD = 44.3, p < .001; t2(31) = 8.89, SD = 44.1, p < .001).

The effect of Distractor Type obtained at SOA +150 ms was significant in both analyses (F1(3,66) = 14.28, MSE = 1058.01, p < .001; F2(3,93) = 22.59, MSE = 907.33, p < .001). The semantic condition did not significantly differ from the unrelated condition in this SOA (1 ms) (both ts < 1). The phonological facilitation effect decreased to 44 ms at SOA +150 ms but stayed significant in both analyses (t1(22) = 5.57, SD = 37.8, p < .001; t2(31) = 5.38, SD = 44.1, p < .001).

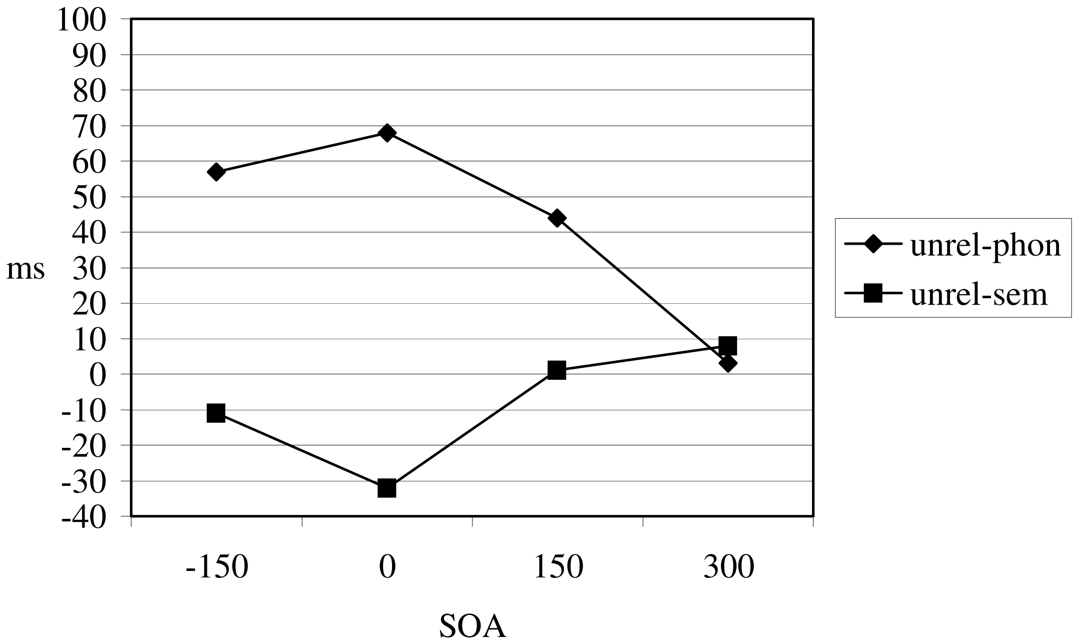
At SOA +300 ms the effect of Distractor Type was neither significant in the analysis by participants (F1<1) nor in the analysis by items (F2(3,93) = 1.06, MSE = 483.20, n.s.). The semantic distractors led to a non-significant facilitation effect of 8 ms (t1(22) = 1.46, SD = 27.3, n.s.; t2(31) = 1.70, SD = 32.0, n.s.) The phonological facilitation effect (3 ms) was no longer significant (both ts < 1). The effects obtained in Experiment 6A are visualized in Figure 16.

Error rates. A significant effect of Distractor Type was obtained in the analysis by participants (F1(3,66) = 7.86, MSE = 1.27, p < .001) and in the analysis by items (F2(3,93) = 6.84, MSE = 1.05, p < .001). The effect of SOA was not significant in both analyses (both Fs < 1) as well as the interaction of Distractor Type and SOA (F1(9,198) = 1.13, MSE = 1.41, n.s.; F2 < 1).

In the analysis of simple effects the effect of Distractor Type obtained at SOA -150 ms was not significant (F1(3,66) = 1.92, MSE = 1.50, n.s.; F2(3,93) = 1.98, MSE = 1.04, n.s.). Paired-samples t-tests revealed that participants made more errors in the semantically related condition than in the unrelated condition

(+1.7%). This effect was neither significant in the analysis by participants nor in the analysis by items (t1(22) = 1.24, SD = 2.2, n.s.; t2(31) = 1.53, SD = 1.5, n.s.). Slightly fewer errors occurred in the phonologically related condition than in the unrelated condition (-0.8%) (both ts < 1).

Figure 16: Semantic and phonological effects obtained in Experiment 6A.



At SOA 0 ms a significant effect of Distractor Type was obtained (F1(3,66) = 4.38, MSE = 1.62, p < .01; F2(3,93) = 3.83, MSE = 1.33, p < .05). In the semantically related condition the error rate was higher (+2.2%) than in the unrelated condition. This effect was marginally significant in the analysis by participants (t1(22) = 2.01, SD = 1.7, p = .06) and not significant in the analysis by items (t2(31) = 1.58, SD = 1.8, n.s.). In the phonological condition fewer errors were made than in the unrelated condition (-1.5%). The phonological effect was not significant in both analyses (t1(22) = 1.25, SD = 1.8, n.s.; t2(31) = 1.48, SD = 1.3, n.s.).

The effect of Distractor Type was not significant at SOA +150 ms (F1(3,66) = 1.71, MSE = 1.27, n.s.; F2(3,93) = 1.24, MSE = 1.25, n.s.). Non-significant +0.9% more errors were made in the semantically related condition than in the unrelated condition (both ts < 1). Participants made non-significantly fewer errors (-0.4%) in the phonological condition than in the unrelated condition (both ts < 1).

At SOA +300 ms the effect of Distractor Type was marginally significant in the analysis by participants ($F1(3,66) = 2.39$, $MSE = 1.21$, $p = .08$) and not significant in the analysis by items ($F2(3,93) = 2.09$, $MSE = 0.92$, n.s.). Significantly more errors +2.3% were made in the semantically related condition than in the unrelated condition ($t1(22) = 2.34$, $SD = 1.5$, $p < .05$; $t2(31) = 2.65$, $SD = 1.1$, $p < .05$). Participants made non-significantly more errors (+0.6%) in the phonological condition than in the unrelated condition (both ts < 1).

Discussion

Distractors in Experiment 6A influenced the participants' reaction times in the expected way.

Significant semantic inhibition was detected at SOA 0 ms. According to the effects obtained in the previous picture naming studies (e.g. Experiment 1A and 2A) and to the impact of semantically related distractors reported in the literature (e.g. Schriefers, Meyer & Levelt, 1990; Damian & Martin, 1999), it was expected to detect semantic interference at an early SOA. Semantic interference can be explained by all models under consideration, so there will be no focus on this effect in the further discussion. The semantic inhibition effect ensures that the semantic distractors work as expected, so the data for the phonological distractors should be reliable, too.

Phonological distractors affected the response latencies across a wide SOA range in Experiment 6A. Significant facilitation effects were detected from SOA -150 ms to SOA +150 ms. The phonological effects can be ascribed to the segmental level because they are caused by non-words that cannot activate a corresponding word form. The naming of the picture of a pig (**varken**) was sped up by presentation of the distractor **knevar**. The recognition of the distractor activates the phonemes /k/, /n/, /a/ and /r/ which are needed during the preparation of the picture name in another sequence[13]. So the retrieval of the segments needed to encode the target word is facilitated by the presentation of the non-words (q.v. Levelt, Roelofs & Meyer, 1999). So the picture name can be produced faster in

[13] The letters "v" and "e" will perhaps not directly activate the phonemes needed for the encoding of "varken", because their pronounciation could be different in the non-word, due to their position in the word (e.g. "v" word-initial: /f/, else: /v/). Depending on the visual presentation this does not seem to be a critical fact.

case that a phonological distractor is presented compared to an unrelated distractor word.

The results of Experiment 6A show that the presented distractors affect the encoding of the picture name. It is assured that a phonological distractor that impacts only the level of segmental encoding can lead to facilitating effects in a picture naming task. So the phonological distractors used in Experiment 6A can be used in an associate naming task to investigate up to which level the picture name is activated while preparing an associate for articulation. This is done with Experiment 6B.

Experiment 6B – Associate Naming

Method

Participants. Twenty-four undergraduate students of Maastricht University, who were all native speakers of Dutch, participated in Experiment 6B. None of them had participated in one of the earlier experiments. The participants were between 18 and 31 years of age (average: 21 years). They were paid € 7.50 for their participation in the experiment. All participants had normal or corrected-to-normal vision.

Materials. Pictures and distractors used in Experiment 6B were the same as the material used in Experiment 6A. The target associates were the same as in the previous associate naming studies. The material used in Experiment 6B is listed in Appendix E.

Design. The experimental design was the same as in the previous associate naming experiments.

Procedure. The procedure was identical to Experiment 6A.

Results

Trials including naming errors, lip smacks, or technical failures (5.0% of the data) were discarded from the RT analysis as well as all naming latencies shorter or longer than 2.5 SDs of the mean per participant and item per condition (5.4% of the data), which were counted as outliers. Altogether 10.4% of the data were excluded from the analysis. The mean naming latencies and error rates are summarized in Table 12. Analyses of variance (4 x 4) were run with Distractor Type (semantic, phonological, unrelated, or control) and SOA (–150 ms, 0 ms, +150 ms, +300 ms) as independent variables. Separate analyses were carried out with participants ($\underline{F}_1$) and items ($\underline{F}_2$) as random variables.

Table 12: Mean response latencies (in ms) and error rates (in %) obtained in Experiment 6B.

	SOA (in ms)			
	–150	0	+150	+300
Distractor Type				
semantically related	831 (5.7)	858 (5.2)	876 (5.3)	843 (5.1)
phonologically related	844 (4.0)	855 (3.6)	883 (5.2)	845 (4.4)
unrelated	851 (5.7)	866 (5.3)	892 (4.3)	851 (5.7)
control	827 (4.3)	829 (4.6)	839 (6.0)	821 (4.9)
net semantic effect [a]	20 (0)	8 (0.1)	16 (-1.0)	8 (0.6)
net phonological effect [a]	7 (1.7)	11 (1.7)	9 (-0.9)	6 (1.3)

[a] The net effects are computed by subtracting the semantically related or phonologically related condition from the unrelated condition, respectively.

Reaction times. The effect of Distractor Type was significant in the analyses of variance (F1(3,69) = 19.66, MSE = 1176.25, p < .001; F2(3,93) = 19.69, MSE = 1508.70, p < .001). The effect of SOA was marginally significant in the analysis by participants (F1(3,69) = 2.44, MSE = 9891.81, p = .07) and significant in the analysis by items (F2(3,93) = 25.18, MSE = 1209.16, p < .001). The interaction between Distractor Type and SOA did not yield significant effects (F1(9,207) = 1.51, MSE = 723.05, n.s.; F2(9,279) = 1.20, MSE = 1263.82, n.s.).

At SOA -150 ms the effect of Distractor Type was significant in the analysis of simple effects (F1(3,69) = 4.89, MSE = 624.42, p < .005; F2(3,93) = 3.04, MSE = 1085.28, p < .05). For all four SOAs paired-samples t-tests were conducted to compare the semantically related distractor condition and the phonologically related condition with the unrelated distractor condition. At SOA –150 ms, a semantic facilitation effect of 20 ms was observed which was significant in both analyses (t1(23) = 2.77, SD = 35.8, p < .05; t2(31) = 2.46, SD = 43.9, p < .05). A slight trend to phonological facilitation (7 ms) was obtained at this SOA which was not significant (t1(23) = 1.12, SD = 34.5, n.s.; t2(31) = 1.02, SD = 45.9, n.s.).

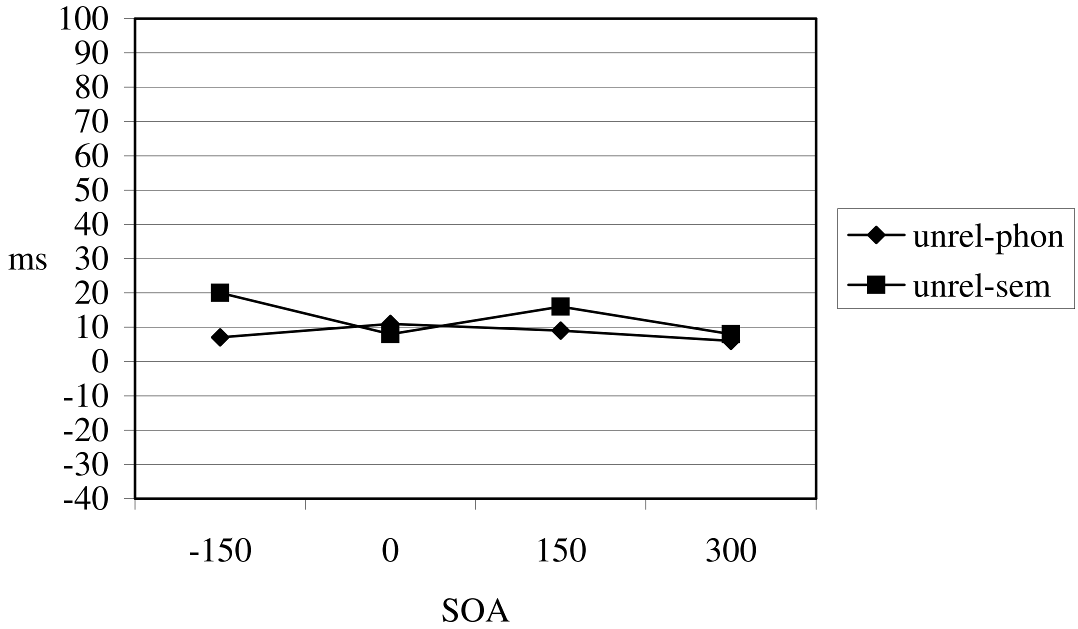
The effect of Distractor Type obtained for SOA 0 ms was significant in both analyses (F1(3,69) = 5.91, MSE = 1039.62, p < .005; F2(3,93) = 7.46, MSE = 1100.00,p < .001). At SOA 0 ms, the semantic facilitation trend decreased to 8 ms and was not significant in both analyses (t1 < 1; t2(31) = 1.11, SD = 45.8, n.s.). The phonological facilitation trend increased to non significant 11 ms (t1 < 1; t2(31) = 1.16, SD = 45.7, n.s.).

A significant effect of Distractor Type was obtained at SOA +150 ms (F1(3,69) = 14.86, MSE = 866.51, p < .001; F2(3,93) = 8.79, MSE = 1871.11, p < .001). A trend to semantic facilitation of 16 ms was obtained at this SOA, which was marginally significant in the analysis by participants (t1(23) = 1.82, SD = 44.1, p = .08) and not significant in the analysis by items (t2(31) = 1.68, SD = 60.6, n.s.). The phonological facilitation trend decreased (9 ms) and stayed non significant at SOA +150 ms in both analyses (t1(23) = 1.30, SD = 34.6, n.s.; t2 < 1).

At SOA +300 ms a significant effect of Distractor Type was observed (F1(3,69) = 5.31, MSE = 814.83, p < .005; F2(3,93) = 5.06, MSE = 1243.77, p < .005). The trend to semantic facilitation decreased (8 ms) and was not significant at this SOA (t1(23) = 1.49, SD = 26.6, n.s. t2 < 1). The trend to phonological facilitation (6 ms) obtained at SOA +300 ms was not significant in both analyses (both ts < 1). The results of Experiment 6B are shown in Figure 17.

Error rates. Neither the effect of Distractor Type (F1(3,69) = 1.83, MSE = 1.14, n.s.; F2(3,93) = 1.02, MSE = 1.54, n.s.) nor the effect of SOA (both Fs < 1) nor the interaction of Distractor Type and SOA were significant (both Fs < 1) in the error analyses.

Figure 17: Semantic and phonological effects obtained in Experiment 6B.



Discussion

As expected, the semantically related distractor words caused facilitation effects at SOA -150 ms in Experiment 6B. The distractor (e.g. **ezel**, donkey) pre-activates the lemma of the picture name (e.g. *koe*, cow). Via the conceptual links, the target concept (e.g. MELK, milk) also gets a certain amount of pre-activation. The moment the picture is presented, the target concept receives more activation. So, the activation of the target concept is sped up in case of the early presentation of a distractor word that is semantically related to the picture name compared to the presentation of an unrelated distractor word. Assuming lateral inhibition (e.g. Berg & Schade, 1992; Schade & Berg, 1992) it seems also likely that the target lemma can be selected more easily if a distractor word is presented that is semantically related to the picture name. Distractor lemma and the lemma of the picture name will inhibit each other more, than each of them inhibits the selection of the associate's lemma, because of a closer semantic relatedness. But even if the commonly accepted "Luce-ratio" (e.g. Luce, 1959; Levelt, Roelofs & Meyer, 1999) is assumed to rule the process of lemma selection, the selection of the target associate does not seem to have strong competitors. Picture and distractor are closely related, but the relation to the associate is semantically less close, so the competition effect at the lemma level should have a stronger impact on the response latencies in case of picture naming.

Although no significant phonological effects could be detected in Experiment 6B, the role of the picture name during the encoding of an associate has become clearer. The difference to the phonological distractors used in the previous experiments is that the non-words used in Experiment 6B cannot prime the word form of the picture at the level of word form encoding. The word form of the picture does not receive enough activation to spread it back to the lemma level, so the encoding of the target associate is not sped up by this kind of phonological distractors. It cannot be definitely stated that the segments of the picture name get activated in case of associate naming, where the picture name is not articulated. The trend to phonological facilitation obtained at SOA 0 ms gives a hint that they get activated, but more importantly it can be stated that the picture name usually gets activated at least up to the word form level. The results of Experiment 6B offer two possibilities to explain the processes during associate naming. First, the lexical access works in a cascading way, but then the assumption of associative links at the level of word form encoding is necessary. Secondly, the lexical access works with feedback connections, so that activation can spread back from the segmental to the word form level and from the word form level to the lemma level. An explanation of the results obtained in Experiment 6B in the scope of the discrete two-stage model is not likely. In the general discussion the most probable model according to the results of all experiments is presented.

6 General discussion

With the experiments reported in the previous chapter a new method of investigating the parallel activation of different word forms, the associate naming task, was applied. In the recent discussion on different models of lexical access, parallel activation of non-target word forms became a popular topic of investigation, due to the different model assumptions concerning processes at the level of phonological encoding. As described in chapter 3, the discrete two-stage model (e.g. Levelt, Roelofs & Meyer, 1999) predicts phonological activation only for the target word, while the cascading model (e.g. Humphreys, Riddoch & Quinlan, 1988) and the interactive feedback model (e.g. Dell, 1986) assume that all activated lemmas, not only the one selected for further production, spread activation to the corresponding word forms during lexical access.

Following the strategy of Peterson and Savoy (1998) and Jescheniak and Schriefers (1998), who tested the phonological activation of synonyms, a new approach was done with the studies reported in chapter 5, using associates within a mediated priming technique to obtain phonological activation of semantic alternatives. Participants saw a picture (e.g. **koe**, cow) and were asked to name a word that was semantically highly associated to the picture (e.g. **melk**, milk). Together with the picture, distractor words were presented that were related to the picture name. While the distractors in the semantically related condition (e.g. **ezel**, donkey) stayed the same across almost all experiments (except Experiment 3B, where distractor words related to the associates were used), the phonologically related distractors varied in order to obtain a preferably detailed view on the stages of phonological encoding, which are the topic of this investigation. Begin-related stimuli (e.g. **koek**, cake; Experiment 1B) were tested as well as phonologically end-related distractors (e.g. **taboe**, taboo; Experiment 2B), or non-words mixed up from the letters of the picture name (e.g. **oek**; Experiment 6B). Experiment 3B included phonological distractors begin-related to the target associate (e.g. **merk**, mark). In Experiment 4B and 5B, the distractor presentation modality was changed from visual to auditory, re-using the begin- or end-related distractors of Experiment 1B and 2B respectively. This variety of distractors ensures a very detailed view on the processes during phonological encoding and is a stable base for the interpretation of the obtained effects.

To control the effects obtained in the new kind of task, each associate naming experiment was preceded by a common picture naming study, conducted with the same material. In general, trustable data were obtained in the picture naming tasks, which means that they yielded effects that were reported in the literature most often.

Semantically related distractors lead to significant inhibition effects at early SOAs (-150 ms and/or 0 ms) in most of the experiments (q.v. Experiments 1A, 2A, 3A and 6A). All three models under consideration can handle these effects. While the distractor word (e.g. **ezel**, donkey) pre-activates its concept and a set of categorically related concepts, including the picture's concept (e.g. KOE, cow), a competitive situation is evoked at the stage of lemma selection. Two highly activated lemmas, *ezel* and *koe*, compete for selection. Whereas these kinds of interfering effects are reported in the literature most often (e.g. Schriefers, Meyer & Levelt, 1990; Starreveld & LaHeij, 1995; Damian & Martin, 1999), facilitating effects for semantically related distractors, as found in Experiments 4A and 5A, are obtained only scarcely and usually not in pure picture naming studies. Facilitating effects are sometimes reported in the scope of translation tasks (e.g. Bloem & LaHeij, 2003) or in categorization tasks (e.g. Costa, Mahon, Savova & Caramazza, 2003). In Experiments 4A and 5A semantic facilitation effects were obtained at SOA +150 ms with auditory distractor presentation. These effects are not interpreted as artefact of the data, because they occurred with full significance in two experiments. A first and careful explanation for these effects would be, to ascribe them to semantic priming effects at the level of word form encoding. This interpretation seems probable due to two reasons. First, the effects occurred with auditory presentation of the distractors, only. It is assumed that the word form of the distractor will be activated more strongly in this case than in visual presentation. Second, semantic effects, although interfering, were ascribed to the word form level in earlier studies, too (e.g. Starreveld & LaHeij, 1995). In detail, it is assumed that the semantic distractor word enters the perception network at least at two stages, at the word form level and at the lemma level. In visual presentation, the usual effects of a semantic distractor are categorical priming and inhibition at the lemma level and perhaps a not measurable trend to prime the picture's word form. In total, the inhibition effect at the lemma level is the strongest one and compensates conceptual pre-activation and word form priming. In auditory presentation, the priming rate at the level of word form encoding should be higher and so, the inhibition effect at the lemma level could be compensated, or inefficient. The facilitation effect occurs at a relatively late SOA (+150 ms) at which the conceptual and lexical activation of the picture name can already be started or even finished. To confirm this interpretation of the semantic facilitation effect more experimental studies would be necessary, but semantic effects are not in the focus of the current study.

In contrast to the semantically related effects, all kinds of phonologically related distractors lead to the same effects at comparable SOAs in the picture naming studies. Begin-related, as well as end-related distractors, visually presented as well as auditorily presented distractors and even non-words led to significant facilitation effects at the SOA range from -150 ms to +150 ms. Begin-related distractors presented auditorily facilitated picture naming even at SOA +300 ms in Experiment 4A, due to very strong priming for the picture's word form caused by these distractors. The only inhibitory effect obtained with phonologically related distractors in the picture naming tasks occurred at SOA +300 ms in Experiment 5A and is regarded as artefact. The test of begin-related and end-related distractors within one experiment in Experiment 3A yielded interesting effects for the comparison of the efficiency of the two conditions. It can be stated that both distractors can be effective up to the same degree and that the amount of segmental overlap between distractor and picture name seems to play an important role for the efficiency no matter if the mismatching segments are word-initial or word-final. To conclude, the phonological effects obtained in the picture naming tasks can be explained easily by the cascading model (e.g. Humphreys, Riddoch & Quinlan, 1988) and the interactive feedback model (e.g. Dell, 1986), because both accounts assume that semantic and phonological encoding stages overlap in time. So, early phonological facilitation effects are expected in these models. The discrete two-stage model (e.g. Levelt, Roelofs & Meyer, 1999) cannot handle the phonological effects at SOA -150 ms without additional assumptions, because a phase of pure semantic activation is assumed to precede the phonological encoding stages in this account. However, this model cannot be completely excluded as a possibility for the explanation of the effects obtained in the picture naming studies, because an SOA with pure semantic activation could have been found, if earlier SOAs (e.g. -300 ms) had been tested in the experiments.

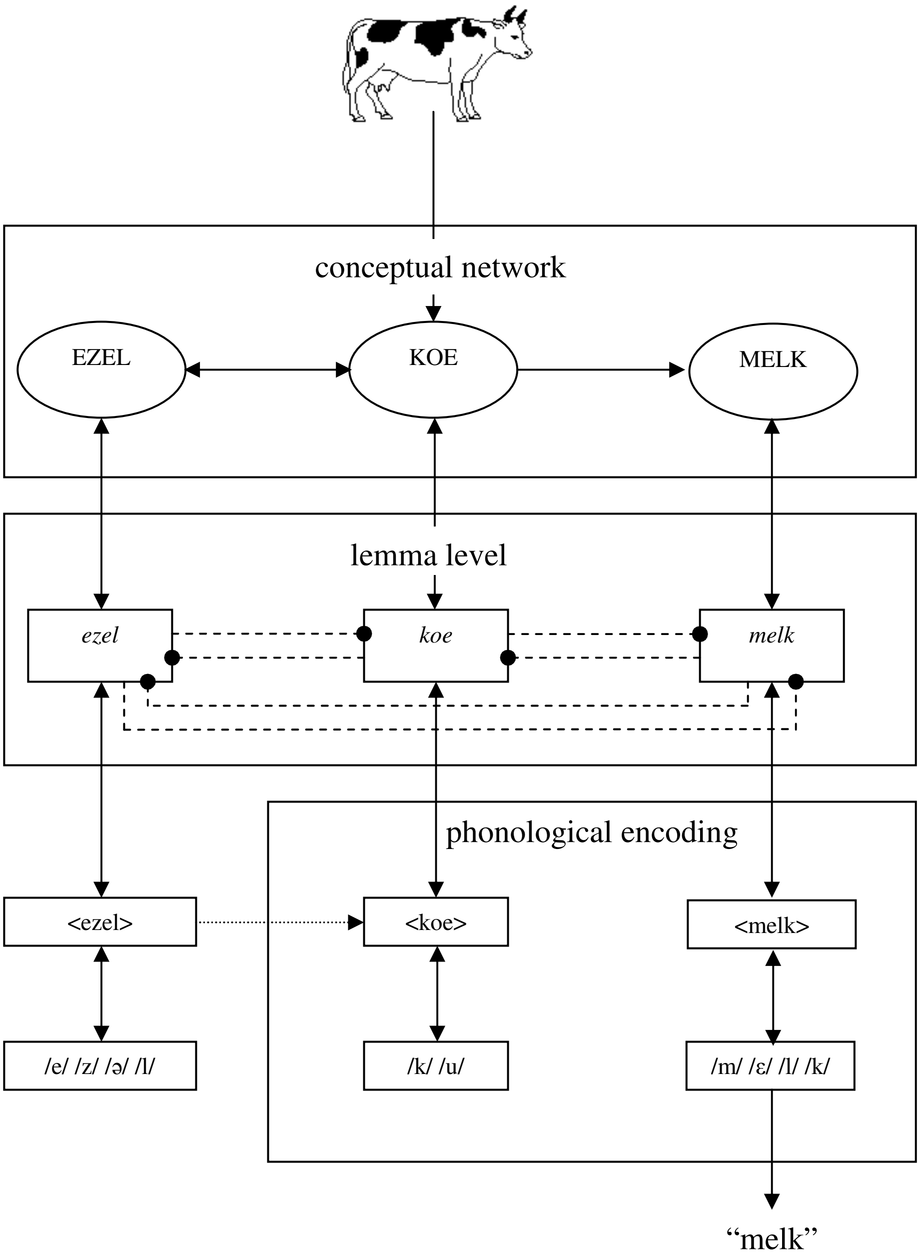
Although the picture naming experiments were not conducted to obtain effects that could help to distinguish between the three models in the actual discussion, they at least showed that the material used in the associate naming tasks is reliable. Interesting results for the discussion on the discrete two-stage model (e.g. Levelt, Roelofs & Meyer, 1999), the cascading model (e.g. Humphreys, Riddoch & Quinlan, 1988) and the interactive feedback model of lexical access (e.g. Dell, 1986) were retrieved in the associate naming studies reported in chapter 5.

A general effect that was expected to occur due to the characteristic of a mediated priming technique is the delay of approximately 100 ms in the reaction times in the associate naming studies compared to the picture naming tasks. The effect can be explained with the indirect way of activation of the target concept in associate naming (q.v. discussion of Experiment 3B). While the target concept is activated directly via the presentation of the picture in picture naming, activation of the target concept (e.g. MELK, milk) takes place exclusively via associative links with the picture's concept (e.g. KOE, cow) in associate naming.

Reviewing the effects obtained with semantically related distractors in the associate naming task, it can be stated that usually contrary effects occur compared to the picture naming task.

While semantic interference was obtained for distractors related to the picture name in the picture naming experiments using visual presentation of the distractors, the same distractors facilitated the naming of the associate. The facilitating effects at SOA +150 ms reported in Experiments 4A and 5A turned to an inhibitory trend in the associate naming studies 4B and 5B. It is assumed that the main difference between the two tasks occurs during lemma selection. While two highly activated lemmas compete for selection in picture naming, three lemmas are competitors in associate naming. The most probable account to explain the obtained effects is the theory of lateral inhibition (e.g. Berg & Schade, 1992; Schade & Berg, 1992). Figure 18 shows the processes that are assumed for lemma selection in associate naming.

Figure 18: Schematic view of an interactive feedback model including lateral inhibition at the lemma level, which can explain the semantic results of the experiments reported in chapter 5.
Activating connections are represented by arrows, broken lines represent inhibitory connections. Dotted arrows represent priming effects of distractors in the perceptual network on the phonological representations in the production network. Differences in the strength of the connections are not represented in the scheme. Production and perception network are assumed to coincide for the lemma level and the conceptual level.



The distractor (e.g. **ezel**, donkey) semantically related to the picture name (e.g. **koe**, cow) enters the perceptual network at three stages. Most effectively the lemma *ezel* will receive activation in the semantic network, coinciding for perception and production, and will pre-activate the concept EZEL and a set of categorically related concepts including KOE, if presented at an early SOA (e.g. -150 ms). KOE will spread an amount of activation to the target concept MELK (milk). All activated concepts will spread activation to the corresponding lemmas, so *ezel*, *koe* and *melk* will get activated. With the presentation of the picture, all concepts and lemmas will receive additional activation. At the stage of lemma selection all activated lemmas will inhibit each other. The amount of inhibition one node will spread to another node depends on the activation rate and the kind of strength of the link (e.g., categorical relation is assumed to be represented in a stronger link than associative relationship). The selected target lemma will be the most activated one and the least inhibited one (q.v. Schade & Berg, 1992). The theory of lateral inhibition (q.v. Berg & Schade, 1992; Schade & Berg, 1992) was preferred for the explanation of the semantic effects in the associate naming tasks compared to the "Luce-ratio" (q.v. Luce, 1959) due to one reason. While the "Luce-ratio" can explain the effects in Experiments 1B, 2B and 6B by assuming that the distractor lemma *ezel* (donkey) and the picture's lemma *koe* (cow) are not counted as strong competitors for the target lemma *melk* (milk) and will therefore not inhibit the selection process, this argument is not suitable for the explanation of the facilitation effects caused by the distractor **sap** (juice) in Experiment 3B.

The scheme of the model shown in Figure 18 includes an explanation for the semantic effects obtained in the experiments using auditory distractor presentation. It is assumed that the auditorily presented distractor **ezel** (donkey) will be highly activated at the word form level and therefore will prime the word form of the picture name in the production network.[14] Assuming feedback of activation between the word form level and the lemma level, the picture's lemma *koe* (cow) will be activated up to a higher degree and so the selection of the target lemma *melk* (milk) will take more time than in the situation with visual distractor presentation. So, no facilitation effects are retrieved at the early SOAs as in the other associate naming tasks and a trend to inhibition is detectable at SOA +150

[14] A visually presented distractor would also be activated at the word form level, but up to a much lesser degree and so would not lead to measurable priming effects.

ms, when the distractor will probably not facilitate the conceptual activation of the target associate, because this stage is already passed. More experiments should be done, concentrating on these differences between visual and auditory presentation of semantically related distractor words to collect reliable evidence. This could for example be done by using visual and auditory presentation of semantically related distractor words within one experiment.

Investigating the parallel activation of more than one word form, the most interesting results are retrieved by the distractor words phonologically related to the picture name. In general, it can be concluded that all kinds of phonologically related distractors led to effects in the associate naming tasks. This finding contradicts the assumption of the discrete two-stage model (Levelt, Roelofs & Meyer, 1999) that only selected lemmas will be phonologically encoded. While the discrete two-stage model (Levelt, Roelofs & Meyer, 1999) can explain the facilitating effects of begin-related distractors in Experiment 1B assuming that cohorts of lemmas with overlapping begin segments will become activated, this model has to be ruled out for the explanation of the effects retrieved with end-related distractor words. The auditory presentation of the end-related distractors in Experiment 5B ensures a strictly serial way of recognition. Accordingly, the last possibility to explain the effects in the scope of the discrete two-stage model can be excluded. In visual presentation it could have been that even in case of end-related distractors phonological cohorts had been activated at the lemma level due to a minimum of onset mismatch between picture name and distractor name and a non-serial recognition process.

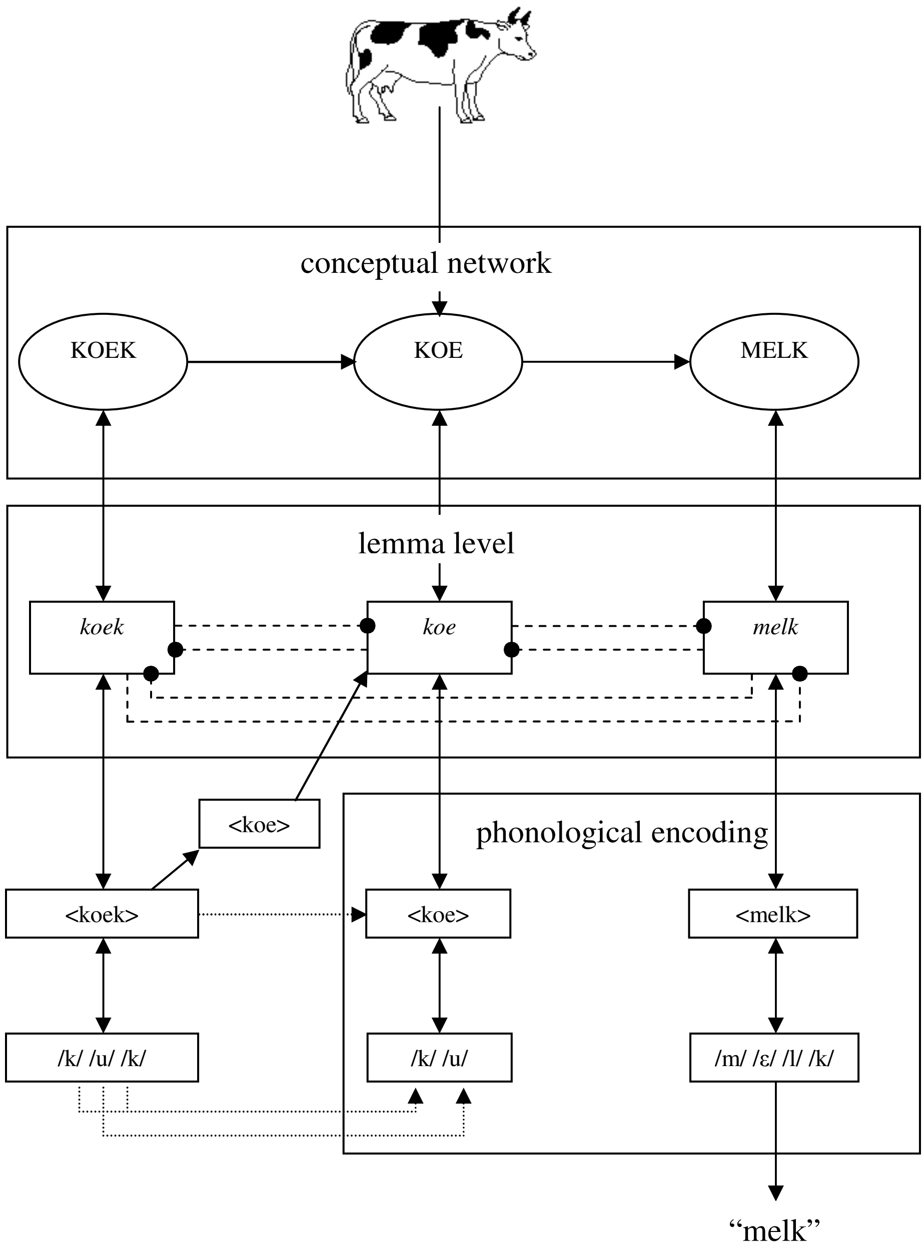
The explanation of the phonological effects by means of the cascading model of lexical access (e.g. Humphreys, Riddoch & Quinlan, 1988) is also difficult. Although the model assumes that the picture name will become phonologically activated, there is no explanation, how the activation of the target associate should be sped up. Assuming associative links at the level of word form encoding would keep the cascading model in the discussion. If semantic priming is already assumed to be possible at the word form level (see above), it could also be stated that the word form of the picture name can spread activation to the target word form. This possibility is not likely, according to the assumptions of associative networks, but cannot be ruled out definitely. According to mental models (e.g. Kintsch, 1998; q.v. section 3.4) associative links are expected to exist between conceptual nodes and not between lemmas or word forms. Even if semantic priming is assumed at the level of word form encoding, a difference lies in the strength of the connection. Due to the fact that members of the same semantic category are closer related than associates, it is assumed that links should be weaker between associates. So it is hard to imagine that facilitating effects as detected in the reported experiments are caused by spreading of activation via these relatively weak links.

The most probable model for the explanation of the phonological effects obtained in the associate naming tasks is the interactive feedback model, as shown in Figure 19. Due to the presentation of a phonologically related distractor (e.g. **taboe**, taboo), the word form and some segments of the picture name (e.g. <koe> and /u/) will receive additional activation. Via bidirectional links, this activation can be spread back to the lemma level and from there to the conceptual level. The concept of the picture name (e.g. KOE, cow) can then spread additional activation to the target associate (e.g. MELK, milk). This way the response latencies can be sped up.

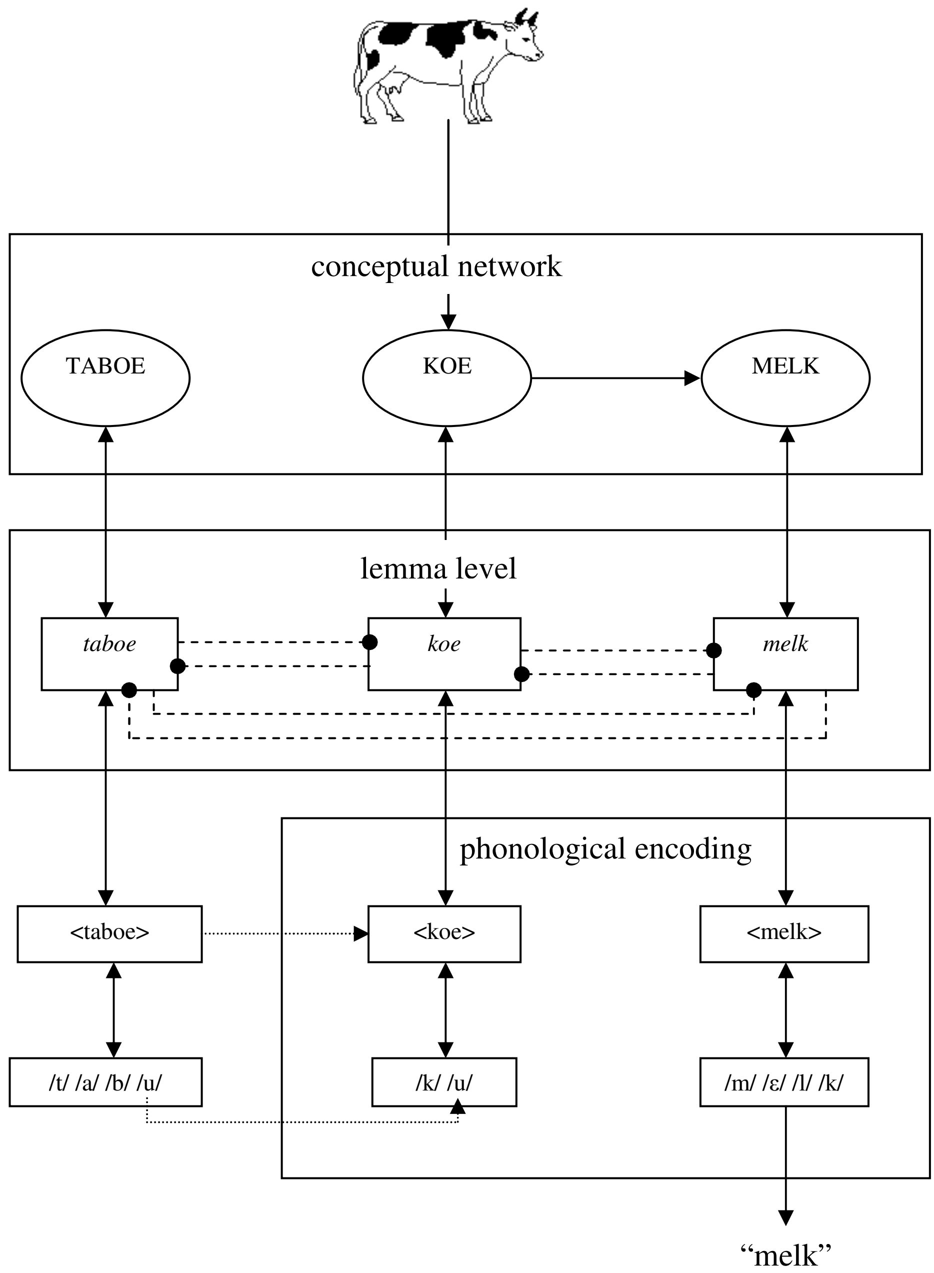
While this model can explain most of the effects, obtained in the associate naming studies, the inhibitory effects obtained in Experiment 4B do not seem to fit into the model at the first sight. Compared to Experiment 1B, it is assumed that the phonological representation of the picture name will become activated up to a much higher degree, due to the immediate activation caused by an auditorily presented distractor. This assumption is supported by the results of the picture naming task, which shows the strongest phonological facilitation effects (up to 92 ms) compared with the other experiments. One possibility to explain the phonological inhibition effects in the associate naming task could be that the picture name receives such an overwhelming amount of activation that the retrieval of the target is inhibited. Due to the initial overlap of distractor word and picture name most of the inhibition could be situated at the level of lemma selection, because the picture's lemma could get additional activation via cohorts and via feedback from the word form level. The model predictions, shown in Figure 19, hold for this case, too, but the situation with auditory distractors is not represented in detail in the scheme, because the strength of connections is not accounted for.

Figure 19: Schematic view of an interactive feedback model including lateral inhibition at the lemma level, which can explain the phonological results of the experiments reported in chapter 5.
Effects caused by begin-related distractors are presented in a), assuming activation of phonological cohorts in the perceptual network, b) shows effects of an end-related distractor. Activating connections are represented by arrows, broken lines represent inhibitory connections. Dotted arrows represent priming effects of distractors in the perceptual network on the phonological representations in the production network. Differences in the strength of the connections are not represented in the scheme. Production and perception network are assumed to coincide for the lemma level and the conceptual level.

a)



b)



Although more investigation would be necessary to explain the effects that occurred in Experiment 4B in more detail, it can be stated that the word form of the picture name will be activated in parallel to the encoding of the target associate, which was the goal of this investigation. Even the results of Experiment 6B, where no phonological effects could be obtained, do not contradict this conclusion. Non-words were presented visually in this experiment and so it is assumed that only the segmental level is affected and not the word form level or the lemma level. So it could be possible that the segments of the picture name are pre-activated but do not cause any effect, because the word form of the picture name is only activated by top down connections from the lemma level and not primed by the word form of a distractor. Another explanation would be that the segments of the picture name are not activated in associate naming. Nevertheless, the word form of the picture name is activated as shown in the results of the other associate naming tasks and so an important contribution to the actual discussion on the different models could be made with this study.

Based on the results obtained so far, evidence for an interactive feedback model including lateral inhibition at the lemma level is retrieved. Further experiments should be conducted to get more insights into the processes. As mentioned before, an experiment containing visual and auditory presentation of the distractor words could give more information on the effects of the semantically related distractors.

Further details of phonological encoding could be tested in a replication of Experiments 6A and 6B. Using only non-words that keep the syllabic structure of the picture name (e.g. **paasch** seems to consist of CVC as well as the related picture name **schaap**, sheep, in contrast to some other distractors used in Experiments 6A and B **oek** – VC and picture name **koe**, cow, CV) as phonologically related distractor words could yield phonological effects in contrast to Experiment 6B. The overlap of segments and syllabic structure can enlarge the probability that activation can spread back from the pre-activated segments to the picture's word form. The response latencies in an associate naming task should be sped up in this situation.

One further experiment that should be conducted is an associate naming task, including distractors related to the picture name and distractors related to the associate (e.g. picture: **koe**, cow; semantically related distractor: **ezel**, donkey; phonologically related distractor: **koek**, cake; associate: **melk**, milk; semantically related distractor: **sap**, juice; phonologically related distractor: **merk**, mark). This experiment could possibly clarify, if the phonological activation of the picture name and the phonological activation of the associate will overlap in time. It is assumed that the word form of the picture will be activated earlier than the associate's word form, due to the direct activation of the picture's representations and the mediated priming of the associate. Overlap of the activation is likely, because in Experiment 3B the distractors phonologically related to the associate led to facilitating effects at SOA +150 ms. At this SOA also phonological effects caused by distractors related to the picture name were found in Experiments 1B and 4B. Furthermore, the mean reaction times in picture naming and associate naming differ only by approximately 100 ms. The experiment using distractors related to the picture name and distractors related to the associate should test SOAs with small timing differences (e.g. 50 ms) to detect the precise moment of activation onset and decay for both word forms. According to the effects in Experiments 1B and 3B it is expected to find semantic facilitation effects for both kinds of distractors at early SOAs (-200 ms up to 0 ms) and phonological facilitation for both kind of distractors at later SOAs (0 ms up to 200 ms), if the distractors are presented visually.

The described experiment could also be used to rule out the alternative that the picture name is encoded completely before the encoding of the associate starts. In this case the associate naming paradigm would be inadequate to investigate the parallel activation of different word forms. The effects obtained in Experiments 1B and 3B and the short difference in the mean naming latencies between picture naming and associate naming, however, make this possibility very unlikely.

Without further studies, the results of the experiments described in chapter 5 support the interactive feedback model of lexical access (e.g. Dell, 1986) and the theory of lateral inhibition for lemma selection (e.g. Berg & Schade, 1992; Schade & Berg, 1992). The cascading model (e.g. Humphreys, Riddoch & Quinlan, 1988) cannot be ruled out definitely, because associative links at the level of word form encoding can be assumed. The discrete two-stage model (e.g. Levelt, Roelofs & Meyer, 1999) cannot handle the results without additional assumptions and can be excluded from further discussion.

7 Summary

This dissertation was started with a historical review on the development of the investigation of speech production. In section 2.1 the results of error analysis (e.g. Fromkin, 1971; Garett, 1975 and 1988) were presented that led to the first assumptions on the mental processes of speech production. Further details were provided by the development of the picture-word interference paradigm (e.g. Lupker, 1979; Glaser & Düngelhoff, 1984), a method for the experimental investigation of speech production. This method was developed based on the color naming task (e.g. Stroop, 1935) and was modified several times by the use of different distractor words. An overview on the various kinds of distractors that can be used to manipulate the response latencies in a picture naming task (e.g. Schriefers, Meyer & Levelt, 1990) was given in the following chapter. Most of the findings obtained in the described studies resulted in interesting assumptions on the speech production process that were summarized in one of the most popular speech production models by Levelt in 1989.

Not all assumptions on the different stages during the encoding of speech are commonly accepted. Especially the spreading of activation during lexical access is a main topic in the actual discussion. Chapter 3 introduced three competing approaches on lexical access. The discrete two-stage model (e.g. Levelt, Roelofs & Meyer, 1999) predicts that only selected target lemmas spread activation to their corresponding word form. In contrast, the cascading model of lexical access (e.g. Humphreys, Riddoch & Quinlan, 1988) assumes that all activated lemmas spread activation to their phonological representations. In addition to the assumptions of cascading models, bidirectional links are included in the interactive feedback theory (e.g. Dell, 1986), which means that activation can also spread back from the phonological representations to the lemma level. Chapter 3 was concluded with a description of a mental model (e.g. Kintsch, 1998) that provides an account of semantic and associative connections between conceptual nodes in a propositional network.

In the following, different studies were reported in which evidence for the different models of lexical access was obtained. While evidence for the discrete two-stage model was obtained in a picture naming task (Levelt et al., 1991), Peterson and Savoy (1998) reported results in favour of the cascading model obtained in a study using mediated priming with synonyms (q.v. Jescheniak & Schriefers, 1998). Cutting and Ferreira (1999) collected evidence for the interactive feedback model in a study with homophones. To contribute to the discussion on the different model assumptions, a new technique of mediated priming with associates was developed in the scope of this dissertation that was described in section 4.2.

Chapter 5 reported a series of six experiments conducted with the associate naming task. The participant's task in these studies was to name a word associated with the picture name. With the presentation of different kinds of phonological distractor words related to the picture name, the degree of phonological activation of the picture name during the production of the associate was investigated as detailed as possible. With the visual presentation of begin-related or end-related distractors significant facilitation effects were obtained, as well as for the auditory presentation of end-related stimuli. Semantically related distractors triggered facilitation effects in most of the experiments as well. To control the material used in the associate naming studies, each experiment was preceded by a picture naming task, which are reported in chapter 5, too.

In the general discussion it turned out that the effects retrieved in the associate naming studies provide evidence for the interactive feedback model of lexical access (e.g. Dell, 1986), including lateral inhibition (e.g. Berg & Schade, 1992; Schade & Berg, 1992) at the lemma level. While the cascading model (e.g. Humphreys, Riddoch & Quinlan, 1988) is not definitely ruled out by the results of the experiments, the discrete two-stage model cannot account for the data without changes in the model assumptions and can be excluded from the further discussion. More experimental studies should be conducted for deeper investigation of the parallel activation of more than one word form. Nevertheless, the experiments described in the scope of this dissertation present an effective new paradigm for the experimental investigation of the stages of lexical access, which offers results that are an important contribution to the actual discussion of the models under investigation.

German Summary

Sprechen ist eine der natürlichsten und automatisiertesten Fähigkeiten des Menschen. Pro Sekunde können etwa drei bis vier Wörter geäußert werden. Trotz des automatisierten Ablaufs ist der Sprachproduktionsprozess sehr komplex, wie sich zum Beispiel in der langen Phase des Erwerbs der Muttersprache zeigt. Kinder brauchen etwa dreieinhalb Jahre, bis sie komplexe Äußerungen in ihrer Muttersprache bilden können. Auch das Auftreten von Versprechern in der Erwachsenensprache verdeutlicht die Komplexität des Vorgangs.

In der Erforschung der Sprachproduktion haben sich zwei Methoden etabliert. Die Fehlerforschung untersucht die Abläufe der Sprachproduktion anhand natürlicher Sprachdaten, während mit dem Bild-Wort-Interferenz-Paradigma eine Methode zur experimentellen Untersuchung entwickelt wurde.

Die ersten Erkenntnisse in der Analyse von Sprachfehlern wurden bereits Ende des 19. Jahrhunderts gesammelt. Meringer und Mayer (1895) klassifizierten ihr Korpus von Sprachfehlern und stellten fest, dass Bedeutungsfehler (z.B. “Maus” anstelle von “Katze”) von Formfehlern (z.B. “Maul” anstelle von “Maus”) unterschieden werden können. Victoria Fromkin (1971) analysierte ihr Fehlerkorpus auf Basis der sprachlichen Einheiten, die in einen Fehler involviert sein können. Dabei wurde zum Beispiel deutlich, dass die häufigsten Fehler auf der Phonemebene auftreten, aber auch andere Einheiten, beispielsweise Wortteile und ganze Wörter fehlerhaft produziert werden können. Fromkin leitete aus ihren Analysen einige Anforderungen an Sprachproduktionsmodelle und Rückschlüsse über die Einteilung des mentalen Lexikons ab. Beispielsweise wird angenommen, dass Einträge orthographisch geordnet sind, aber unter anderem auch in semantische Felder eingeteilt werden. Nach zahlreichen weiteren Fehleranalysen, zum Beispiel durch Garrett (1975 und 1988), der sich besonders mit dem Auftreten von so genannten “mixed errors” (Fehler, die dem Zielwort sowohl semantisch als auch phonologisch ähnlich sind, z.B. “Maus” anstelle von “Maulwurf”) beschäftigte, entwickelte sich die Annahme, dass der Zugriff auf das mentale Lexikon in zwei Stufen stattfindet, in denen die semantischen bzw. die phonologischen Eigenschaften des zu produzierenden Wortes aufgerufen werden.

Parallel zur Fehlerforschung enstand mit dem Bild-Wort-Interferenz-Paradigma eine Methode zur experimentellen Untersuchung der Sprachproduktion. Als Grundlage dienten die Experimente von Stroop (1935), der Farben benennen ließ. Er präsentierte seinen Probanden Rechtecke oder Wörter und bat darum, jeweils die Farbe zu benennen, in welcher der Stimulus angeboten wurde. Die Benennung der Farbe dauerte länger, wenn ein Wort präsentiert wurde. 1979 wandelte Lupker diese Methode zum Bild-Wort-Interferenz-Paradigma um, welches seither in zahlreichen Studien Anwendung gefunden hat. Die Aufgabe der Probanden war die Benennung eines Bildes, das zeitgleich mit einem Störwort präsentiert wurde. Das Störwort konnte in semantischer Relation zum Bildnamen stehen (z.B. Bild: Maus, Distraktor: Hund) oder zu einer anderen semantischen Kategorie gehören (z.B. Hand). Im ersten Fall waren die durchschnittlichen Reaktionszeiten im Vergleich zur unrelatierten Kategorie signifikant langsamer.

Eine erste Modifikation nahmen Glaser und Düngelhoff (1984) am Bild-Wort-Interferenz-Paradigma vor. Sie variierten den zeitlichen Einsatz von Bild und Störwort in so genannten SOAs (stimulus onset asynchronies), um einen detaillierteren Einblick in den zeitlichen Ablauf der Sprachproduktion zu erhalten. Weitreichende Veränderungen an der Methode wurden außerdem von Schriefers, Meyer und Levelt (1990) eingebracht. Sie wechselten nicht nur die Modalität der Präsentation des Störwortes, indem sie auditive Distraktoren verwendeten, sondern führten mit dem Gebrauch von phonologisch relatierten Distraktoren eine neue Art von Störwörtern ein.

In einer Vielzahl von experimentellen Studien wurde der Einsatz von Distraktoren variiert, um möglichst viele Einzelheiten über den Prozess der Sprachproduktion untersuchen zu können. Als phonologische Distraktoren wurden beispielsweise auch end-relatierte Störwörter getestet (z.B. Bild: Maus, Distraktor: Haus) (z.B. Meyer & Schriefers, 1991), aber auch Wortteile (z.B. Bild: **banaan**, Banane; Distraktor: "naan") wurden als phonologische Störwörter präsentiert (z.B. Schiller, 2004). Üblicherweise führte die Präsentation von phonologisch relatierten Distraktoren zu beschleunigten Reaktionszeiten, im Vergleich zu unrelatierten Störwörtern. Die ebenfalls vielfach verwendeten semantischen Distraktoren verzögerten im Allgemeinen die Benennzeit des Bildes (z.B. Starreveld & LaHeij, 1995), jedoch können je nach Aufgabenstellung und je nach Art des Distraktors auch erleichternde Effekte hervorgerufen werden. So berichteten Costa, Mahon, Savova und Caramazza (2003) beispielsweise von Beschleunigungseffekten in einem Kategorisierungsexperiment. Alario, Segui und Ferrand (2000) erhielten Erleichterungseffekte durch Distraktoren, die assoziativ mit dem Bildnamen verknüpft waren (z.B. **Hund** und **Knochen**).

Die Ergebnisse aus zahlreichen Studien mit dem Bild-Wort-Interferenz-Paradigma führten zu der allgemein anerkannten Idee, dass bei der Produktion eines Wortes die semantische und die phonologische Enkodierung des Wortes in zwei Stufen erfolgen. Dabei geht die Phase der semantischen Enkodierung der phonologischen Enkodierung voraus, da semantische Effekte üblicherweise in früheren SOAs auftreten als phonologische Effekte.

1989 fasste Levelt die Ergebnisse vieler Studien in einem der anerkanntesten Sprachproduktionsmodelle zusammen. Er unterteilte die Prozesse der Sprachproduktion in drei Hauptphasen. Die erste Phase umfasst die Erstellung einer präverbalen Nachricht auf dem konzeptuellen Level. Dabei wird die intendierte Idee mithilfe von zugrunde liegendem Wissen in konzeptueller Form formuliert. Anschließend findet in der zweiten Phase der Zugriff auf das mentale Lexikon statt. Unterschieden wird hierbei zwischen grammatikalischer Enkodierung und phonologischer Enkodierung. Während in der grammatikalischen Enkodierung das Ziel-Lemma aus dem mentalen Lexikon abgerufen wird, werden in der darauffolgenden phonologischen Enkodierung morphologische und phonologische Merkmale aufgerufen, um die grammatikalische Oberflächenstruktur in einen artikulatorischen Plan umzuwandeln. Der Sprachproduktionsprozess schließt mit der dritten Phase, der Artikulation der Äußerung ab.

Während die grundsätzliche Einteilung des Levelt-Modells weithin akzeptiert ist, sind die Abläufe innerhalb der zweiten Phase ein Hauptthema in der aktuellen Diskussion. Neben dem diskreten Zwei-Stufen-Modell (z.B. Levelt, Roelofs & Meyer, 1999) werden das kaskadierende Modell (z.B. Humphreys, Riddoch & Quinlan, 1988) und das interaktive Feedback-Modell (z.B. Dell, 1986) besonders diskutiert.

Bei der Produktion eines Wortes, zum Beispiel bei der Benennung des Bildes einer Kuh, erfolgt zunächst eine Aktivierung auf dem konzeptuellen Level.

Das Konzept KUH wird ebenso wie Konzepte derselben semantischen Kategorie (z.B. PFERD) aktiviert. Alle aktivierten Konzepte geben Aktivierung an das jeweilige Lemma weiter. Während der Lemma-Selektion sind somit mehrere Lemmata (z.B. *kuh* und *pferd*) hoch aktiviert. Das Ziel-Lemma *kuh* wird selektiert, da es verglichen mit den mitaktivierten Lemmata die höchste Aktivierungsrate besitzt und sich somit in der Wettbewerbssituation durchsetzen kann. Im diskreten Zwei-Stufen-Modell wird davon ausgegangen, dass nur das selektierte Lemma phonologisch enkodiert wird. Die Wortform <kuh> wird demnach mit ihren morphologischen und phonologsichen Merkmalen vom mentalen Lexikon abgerufen. Nach der Enkodierung auf der segmentellen Ebene, bei der die Segmente /k/ und /u/ Aktivierung erhalten, wird das Wort „Kuh" artikuliert. Während im diskreten Zwei-Stufen-Modell (z.B. Levelt, Roelofs & Meyer, 1999) also nur das selektierte Lemma phonologisch enkodiert wird, nimmt das kaskadierende Modell (z.B. Humphreys, Riddoch & Quinlan, 1988) an, dass alle aktivierten Lemmata Aktivierung an die zugehörigen Wortformen weitergeben. Es werden also in diesem Fall die Wortform und die Segmente zum Lemma *pferd* mitaktiviert. Das interaktive Feedback-Modell (z.B. Dell, 1986) baut auf den Annahmen des kaskadierenden Modells auf. Auch in diesem Modell wird angenommen, dass alle aktivierten Lemmata Aktivierung an die zugehörigen Wortformen weitergeben. Darüberhinaus ist die Aktivierungsausbreitung im interaktiven Feedback-Modell über bidirektionale Verknüpfungen zwischen allen Enkodierungsstufen möglich, während im diskreten Zwei-Stufen-Modell und im kaskadierenden Modell bidirektionale Aktivierung nur zwischen konzeptueller Ebene und Lemma-Level angenommen wird. Im interaktiven Feedback-Modell kann also Aktivierung von der segmentellen Ebene zur Wortform-Enkodierung und von dort zum Lemma-Level zurückfließen.

In der bisherigen Erforschung des lexikalischen Zugriffs wurde Evidenz für alle drei beschriebenen Modelle gefunden. Levelt, Schriefers, Vorberg, Meyer, Pechmann, und Havinga (1991) führten ein Experiment durch, in dem sie verschiedene Arten von Distraktoren testeten. Zum Bild eines Schreibtischs (bureau) präsentierten sie unter anderem ein semantisch relatiertes Störwort (z.B. **stoel**, Stuhl) und ein Störwort, das phonologisch relatiert zu einer semantischen Alternative war (z.B. **stoep**, Bürgersteig). Da Effekte in der semantischen, aber nicht in der phonologischen Bedingung gefunden werden konnten, argumentierten die Autoren, dass semantische Alternativen zwar mitaktiviert werden, aber nicht phonologisch enkodiert werden. Sie werteten die Ergebnisse ihrer Studien als Evidenz für das diskrete Zwei-Stufen-Modell[15].

Mit einem Experiment, in dem sie sowohl Bildbenennung wie auch Wortbenennung kombinierten, lieferten Peterson und Savoy (1998) experimentelle Evidenz für das kaskadierende Modell. Sie präsentierten Probanden Bilder von Objekten, für die zwei synonyme Bezeichnungen möglich waren, z.B. „Sofa“ und „Couch“. Während die Probanden angehalten waren, immer einen speziellen Namen für jedes Objekt zu verwenden, untersuchten Peterson und Savoy (1998) den Einfluss dieses Namens auf zu benennende Zielwörter, die zu jeweils einem der beiden synonymen Namen phonologisch relatiert waren.

Die Autoren beobachteten phonologische Effekte für beide Zielwortarten. Daraus ergab sich die Annahme, dass bei Synonymen beide phonologischen Repräsentationen enkodiert werden. Jescheniak und Schriefers (1998) replizierten die Effekte von Peterson und Savoy (1998) in einem vergleichbaren Experiment.

Nachdem durch die Experimente mit Synonymen (Peterson & Savoy, 1998; Jescheniak & Schriefers, 1998) Evidenz für die phonologische Enkodierung von semantischen Alternativen geliefert wurde, untersuchten Cutting und Ferreira (1999) die phonologische Enkodierung anhand von Homophonen. Sie präsentierten Versuchspersonen Bilder von Objekten, deren Name ein Homophon darstellte. Z.B. zeigten sie ein Bild von einem Spielzeugball, das die Probanden mit dem Wort „Ball“ benennen sollten. Als Distraktoren wählten Cutting und Ferreira (1999) semantisch relatierte Wörter zur nicht-dargestellten Bedeutung des Wortes (z.B. „Tanz“), die einen Beschleunigungseffekt auf die Benennung des dargestellten Objektes ausübten. Da der beschleunigende Einfluss laut Cutting und Ferreira (1999) auf der Wortformebene stattfinden muss, deuteten sie die Resultate dieser Studie als Evidenz für das interaktive Feedback-Modell.

[15] Die Ergebnisse von Levelt et al. (1991) können auch als Evidenz für das kaskadierende Modell gewertet werden, weil phonologische Aktivierung in frühen SOAs gemessen wurde. Die Autoren sind sich dieser Diskrepanz bewusst: “Contrary to the prediction of the two-stage model [...], there is evidence for early phonological activation. And contrary to the backward-spreading connectionist model […], there is no evidence for late semantic activation” (ebd.., S. 131).

Um einen Beitrag zur aktuellen Diskussion um die verschiedenen Modelle zum Zugriff auf das mentale Lexikon zu liefern, wurde im Rahmen dieser Dissertation eine Reihe von Experimenten durchgeführt, in denen eine neue Methode zur Untersuchung von paralleler Aktivierung verschiedener Wortformen angewendet wurde. Basierend auf den Experimenten mit Synonymen (Peterson & Savoy, 1998; Jescheniak & Schriefers, 1998) und Homophonen (Cutting & Ferreira, 1999) wurden die Effekten von mittelbar-ähnlichen Distraktoren mithilfe von Assoziationen im Niederländischen untersucht.

Bilder von bekannten Objekten (z.B. **koe**, Kuh) wurden als Stimuli gebraucht und zu diesen Objekten assoziativ relatierte Zielwörter (z.B. **melk**, Milch) sollten durch die Probanden genannt werden. Die verwendeten Distraktor-Wörter waren beispielsweise semantisch relatiert (z.B. **ezel**, Esel), phonologisch relatiert (z.B. **koek**, Kuchen), unrelatiert (z.B. **appel**, Apfel) oder neutral (z.B. **XXXXX**) zum Bildnamen, um die zum Zielwort parallele Enkodierung des nicht zu benennenden Bildnamens zu untersuchen.

Basierend auf dem mentalen Modell von Kintsch (1998) wird davon ausgegangen, dass Assoziationen auf der konzeptuellen Ebene verknüpft sind, so dass die Aktivierung des Zielwortes indirekt über die Aktivierung des Bildnamens erfolgt. Somit sagen alle drei Sprach-Produktions-Modelle Aktivierung des Konzepts, sowie des Lemmas des Bildnamen voraus. Phonologische Aktivierung des Bildnamens kann jedoch nur mit den Annahmen des kaskadierenden und des interaktiven Feedback-Modells erklärt werden, da das diskrete Zwei-Stufen-Modell phonologische Aktivierung von semantischen Alternativen ausschließt. Zur Kontrolle des Materials, das in den Experimenten mit der Benennung von Assoziationen verwendet wird, ging jeder Studie ein Experiment mit Bildbenennung voraus.

In den ersten beiden Experimenten wurde die grundsätzliche Funktionsweise von Distraktoren getestet, die zum Bildnamen relatiert sind. Die Distraktoren wurden visuell, in vier verschiedenen SOAs (-150 ms, 0 ms, +150 ms und +300 ms), angeboten. In der phonologischen Bedingung wurden Störwörter verwendet, die am Wortanfang mit dem Bildnamen überlappen (z.B. Bild: **koe**, Kuh; Störwort: **koek**, Kuchen).

Im Bildbenennungsexperiment zeigten sich - wie erwartet - semantische Verzögerungseffekte in der frühesten SOA (s.a. Schriefers, Meyer & Levelt, 1990; Starreveld & LaHeij, 1995). Die phonologischen Störwörter führten zu beschleunigenden Effekten in den Reaktionszeiten, verglichen mit der unrelatierten Bedingung. Phonologische Effekte wurden im SOA-Bereich von -150 ms bis +150 ms beobachtet. Das frühe Auftreten der phonologischen Effekte kann im Rahmen des kaskadierenden und des interaktiven Feedback-Modells adäquat erklärt werden. Das diskrete Zwei-Stufen-Modell kann die Effekte nur unter der Annahme erklären, dass in einer früheren SOA (z.B. +300 ms) rein semantische Aktivierung aufgetreten wäre.

Bei der Benennung von Assoziationen lieferten die gleichen Distraktoren semantische Beschleunigungseffekte bei SOA -150 ms und SOA 0 ms, sowie phonologische Erleichterung bei SOA 0 ms und +150 ms. Die semantische Erleichterung kann auf die konzeptuelle Ebene zurückgeführt werden. Das Störwort **ezel** (Esel) wird hier den Bildnamen (z.B. KOE, Kuh) bereits vor der Präsentation des Bildes aktivieren. Somit kann auch Aktivierung an das Zielkonzept MELK (Milch) weitergegeben werden. Gleichzeitig werden alle zugehörigen Lemmata Aktivierung erhalten. Es wird angenommen, dass die Situation während der Lemma-Selektion ebenfalls zur Beschleunigung der gesamten Reaktionszeit beiträgt, da sowohl das Lemma des Distraktors als auch das Lemma des Bildnamens keine starken Konkurrenten für das Ziellemma darstellen, da sie nicht zur selben semantischen Kategorie gehören, oder weil der Selektionsprozess durch laterale Inhibition (s.a. Berg & Schade, 1992; Schade & Berg, 1992) gesteuert wird. Die phonologischen Effekte können im interaktiven Feedback-Modell problemlos erklärt werden, da phonologische Aktivierung für den Bildnamen erwartet wurde und diese Aktivierung über die bidirektionalen Verbindungen bis zur konzeptuellen Ebene zurück geleitet werden kann. Durch die verstärkte Aktivierung des Konzepts des Bildnamen kann das Konzept der Assoziation ebenfalls verstärkt aktiviert werden. Das kaskadierende Modell erwartet ebenfalls, dass die phonologischen Repräsentationen des Bildnamens Aktivierung erhalten, kann aber nur unter der Annahme von assoziativen Verbindungen auf der Wortform-Ebene die Beschleunigung der Benennung der Assoziation erklären. Möglich ist außerdem eine Erklärung über Kohorteneffekte (s.a. Marslen-Wilson & Welsh, 1978; Roelofs, Meyer & Levelt, 1996). Da die phonologischen Distraktoren beginn-realtiert waren, ist es möglich, dass das Störwort (z.B. **koek**, Kuchen) phonologische Kohorten (z.B. **koe**, Kuh; **koelkast**, Kühlschrank) aktiviert, die Aktivierung zum Lemma-Level verteilen. Die Kohortentheorie ist nötig, um die Effekte innerhalb des diskreten Zwei-Stufen-Modells erklären zu können.

In den beiden folgenden Experimenten wurde nun die Rolle von end-relatierten phonologischen Distraktoren untersucht, um die Kohortentheorie zu überprüfen.
Alle experimentellen Parameter wurden im Vergleich zu den ersten Experimenten konstant gehalten, nur die Distraktoren der phonologischen Bedingung wurden verändert. Anstelle von beginn-relatierten Distraktoren wurden nun Distraktoren ausgewählt, die am Wortende mit dem Bildnamen übereinstimmten (z.B. Bild: **koe**, Kuh; Distraktor: **taboe**, Tabu).

Im Bildbenennungsexperiment stellten sich erneut semantische Verzögerungseffekte in den ersten beiden SOAs ein, sowie phonologische Beschleunigungseffekte in den ersten drei SOAs. Nach der Bestätigung des Materials durch die erwarteten Effekte wurde es in der Studie zur Benennung von Assoziationen eingesetzt, in der marginale semantische Beschleunigungseffekte bei SOA -150 ms sowie phonologische Beschleunigung in den ersten beiden SOAs festgestellt werden konnten. Die Effekte der end-relatierten phonologischen Distraktoren sind am ehesten der segmentalen Ebene und der Ebene der Wortform-Enkodierung zuzuschreiben. Jedoch kann die Kohortentheorie noch nicht vollständig von der Erklärung der Effekte ausgeschlossen werden, da die Perzeption des Distraktors bei visueller Präsentation nicht zwingend sequenziell erfolgen muß.

Im Folgenden wurden zwei Experimente mit Distraktoren, die zur Assoziation relatiert waren, durchgeführt (z.B. Bild: **ooievaar**, Storch; Assoziation: baby, Baby; semantisches Störwort: **kleuter**, Kleinkind, phonologisches Störwort: **beek**, Bach). Dazu wurden für das Bildbenennungsexperiment 20 neue Bilder ausgewählt. Zu zwölf Assoziationen konnten keine adäquaten Bilder gefunden werden (z.B. **lucht**, Luft). Durch die Reduzierung des Materials bot sich die Möglichkeit, eine weitere Bedingung zu testen, sodass im Bildbenennungsexperiment neben den beginn-relatierten Distraktoren auch end-relatierte Distraktoren (z.B. fobie, Phobie) verwendet wurden, um beide Bedingungen innerhalb eines Experimentes vergleichen zu können.

Bei der Bildbenennung stellten sich die erwarteten Effekte ein. Semantische Interferenz wurde bei SOA 0 ms beobachtet und sowohl die beginn-relatierten, als auch die end-relatierten Distraktoren führten zu beschleunigenden Effekten im SOA Bereich von -150 ms bis +150 ms. Beim Vergleich der beiden phonologischen Bedingungen wurde deutlich, das beide Bedingungen Effekte mit vergleichbarer Stärke hervorrufen können und somit die end-relatierte Bedingung nicht weniger effektiv ist als die beginn-relatierten Störwörter. Bei der Benennung von Assoziationen riefen die semantischen Störwörter erleichternde Effekte in der ersten SOA hervor. Diese sind vor allem auf die Erleichterung der Aktivierung des Zielkonzeptes zurück zu führen und legen außerdem die Theorie der lateralen Inhibition auf dem Lemma-Level nahe, da die Unterschiede in den Aktivierungsraten bei der Annahme von lateraler Inhibition zugunsten des Ziellemmas verstärkt werden. Phonologische Effekte wurden in den letzten beiden SOAs gemessen. Das relativ späte Auftreten der Effekte kann durch die indirekte Aktivierung des Zielwortes auf dem konzeptuellen Level erklärt werden. Da bei SOA +150 ms jedoch phonologische Effekte sowohl von Distraktoren, die zum Bildnamen relatiert sind, als auch von Distraktoren, die zum Zielwort relatiert sind, gefunden wurden, ist davon auszugehen, dass Bildname und Assoziation bei der Enkodierung von Assoziationen zeitgleich aktiviert sind.

Bei den beiden folgenden Experimenten handelt es sich um eine Wiederholung der beiden zuerst beschriebenen Studien mit auditiv präsentierten Distraktoren. In der Bildbenennungsstudie zeigten sich erwartet starke phonologische Effekte in allen vier SOAs. Die auditive Präsentation eines beginn-relatierten Störwortes rief Aktivierung für die phonologischen Repräsentationen des Bildnamens und vermutlich über Kohorteneffekte auch für das Lemma des Bildnamens hervor. Erstaunlicherweise führten die semantischen Distraktoren nicht wie erwartet zu inhibierenden Effekten in frühen SOAs, sondern zu erleichternden Effekten bei SOA +150 ms. Ohne weitere Untersuchung können diese Effekte zunächst semantisch aktivierenden Verbindungen auf der Wortform-Ebene zugeschrieben werden, da der einzige Unterschied zum ersten Experiment die auditive

Darbietung des Störwortes war und davon ausgegangen werden muß, dass dies insbesondere die phonologischen Repräsentationen stark aktiviert.

Die Benennung von Assoziationen wurde durch die semantischen Distraktoren kaum beeinflusst. Bei SOA +150 ms wurde lediglich eine Tendenz zu semantischer Inhibition sichtbar. Dieser Trend unterstützt die Interpretation der semantischen Effekte in der Bildbenennungsstudie. Besonders hohe Aktivierung des Bildnamens auf der Wortform-Ebene, ausgelöst durch das semantische Störwort, kann zum Lemma-Level zurückfließen und die Lemma-Selektion verlangsamen. Die phonologischen Distraktoren wirkten in diesem Experiment inhibierend in SOA -150 ms und in SOA +150 ms. Auch hier muss davon ausgegangen werden, dass die Wortform des Bildnamens durch die auditive Präsentation des Störwortes außergewöhnlich stark aktiviert wird. Da die Distraktoren beginn-relatiert waren, kann der inhibierende Effekt mithilfe der Kohortentheorie dem Lemma-Level zugeschrieben werden.

In den folgenden Experimenten wurden die Untersuchungen mit end-relatierten phonologischen Distraktoren mit auditiver Präsentation wiederholt. Im Bildbenennungsexperiment zeigte sich erneut ein semantischer Beschleunigungseffekt bei SOA +150 ms, der die Interpretation des Effektes im vorangegangenen Experiment bestätigte. Die end-relatierten phonologischen Distraktoren brachten erleichternde Effekte in den ersten drei SOAs hervor, sowie verzögernde Effekte bei SOA +300 ms. Während die beschleunigenden Effekte den Erwartungen entsprachen, wurde der inhibierende Effekt in der letzten SOA als Artefakt der Daten angesehen, da in keinem anderen Experiment ein solcher Effekt messbar war. Im Assoziationsbenennungsexperiment zeigte sich wieder kein semantischer Effekt, jedoch konnte erneut eine Tendenz zu semantischer Inhibition bei SOA +150 ms festgestellt werden. Die end-relatierten phonologischen Distraktoren lieferten Erleichterungseffekte in den ersten beiden SOAs. Da die Perzeption des Distraktors bei auditiver Präsentation sequentiell abläuft, kann eine Erklärung der phonologischen Effekte mithilfe der Kohortentheorie in diesem Falle ausgeschlossen werden. Die Effekte können den phonologischen Repräsentationsebenen zugeordnet werden.

In den abschließenden Studien wurden die phonologischen Distraktoren erneut modifiziert, um einen detaillierteren Einblick in die phonologischen Enkodierungsstufen zu erhalten. In der phonologischen Bedingung wurden Nicht-Wörter getestet, die aus den Segmenten des Bildnamens zusammengestellt wurden (z.B. Bild: **varken**, Schwein; Distraktor: **knerav**). Die Präsentation der Störwörter erfolgte visuell. Im Bildbenennungsexperiment traten wie erwartet semantische Verzögerungseffekte bei SOA 0 ms auf. Die phonologischen Distraktoren führten zu erleichternden Effekten in den ersten drei SOAs. Die Effekte der phonologischen Distraktoren sind der segmentellen Ebene zuzuschreiben, da ein Nicht-Wort keinen direkten Einfluss auf die Wortform-Ebene haben kann. Bei der Benennung der Assoziationen stellten sich semantische Beschleunigungseffekte bei SOA -150 ms ein, wie nach den Ergebnissen der früheren Experimente erwartet. Die phonologischen Distraktoren zeigten keine Wirkung. Segmentelle Aktivierung des Bildnamens beschleunigt die Benennung der Assoziation folglich nur über den Rückfluß der Aktivierung zur Wortform-Ebene.

Die im Rahmen dieser Dissertation durchgeführten Experimente legen ein interaktives Feedback-Modell (z.B. Dell, 1986) mit der Annahme von lateraler Inhibition (z.B. Berg & Schade, 1992; Schade & Berg, 1992) auf dem Lemma-Level als Theorie für den lexikalischen Zugriff nahe. Das kaskadierende Modell (z.B. Humphreys, Riddoch & Quinlan, 1988) kann als Erklärungsansatz noch nicht ausgeschlossen werden, da die Existenz von assoziativen Verbindungen auf der Wortform-Ebene theoretisch möglich bleibt. Das diskrete Zwei-Stufen-Modell (z.B. Levelt, Roelofs & Meyer, 1999) kann die beschriebenen Effekte nicht adäquat erklären und kann somit von der aktuellen Diskussion ausgeschlossen werden. Die hier vorgestellte Methode der Benennung von Assoziationen hat sich als geeignetes Paradigma zur Erforschung von paralleler Aktivierung verschiedener Wortformen herausgestellt und sollte auch in zukünftigen Studien eingesetzt werden, um weitere Details über die phonologischen Repräsentationsstufen zu erhalten.

Figures

Tables

Abbreviations

English

approx.	approximately
begin	begin-related
cf.	confer
e.g.	*[exempli gratia]* for example
end	end-related
ibid.	ibidem
i.e.	*[id est]* that is
Hz	hertz
ms	milliseconds
phon	phonological[ly]
q.v.	*[quod vide]* which see
sem	semantic[ally]
unrel	unrelated
viz.	that is
vs.	versus

German

bzw.	beziehungsweise
ebd.	ebenda
ms	Millisekunden
s.a.	siehe auch
z.B.	zum Beispiel

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Appendices

Appendix A. Materials used in Experiments 1A and 1B.

Pictures		Associates		Distractor Words					
				Semantically related		Phonologically related		Unrelated	
akker	*field*	boer	*farmer*	wei	*pasture*	akte	*act*	schuim	*foam*
ballon	*balloon*	lucht	*air*	vlieger	*kite*	balkon	*balcony*	haak	*hook*
bij	*bee*	honing	*honey*	wesp	*wasp*	bijl	*axe*	fles	*bottle*
brommer	*moped*	helm	*helmet*	motor	*motorbike*	brons	*bronze*	leeuw	*lion*
draad	*thread*	naald	*needle*	touw	*rope*	draak	*dragon*	brood	*bread*
egel	*hedgehog*	stekels	*spine*	muis	*mouse*	ego	*ego*	fiets	*bike*
gum	*rubber*	potlood	*pencil*	lineaal	*ruler*	gulden	*florins*	toren	*tower*
hamer	*hammer*	spijker	*nail*	zaag	*saw*	hamster	*hamster*	sjaal	*scarf*
harp	*harp*	muziek	*music*	gitaar	*guitar*	hart	*heart*	bad	*bath*
heks	*witch*	sprookje	*tale*	tovenaar	*magician*	hek	*fence*	kast	*closet*
kip	*chicken*	ei	*egg*	eend	*duck*	kin	*chin*	schilderij	*painting*
koe	*cow*	melk	*milk*	ezel	*donkey*	koek	*cake*	appel	*apple*
koets	*coach*	paard	*horse*	wagen	*wagon*	koers	*course*	muts	*hat*
kraan	*faucet*	water	*water*	tap	*tap*	kraag	*collar*	lente	*spring*
krab	*crab*	zee	*sea*	garnaal	*shrimp*	krans	*ring*	lantaarn	*lantern*
krokodil	*crocodile*	tanden	*teeth*	hagedis	*lizard*	krokus	*crocus*	pot	*pot*
lerares	*teacher*	school	*school*	directeur	*director*	lepel	*spoon*	vork	*fork*
matroos	*sailor*	schip	*ship*	kapitein	*skipper*	matras	*mattress*	paraplu	*umbrella*
ooievaar	*stork*	baby	*baby*	zwaan	*swan*	olijf	*olive*	storm	*storm*
paprika	*paprika*	chips	*chips*	tomaat	*tomato*	papier	*paper*	dak	*roof*
raam	*window*	glas	*glass*	deur	*door*	raad	*advice*	koffie	*coffee*
rasp	*grater*	kaas	*cheese*	pers	*press*	rat	*rat*	tapijt	*carpet*
riem	*belt*	broek	*trousers*	das	*tie*	riet	*reed*	cactus	*cactus*
schaap	*sheep*	wol	*wool*	geit	*goat*	schaak	*chess*	boom	*tree*
schep	*scoop*	zand	*sand*	emmer	*bucket*	scherm	*screen*	kaars	*candle*
schoen	*shoe*	veter	*lace*	laars	*boot*	schoot	*lap*	behang	*wallpaper*
spin	*spider*	web	*web*	vlieg	*fly*	spil	*spill*	mes	*knife*
ster	*star*	hemel	*sky*	maan	*moon*	stem	*voice*	kopje	*cup*
trein	*train*	rails	*rails*	bus	*bus*	trede	*step*	krant	*newspaper*
varken	*pig*	modder	*mud*	hond	*dog*	valk	*falcon*	herfst	*fall*
vergiet	*colander*	sla	*salad*	zeef	*sieve*	vergissing	*mistake*	wolk	*cloud*
zebra	*zebra*	pad	*path*	giraf	*giraffe*	zede	*custom*	munt	*coin*

Appendix B. Materials used in Experiments 2A and 2B.

Pictures		Associates		Distractor words					
				Semantically related		Phonologically related		Unrelated	
akker	*field*	boer	*farmer*	wei	*pasture*	rakker	*rascal*	schuim	*foam*
ballon	*balloon*	lucht	*air*	vlieger	*kite*	salon	*drawing room*	haak	*hook*
bij	*bee*	honing	*honey*	wesp	*wasp*	tij	*tide*	fles	*bottle*
brommer	*moped*	helm	*helmet*	motor	*motorbike*	kommer	*distress*	leeuw	*lion*
draad	*thread*	naald	*needle*	touw	*rope*	graad	*degree*	brood	*bread*
egel	*hedgehog*	stekels	*quills*	muis	*mouse*	tegel	*tile*	fiets	*bike*
gum	*rubber*	potlood	*pencil*	lineaal	*ruler*	rum	*rum*	toren	*tower*
hamer	*hammer*	spijker	*nail*	zaag	*saw*	kamer	*room*	sjaal	*scarf*
harp	*harp*	muziek	*music*	gitaar	*guitar*	worp	*throw*	bad	*bath*
heks	*witch*	sprookje	*fairytale*	tovenaar	*magician*	reeks	*series*	kast	*closet*
kip	*chicken*	ei	*egg*	eend	*duck*	wip	*seesaw*	schilderij	*painting*
koe	*cow*	melk	*milk*	ezel	*donkey*	taboe	*taboo*	appel	*apple*
koets	*coach*	paard	*horse*	wagen	*wagon*	toets	*test*	muts	*hat*
kraan	*faucet*	water	*water*	tap	*tap*	traan	*tear*	lente	*spring*
krab	*crab*	zee	*sea*	garnaal	*shrimp*	drab	*dregs*	lantaarn	*lantern*
krokodil	*crocodile*	tanden	*teeth*	hagedis	*lizard*	bril	*glasses*	pot	*pot*
lerares	*teacher*	school	*school*	directeur	*director*	minnares	*lover*	vork	*fork*
matroos	*sailor*	schip	*ship*	kapitein	*skipper*	roos	*rose*	paraplu	*umbrella*
ooievaar	*stork*	baby	*baby*	zwaan	*swan*	gevaar	*danger*	storm	*storm*
paprika	*paprika*	chips	*chips*	tomaat	*tomato*	afrika	*africa*	dak	*roof*
raam	*window*	glas	*glass*	deur	*door*	naam	*name*	koffie	*coffee*
rasp	*grater*	kaas	*cheese*	pers	*press*	gesp	*buckle*	tapijt	*carpet*
riem	*belt*	broek	*pants*	das	*tie*	kiem	*germ*	cactus	*cactus*
schaap	*sheep*	wol	*wool*	geit	*goat*	knaap	*boy*	boom	*tree*
schep	*scoop*	zand	*sand*	emmer	*bucket*	klep	*peal*	kaars	*candle*
schoen	*shoe*	veter	*laces*	laars	*boot*	zoen	*kiss*	behang	*wallpaper*
spin	*spider*	web	*web*	vlieg	*fly*	pin	*pin*	mes	*knife*
ster	*star*	hemel	*heaven*	maan	*moon*	ekster	*magpie*	kopje	*cup*
trein	*train*	rails	*rails*	bus	*bus*	brein	*brain*	krant	*newspaper*
varken	*pig*	modder	*mud*	hond	*dog*	kurken	*cork*	herfst	*fall*
vergiet	*colander*	sla	*lettuce*	zeef	*sieve*	termiet	*termite*	wolk	*cloud*
zebra	*zebra*	pad	*path*	giraf	*giraffe*	algebra	*algebra*	munt	*coin*

Appendix C. Materials used in Experiment 3A.

Pictures		Distractor words							
		Semantically related		Begin-related		End-related		Unrelated	
baby	*baby*	kleuter	*pre-school child*	beek	*brook*	fobie	*phobia*	storm	*storm*
broek	*pants*	jurk	*dress*	broer	*brother*	vloek	*curse*	lamp	*lamp*
ei	*egg*	brood	*bread*	eind	*end*	klei	*clay*	schilderij	*painting*
glas	*glass*	porselein	*porcelain*	glazuur	*glaze*	plas	*pool*	park	*park*
helm	*helmet*	pet	*cap*	held	*hero*	film	*film*	leeuw	*lion*
kaas	*cheese*	salami	*salami*	kaars	*candle*	baas	*boss*	tapijt	*carpet*
naald	*needle*	schroef	*screw*	natie	*nation*	veld	*field*	muis	*mouse*
paard	*horse*	ezel	*donkey*	paal	*post*	zwaard	*sword*	laars	*boot*
pad	*path*	weg	*way*	pap	*porridge*	blad	*leaf*	haak	*hook*
potlood	*pencil*	viltstift	*felt-tip*	post	*mail*	nood	*distress*	toren	*tower*
rails	*rails*	straat	*street*	religie	*religion*	mails	*mail*	mes	*knife*
schip	*ship*	vlot	*raft*	schim	*shadow*	tip	*tip*	paraplu	*umbrella*
sla	*lettuce*	kool	*cabbage*	slaap	*sleep*	la	*drawer*	wolf	*wolf*
spijker	*nail*	punaise	*pushpin*	spijt	*regret*	kijker	*field-glass*	motor	*engine*
stekels	*quills*	doorn	*thorn*	steen	*stone*	rekels	*rascal*	bier	*beer*
tanden	*teeth*	gebit	*(set of) teeth*	tandem	*tandem*	wanden	*walls*	vliegtuig	*plane*
veter	*laces*	zool	*sole*	veteraan	*veteran*	meter	*meter*	bus	*bus*
water	*water*	olie	*oil*	wagen	*wagon*	krater	*crater*	lente	*spring*
web	*web*	nest	*nest*	wet	*law*	eb	*ebb*	cadeau	*gift*
zee	*sea*	vijver	*pond*	zeep	*soap*	thee	*tea*	pot	*pot*

Appendix D. Materials used in Experiment 3B.

Pictures		Associates		Distractor words					
				Semantically related		Phonologically related		Unrelated	
akker	*field*	boer	*farmer*	visser	*fisherman*	boel	*loads*	telefoon	*telephone*
ballon	*balloon*	lucht	*air*	helium	*helium*	lust	*lust*	eend	*duck*
bij	*bee*	honing	*honey*	jam	*jam*	hoon	*scorn*	maan	*moon*
brommer	*moped*	helm	*helmet*	pet	*cap*	held	*hero*	leeuw	*lion*
draad	*thread*	naald	*needle*	schroef	*screw*	natie	*nation*	muis	*mouse*
egel	*hedgehog*	stekels	*quills*	doorn	*thorn*	steen	*stone*	bier	*beer*
gum	*rubber*	potlood	*pencil*	viltstift	*felt-tip*	post	*mail*	toren	*tower*
hamer	*hammer*	spijker	*nail*	punaise	*pushpin*	spijt	*regret*	motor	*engine*
harp	*harp*	muziek	*music*	klank	*sound*	museum	*museum*	sjaal	*scarf*
heks	*witch*	sprookje	*fairytale*	fabel	*fable*	sprong	*leap*	kast	*closet*
kip	*chicken*	ei	*egg*	brood	*bread*	eind	*end*	schilderij	*painting*
koe	*cow*	melk	*milk*	sap	*juice*	merk	*mark*	bril	*glasses*
koets	*coach*	paard	*horse*	ezel	*donkey*	paal	*post*	laars	*boot*
kraan	*faucet*	water	*water*	olie	*oil*	wagen	*wagon*	lente	*spring*
krab	*crab*	zee	*sea*	vijver	*pond*	zeep	*soap*	pot	*pot*
krokodil	*crocodile*	tanden	*teeth*	gebit	*(set of) teeth*	tandem	*tandem*	vliegtuig	*plane*
lerares	*teacher*	school	*school*	universiteit	*university*	schoot	*lap*	vork	*fork*
matroos	*sailor*	schip	*ship*	vlot	*raft*	schim	*shadow*	paraplu	*umbrella*
ooievaar	*stork*	baby	*baby*	kleuter	*pre-school child*	beek	*brook*	storm	*storm*
paprika	*paprika*	chips	*chips*	noot	*nut*	chic	*chic*	dak	*roof*
raam	*window*	glas	*glass*	porselein	*porcelain*	glazuur	*glaze*	park	*park*
rasp	*grater*	kaas	*cheese*	salami	*salami*	kaars	*candle*	tapijt	*carpet*
riem	*belt*	broek	*pants*	jurk	*dress*	broer	*brother*	lamp	*lamp*
schaap	*sheep*	wol	*wool*	linnen	*linen*	wolk	*cloud*	emmer	*bucket*
schep	*scoop*	zand	*sand*	klei	*clay*	zang	*song*	fiets	*bike*
schoen	*shoe*	veter	*laces*	zool	*sole*	veteraan	*veteran*	bus	*bus*
spin	*spider*	web	*web*	nest	*nest*	wet	*law*	cadeau	*gift*
ster	*star*	hemel	*heaven*	aarde	*earth*	heden	*present*	kopje	*cup*
trein	*train*	rails	*rails*	straat	*street*	religie	*religion*	mes	*knife*
varken	*pig*	modder	*mud*	stof	*dust*	mocassin	*moccasin*	herfst	*fall*
vergiet	*colander*	sla	*lettuce*	kool	*cabbage*	slaap	*sleep*	wolf	*wolf*
zebra	*zebra*	pad	*path*	weg	*way*	pap	*porridge*	haak	*hook*

Appendix E. Materials used in Experiment 6A and 6B.

Pictures		Associates		Distractor words				
				Semantically related		Phonologically related	Unrelated	
akker	*field*	boer	*farmer*	wei	*pasture*	rekka	telefoon	*telephone*
ballon	*balloon*	lucht	*air*	vlieger	*kite*	nollba	eend	*duck*
bij	*bee*	honing	*honey*	wesp	*wasp*	ijb	maan	*moon*
brommer	*moped*	helm	*helmet*	motor	*motorbike*	emmbror	leeuw	*lion*
draad	*thread*	naald	*needle*	touw	*rope*	raadd	muis	*mouse*
egel	*hedgehog*	stekels	*quills*	muis	*mouse*	glee	bier	*beer*
gum	*rubber*	potlood	*pencil*	lineaal	*ruler*	mgu	toren	*tower*
hamer	*hammer*	spijker	*nail*	zaag	*saw*	merah	motor	*engine*
harp	*harp*	muziek	*music*	gitaar	*guitar*	prah	sjaal	*scarf*
heks	*witch*	sprookje	*fairytale*	tovenaar	*magician*	kesh	kast	*closet*
kip	*chicken*	ei	*egg*	eend	*duck*	ipk	schilderij	*painting*
koe	*cow*	melk	*milk*	ezel	*donkey*	oek	bril	*glasses*
koets	*coach*	paard	*horse*	wagen	*wagon*	tsoek	laars	*boot*
kraan	*faucet*	water	*water*	tap	*tap*	naark	lente	*spring*
krab	*crab*	zee	*sea*	garnaal	*shrimp*	bakr	pot	*pot*
krokodil	*crocodile*	tanden	*teeth*	hagedis	*lizard*	drokliko	vliegtuig	*plane*
lerares	*teacher*	school	*school*	directeur	*director*	relesar	vork	*fork*
matroos	*sailor*	schip	*ship*	kapitein	*skipper*	toomsra	paraplu	*umbrella*
ooievaar	*stork*	baby	*baby*	zwaan	*swan*	aavoorie	storm	*storm*
paprika	*paprika*	chips	*chips*	tomaat	*tomato*	kaparip	dak	*roof*
raam	*window*	glas	*glass*	deur	*door*	mraa	park	*park*
rasp	*grater*	kaas	*cheese*	pers	*press*	srap	tapijt	*carpet*
riem	*belt*	broek	*pants*	das	*tie*	ierm	lamp	*lamp*
schaap	*sheep*	wol	*wool*	geit	*goat*	paasch	emmer	*bucket*
schep	*scoop*	zand	*sand*	emmer	*bucket*	pesch	fiets	*bike*
schoen	*shoe*	veter	*laces*	laars	*boot*	noesch	bus	*bus*
spin	*spider*	web	*web*	vlieg	*fly*	nips	cadeau	*gift*
ster	*star*	hemel	*heaven*	maan	*moon*	tres	kopje	*cup*
trein	*train*	rails	*rails*	bus	*bus*	neirt	mes	*knife*
varken	*pig*	modder	*mud*	hond	*dog*	knerav	herfst	*fall*
vergiet	*colander*	sla	*lettuce*	zeef	*sieve*	tiegver	wolf	*wolf*
zebra	*zebra*	pad	*path*	giraf	*giraffe*	bezar	haak	*hook*