Psychologie

German compounds in language comprehension and production

Inaugural-Dissertation

zur Erlangung des Doktorgrades

der

Philosophischen Fakultät

der

Westfälischen Wilhelms-Universität

zu

Münster (Westf.)

vorgelegt von

Andrea Böhl

aus Teterow

Juli 2007

German compounds in language comprehension and production

Tag der mündlichen Prüfung:	23. August 2007
Dekan:	Prof. Dr. Woyke
Referent:	PD Dr. Jens Bölte
Korreferent:	Prof. Dr. Pienie Zwitserlood

für Michael

DANKE

Während meiner Promotionszeit habe ich oft daran gedacht, dass ich vielen Menschen danken möchte. Nun ist die Zeit der Danksagung gekommen. Zunächst möchte ich allen Mitgliedern der Arbeitseinheit Zwitserlood der Allgemeinen und Angewandten Psychologie des Psychologischen Instituts II der Westfälischen Wilhelms-Universität für die schöne, lustige und einfach nette Zeit, die ich als Neuling in Münster hatte, danken. Ein besonderer Dank geht an Jens Bölte, der mich mit seiner fachlich unterstützenden, zuverlässigen und freundschaftlichen Art zielstrebig auf die Beendigung dieser Dissertation hingeführt hat. Ich danke Pienie Zwitserlood, die neben ihren 1000 anderen Verpflichtungen immer Zeit hatte, um zu zuhören und mitzudenken. Ebenso danke ich Christian Dobel, der nicht nur durch seine wissenschaftlichen Anregungen, sondern auch durch seinen unübertrefflichen Humor vieles erleichterte. Den Dreien danke ich außerdem für ihre Unterstützung bei der Vorstellung einer Vielzahl von Ergebnissen auf nationalen und internationalen Konferenzen. Unser sogenanntes A-Team wurde aber erst komplett durch Heidi Gumnior, Reinhild Glanemann und Annett Jorschick. Ob in der Uni, auf Tagungen oder bei unseren Promi-Essen, die drei waren nicht nur fachlich unterstützend, sondern vor allem freundschaftlich bedeutend für mich. Unsere wöchentliche „A-Team Sitzung“, die oft aus sieben rauchenden Köpfen bestand, hat mit ihren neuen lebendigen Ideen den Inhalt dieser Arbeit mitbestimmt. Durch unser ebenso wöchentlich stattfindenes Kolloquium, gab es auch anregende Ideen von Seiten der Diplomanden, Hilfskräfte und Praktikanten. Dabei sind nicht zu vergessen die stets von Pienie gespendeten „sauren Stäbchen“, „klebrigen süßen Milchkühe“ oder „sauren Apfelringe“, welche unseren Geist anregten. Beim Sammeln der Daten haben mir Ann-Kathrin Bröckelmann, Katharina Geukes, Diana Jahnel, Benedikt Klauke, Julia Meyer und Claudia Schulz geholfen. Ich bin ihnen sehr für ihr Organisationstalent, Mitgestaltung des Stimulusmaterials, und für die Geduld, die Sie beim Durchführen der ziemlich langen Experimente gezeigt haben, dankbar.

Die Zeit in Münster war für mich sehr wichtig und ich werde die „Arbeitseinheit Zwitserlood“ sehr vermissen. Ich freue mich aber ebenso auf die Zukunft und bin gespannt darauf was noch auf mich zukommt.

Ich möchte meiner Mutter Christine und meiner Schwester Stephanie für Ihre liebevolle Unterstützung danken. Ganz besonders danke ich meinem lieben unvergesslichen Vater Lothar für sein unendliches Vertrauen in mich.

Schließlich möchte ich meinem Michael für sein geduldiges Zuhören, Lesen dieser Dissertation und dafür, dass er immer für mich da ist danken.

TABLE OF CONTENTS

CHAPTER 1

CHAPTER 2

CHAPTER 4

INTRODUCTION

CHAPTER 1

Language use is a prerequisite for everyday communication. The language system entails two main processing modes, language comprehension with listening and reading as well as language production with speaking and writing. Although investigations on language comprehension started decades earlier than experimental studies on processes involved in language production, these two processes cannot be regarded independent of one another. Research in language comprehension depends on performance in language production and vice versa (Zwitserlood, 1994). This thesis deals with reading and speaking of particular types of words: compounds. The first part of this introduction briefly describes the main issues relating to language comprehension and production. Subsequently, a general overview of compounds and their different types will be provided.

The investigation of language comprehension entails researching either visual or spoken word recognition. As mentioned above, this thesis focuses on visual word recognition, or more precisely reading. Reading is the conversion of written words into meaning. Readers first have to gain access to word forms in the mental lexicon via the word recognition system. Access to meaning occurs through selecting the best match between conceptual and form representations. These processes leading from print to meaning are dealt with in most models of visual word recognition, although they explain these processes in different ways (e.g., Coltheart, Curtis, Atkins, & Haller, 1993; McClelland & Rumelhart, 1981; Morton, 1969; Rumelhart & McClelland, 1982; Taft, 1986; Taft & Forster, 1975, 1976).

In language production, the processing flows from meaning (or concepts) to speech. Speakers start by selecting a concept or word meaning before the corresponding form representations are activated. Similar to comprehension models, models of speech production differ with respect to the processing steps which mediate between concept and articulation. There are models which propose strictly serial processing stages (Levelt, Roelofs, & Meyer, 1999) whereas others assume that there is cascading between different information types (Caramazza, 1997; Dell, 1986). However, language comprehension and production are assumed to share representations, for instance information about the form of words (Zwitserlood, 1994). This information about the word forms is used in both reading and speaking. Both processes use discrete units of representation such as phonemes, syllables, words or morphemes. Morphemes are the smallest linguistic units that convey meaning. They can occur in free form, as monomorphemic words or in bound form, as part of polymorphemic words as in inflections, derivations or compounds. This thesis focuses on the recognition and production of compounds.

What are compounds?

A compound is a morphologically complex word that consists of more than one free morpheme (constituent). In compounds, the head is the categorical part that contains the basic meaning of the whole compound. The modifier restricts the meaning of the compound. The German bimorphemic compound *Weinflasche* (wine bottle), for instance, where *bottle* is the head and *wine* is the modifier, is a bottle intended for wine. Besides, compounds, of which the meaning cannot be derived directly from its constituent parts, are called semantically intransparent or opaque (Dohmes, Zwitserlood, & Bölte, 2004; Gumnior, Bölte, & Zwitserlood, 2006; Libben, 1998). The German compound *Löwenzahn* (dandelion), for instance, of which the first constituent means lion and the second tooth, is neither a kind of tooth nor a kind of lion. The meaning of the compound *Löwenzahn* cannot be derived from that of its constituents.

Different modifier-head relationships, however, result in three major types of compounds. The most common form of compounds are determinative compounds in which the first constituent usually modifies the second constituent, e.g., *Bierflasche* (beer bottle). A change in the arrangement of the two constituents leads to a change in the semantic relationship between the two constituents, e.g., *Flaschenbier* (bottled beer). There are different subtypes of determinative compounds as for instance, possessive compounds, e.g., *Lästermaul* (scandalmonger), or particle compounds, e.g., *Aberglaube* (superstition). A second major type of compound concerns copulative compounds in which the two constituents have an equal relationship, no constituent modifies the other, e.g., *Kleiderschürze* vs *Schürzenkleid* (housedress). A change in the arrangement does not lead to a change in the semantic relationship between the constituents. A third type of compound is additive compounds in which two words are combined and neither modifies the other, e.g., *wassertriefend* (soaking wet) or *Taugenichts* (good-for-nothing). Thus, German is a morphologically rich language because the formation of compounds in German is very productive. There are no spaces between German compounds, so orthographically they are one word. Instead, linking elements are often inserted in compounds, e.g., *Rindfleisch* (beef) vs *Rind**er**filet* (roast beef). The composition of two free morphemes into a unified orthographic form has an impact on the representation and accessing of compound form and meaning. Compound word processing (e.g., Andrews, Miller, & Rayner, 2004; Bertram & Hyönä, 2003; Hyönä, Bertram, & Pollatsek, 2004; Inhoff, Brihl, & Schwartz, 1996) has been studied extensively in previous research, but to date the role of compounds and their morphemic constituents in processes of language comprehension is still discussed. The importance of various factors such as frequency, length or semantic transparency, involved in the processing of compounds still needs to be addressed. Furthermore, investigations on the production of compounds are rare. Recently, more and more experimental research (Bien, Levelt, Baayen, 2005; Gumnior et al., 2006; Janssen, Bi, & Caramazza, subm.) has been conducted in order to clarify certain processes of compound word production. Questions addressed here are whether speakers use morphemes as planning units in the production of compounds, how complex words are represented or whether frequency influences compound word production. But the question under which conditions compounds are actually produced is not clarified and still needs to be dealt with. The following paragraph gives a brief overview of this chapter.

OUTLINE OF THIS CHAPTER

This chapter provides a substantial theoretical overview for the following chapters of this thesis. Part A of this chapter serves as a general introduction to the issues relevant to all parts of the thesis. This part includes a description of relevant models of morphology. Part B provides necessary background information for the reading study in Chapter 2. This includes general information on reading and eye-tracking as well as an example of one particular model (E-Z Reader), explaining different findings of eye-tracking studies. Part C describes the general background relevant to speaking, the task of Chapter 3. In particular, evidence on production of morphologically complex words precedes a description of factors crucial to perspective taking, an issue highly relevant to our manipulations in Experiments of Chapter 3. This part is followed by an outline of the research presented in Chapter 2 and 3.

PART A: MODELS OF MORPHOLOGICALLY COMPLEX WORD REPRESENTATION AND PROCESSING

Important for understanding the processing of morphologically complex words in language comprehension (see Chapter 2) and production (see Chapter 3) is the lexical representation of these items: Are morphologically complex words represented in terms of their constituent morphemes only, as it is suggested by the full-parsing approach (Taft, 1986, 1994, 2004; Taft & Forster, 1975, 1976) or is there a full-listing of complete morphologically complex words (Butterworth, 1983; Bybee, 1985; Fowler, Napps & Feldman, 1985)? Or are morphologically complex words represented both as wholes and through their morphemes as suggested by a dual-route system (Baayen & Schreuder, 1999; Baayen, Dijkstra & Schreuder, 1997; Caramazza, 1997; Caramazza, Laudanna, & Romani, 1988; Chialant & Caramazza, 1995; Laudanna, Cermele, & Caramazza, 1997; Schreuder & Baayen, 1995)? The embedding and discussion of those models of morphology will be one of the central notions in Chapter 2. For Chapter 3, this issue serves as necessary background knowledge.

First, access to representations of morphologically complex words could directly occur to a complete orthographic or phonological form, the so called whole-word form, stored in the lexicon. The full-listing approach suggests a representation of all words as full forms (Butterworth, 1983; Bybee, 1985). This approach proposes associative and fast access. Butterworth, for instance, assumes a grouping of morphologically related forms but disputes that such group centres around some base form. Thus, there is some morphological structure in the lexicon, but this does not derive from decomposition of morphologically complex forms into their constituents. Rather, lexical access takes place via whole-word forms without any form of decomposition at any level within the word recognition system.

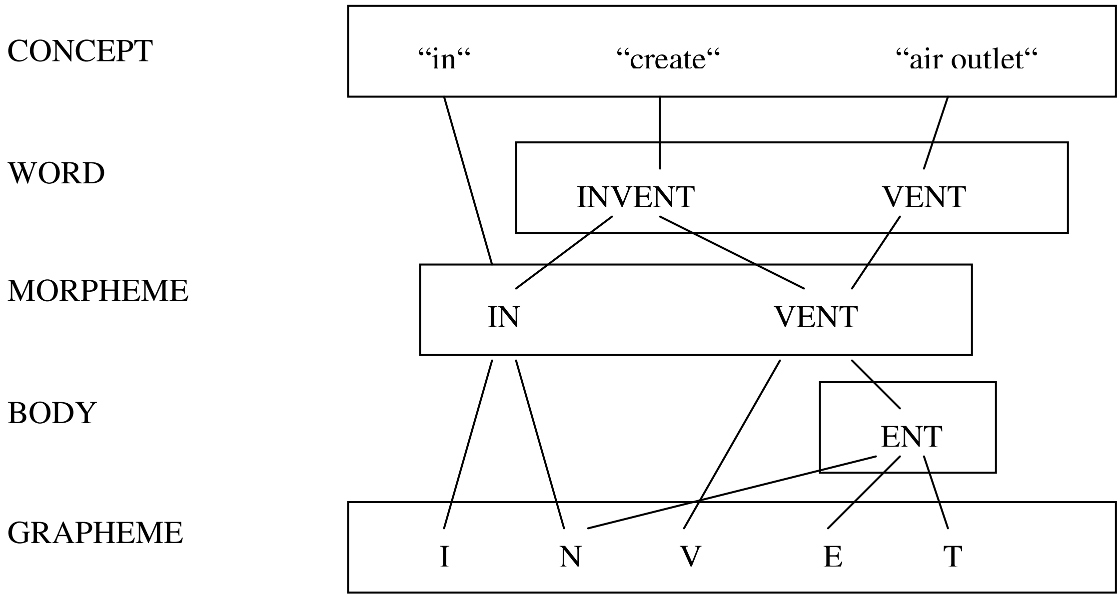
Notice that, Butterworth (1988) suggested rule-application (decomposition) as a fall-back procedure for items not accessible from the whole-word form lexicon. So, the difference to some of the models below is that Butterworth denies that lexical representations of regular morphologically complex words are accessed only via a rule-based route. Butterworth assumes that rule treatment lacks usefulness and generality, implying that rules often apply to only one lexical representation. Therefore, he proposes that rule-based treatment is not more efficient than full-listing, considering, for instance, that there are no rules which are routinely specified or employed for accessing compounds. Supporting Butterworth’s assumptions, Bybee (1985) also suggests that all words are stored listwise in the lexicon.

As Butterworth, Bybee also allows rule-based treatment as a fall-back procedure. Support for whole-word lexical representations of irregular forms comes from experiments in which participants had to supply the past tense form to the base form of an English verb. Participants made less errors when a close semantic relationship and matching consonantal structure existed between the base and the past tense form. Models that assume a rule-based generation of English irregular verbs would have predicted no difference in errors. Bybee suggests that there is a continuum from full-listing to rule-based generation. Note that Bybee does not refer to full-listing as such but rather to terms such as lexical strength and lexical connections. Lexical representations are strengthened by an increased mapping between stored words and words in processing which may also be morphologically complex sharing the same stem or semantic features. One of the basic phenomena that lexical strength accounts for is the correlation of irregularity with frequency which is well documented in most languages. High-frequency irregular words are mapped faster than low frequency words. Lexical connections account for certain relationships among words. Morphological relations are the strongest and closest form of relationship among words, as both semantic and phonological relations are involved. Compared to Butterworth, Bybee also assumes a grouping of close morphological relations. Bybee denies morphological segmentation as the internal structure of morphologically complex words. The use of lexical connections (phonological, morphological or semantic) makes this morphological segmentation unnecessary. In sum, Bybee suggests that formation of and access to complex words is based on central notions such as lexical connection and lexical strength.

Different from Butterworth (1983) and Bybee (1985) is the view of a representation of morphologically complex words in decomposed form. This idea emerged because regularities in word formation and lexical representation are assumed to be based on rules rather than on individual lexical entries. Full-parsing models (Taft, 1986, 1994, 2004; Taft & Forster, 1975, 1976) describe the processing of morphologically complex words as an obligatory decomposition into constituents. Earlier versions of such models assume a prelexical extraction of root forms and their permissible affixes so that complex words are lexically accessed on the basis of their stem (access code) (Taft, 1986). Comparing lexical decision times between responses to real-stem (e.g., *tenuate* from *attenuate*) and non-stem (*zette* from *gazette*) words, longer response times were observed for real-stem words compared to control words. Non-stem words behaved as the control words. This indicates a separate lexical representation of stems of prefixed words. Other evidence for access of a prefixed word through a representation of its stem comes from experiments manipulating the frequency of

the bound stem of a prefixed word, while holding the whole-word frequency constant. Higher bound-stem frequency is associated with faster lexical decision times. A revised version of this model (Taft, 1994) discards the prelexical prefix stripping and favours a decompositional lexical representation of prefixed words. Prelexical prefix stripping necessitates a separate prefix store where all prefixes are listed. There is no evidence for such store, given that subjects were not able to decide adequately whether a letter string was a prefix or not.
The adapted version of Taft (1994) is integrated in an interactive-activation framework (see also McClelland & Rumelhart, 1981). Figure 1 presents the idea of obligatory morphological decomposition within the activation framework (Taft, 1994). This model has no prelexical prefix stripping but implements a separate treatment of prefixes from their stems at a level consisting of morphemic units. This morpheme level, which is located between the so-called body level and the whole-word level (which may be compared to the so-called lemma level in Schreuder & Baayen, 1995), consists of the lexical representation of morphemic units (e.g., *invent* are represented as *in* and *vent*). The morpheme level then activates the level of the whole word which is directly associated with the concept (semantic). So at some level, the model implements some sort of full-listing, because there is a representation of morphemic units at the morpheme level but also a whole-word representation at the word level. Within this framework, there is no differentiation between semantically transparent and opaque forms.

Figure 1 Taft's (1994) interactive-activation model with a schematic depiction of the decomposed representation for INVENT



Taft (2004) provides further evidence for decomposition of words into their individual morphemes and for recognition via their stems. It is widely accepted that if the stem of a polymorphemic word is involved in the recognition of that word, the ease of recognition is influenced by base (stem) frequency. Evidence for base-frequency effects originates from experiments manipulating base frequency while matching surface frequency. Findings of base-frequency effects support the assumption that polymorphemic words are decomposed into their constituents (component morphemes). Taft (2004) proposes an obligatory decomposition taking place at early processing stages. He refers to a lemma level (called word level in Taft, 1994), linking the conceptual level (semantic and syntactic features) with the form level (called morpheme level in Taft, 1994), implying obligatory morphological decomposition. Although obligatory decomposition is proven by findings of base-frequency effects, Taft (2004) argues that it does not mean that whole-word (surface) frequency effects are irrelevant. He believes that base-frequency effects arise at early stages of processing, whereas at lemma representation, stem and affixes are recombined and surface-frequency effects can occur.

In sum, Taft (2004) proposes that the presence of a surface-frequency effect does not necessarily mean that no decomposition is taking place. Rather, potential “interlemma competition” at the combination stage for high-base frequency words leads to a “wash out” of the high-base frequency advantage, and surface-frequency effects emerge. So the less the combinability of stem and affix, the greater the impact of base-frequency effects at earlier stages. The more combinability the lesser the base-frequency effect and the greater the effect of surface frequency (for details see Chapter 2).

Although Taft (2004) assumes that the obligatory decompositional model accounts for the existence of both base and surface-frequency effects, there are also alternative models, the dual-route models which explain these effects within a different framework. The Augmented Addressed Morphology Model (AAM) (Caramazza et al., 1988, Caramazza, 1997; Chialant & Caramazza, 1995; Laudanna et al., 1997) for instance, proposes parallel access via whole-word units and morphemic access units. The access units activate morphologically decomposed lexical representations. The activation via morphemic access units requires an additional parsing process which results in a slower access via these units than via the whole-word route.

Support for processing via both a decompositional and a whole-word route comes from findings of morpheme frequency effects (e.g., Taft, 1979, 1986) and whole-word frequency effects on lexical decision times (e.g., Taft, 2004) and fixation durations (e.g., Bertram &

Hyönä, 2003). Additional evidence for lexical access by means of morphemic units comes from investigations on morphologically structured pseudo-words (Laudanna et al.,1997). According to the AAM (and Taft, 1994, 2004), morphologically complex pseudo-words could never be processed via the whole-word route, as there is no whole access unit corresponding to that orthographic string. Morphologically structured decomposable pseudo-words resulted in slower responses than morphologically structured non-decomposable pseudo-words which are assumed to be rejected at an early level of analysis (access). In naming, it is the opposite case: morphologically decomposable words are named faster than morphologically non-decomposable words, as they do not benefit from pre-assembled morphemic and phonological representations. These results provide clear evidence for those models of lexical access and processing which take morpheme-access units as well as whole-word units into consideration (Caramazza et al., 1988).

An alternative dual-route model is the Morphological Race Model (Parallel Dual-Route Model) (Baayen & Dijkstra, 2003; Baayen & Schreuder, 1999; Baayen et al., 1997; Schreuder & Baayen, 1995). This model proposes simultaneous recognition via the whole-word and the decompositional route. It clearly distinguishes between three layers in morphological processing: 1) formal access representations for whole words and morphemes, 2) concept nodes and 3) syntactic and semantic representations. The model proposes a direct mapping of a full-form onto the corresponding concept node whereas the parallel decompositional route maps onto different concept nodes. The Parallel Dual-Route Model assumes that whether the whole-word or the decompositional route wins the race for lexical access depends on various properties of stems and affixes such as frequency, semantic transparency, and phonological transparency. As far as this model is concerned, composition is restricted to semantically transparent words (Marslen-Wilson et al., 1994; Schreuder & Baayen, 1995).

In sum, there are various models (see Chapter 2 for further discussion) describing the processing and accessing of morphologically complex words. There are different factors, as for instance frequency, influencing the way lexical access takes place. The focus in Chapter 2 will be on these factors, determining the processing of compounds during reading in an eye-tracking and a lexical decision experiment. The next part serves as an introduction to this Chapter, addressing the issues, reading and eye-tracking.

PART B: READING AND LANGUAGE COMPREHENSION

The first part of this thesis concentrates on compound word processing in reading. The simple question *What actually is reading?* concerns many cognitive psychologists studying reading. Are we reading, when we look at maps, at the pages of a computer program when we proofread papers or when we just skim a newspaper? In research, reading is often treated as a process based on text-reading, where printed words are basically read one after the other and then converted into a form that combines these words to our thought processes (Besner & Humphreys, 1991; Rayner & Pollatsek, 1987; Underwood & Batt, 1996). Reading is a complex cognitive skill containing all processes from print to meaning. The ability to master a writing system involves a number of subskills such as word recognition and letter identification, the mapping between letter and sound and certain memory processes. This chapter primarily deals with the modeling of reading and methodological approaches to reading.

First, let us focus on three functional approaches to reading. Models of reading all include how a reader perceives a word, processes clauses and comprehends a text (Singer & Ruddell, 1976). Bottom-up models (Gough, 1976; LaBerge & Samuels, 1974) of reading emphasize the part-to-whole processing of a text. In this model, reading proceeds in a strictly serial fashion. Comprehension begins by processing small linguistic units such as graphemes and phonemes, and goes on with the processing of larger units such as morphemes, syllables, words, phrases etc. and ends with the association to semantic representations.

A second type of reading models is characterised as top-down (Goodman, 1976; Smith, 1988) or concept-driven models. Top-down models suggest whole-to-part processing. Processing of a text begins in the mind of the reader, including prior knowledge, experiences and expectations. Goodman's model of reading assumes that reading is a psycholinguistic guessing game which allows the reader to rely on existing syntactic and semantic knowledge structures when reading and interpreting a sentence.

The third type of reading model presents an intermediate position between these two approaches. Interactive models of reading combine the strong features of both bottom-up and top-down processing (Rumelhart, 1985). They propose an interaction of bottom-up and top-down processes throughout the reading process and stresses both what is written down and what the reader brings in. The interactive model assumes that readers construct meaning by selective use of lower-level information such as graphemes, phonemes, morphemes, semantics or syntax. Simultaneously, the reader also provides input such as prior knowledge.

There are various interactive models (McClelland & Rumelhart, 1981, Rumelhart & McClelland, 1982; La Berge & Samuels, 1974).

The E-Z Reader model (Reichle, Pollatsek, Fisher, & Rayner, 1998), for instance, also implies indirect influences of higher level processes. It assumes an influence of both top-down and bottom-up processes in lexical access, summed up in an interactive processing. The E-Z Reader focuses on the modelling of processes of lexical access and their effects on eye movements. Eye-tracking is one important methodological approach to study reading. Before providing information of the E-Z Reader model, serving here as an example for explaining eye-tracking data, some essential background knowledge of the eye-tracking method is necessary.

Eye-Tracking

The progress of technology during the last decades has improved reading research. The development of eye-trackers, more powerful computers and better statistical packages improved data collection and data analysis. Nevertheless, there is no ideal method in reading research which is why many investigators use different methods. The recording of eye movements, decision making tasks or naming latency paradigms dominate visual word recognition research (Besner & Humphreys, 1991; Haberlandt, 1997).

The recording of eye movements during reading assesses the flow of incoming visual information. Research of eye movements made it possible to study, analyze and model cognitive processes underlying reading (Kliegl, Grabner, Rolfs, & Engbert, 2004; Radach & Kennedy, 2004; Rayner, 1998; Rayner & Juhasz, 2004). Eye movements give information about duration of fixations, location of fixations or saccades. Eye movements are summed into global averages such as mean fixations of passages, paragraphs or sets of sentences. But also the recording of more locally word-based measures is useful when investigating cognitive processes on a moment-to-moment basis.

Word-based measures indicate if, and for how long, readers fixate on words. Typical measurements for words are first-fixation duration, gaze duration or total fixation time. First-fixation duration is the duration of the first fixation on a word. Gaze duration is the sum of all fixations on a word when it is processed for the first time. Total fixation times include gaze duration and regressions, i.e. refixations on the word. Regressions are backward movements of the eyes to previous locations in the text.

Interestingly, our eyes do not move continuously over a text. There are saccades which are little “jumps” between the different fixations. 10-15% of all saccades during reading are regressions. A saccade is 8-9 letters (on average) long which is about two degrees of visual angle (min. one – max. 18 degrees). A two-degree saccade usually takes 25-30 ms. Although visual information cannot or hardly be recognized during a saccade, 10% of the total reading time is due to saccades. A saccade’s basic function is to bring new regions of the text into foveal vision, since reading is not based on parafoveal or peripheral processing.

Foveal vision encompasses the area from 1 to 2 degrees from fixation and usually includes 3-4 letters. The parafovea is the area up to five degrees from fixation, whereas the periphery describes the region of more than 5 degrees from fixation. Fixations mean that the eyes stand still, for usually about 200-250 ms (Haberlandt, 1997; Rayner, 1998; Underwood & Batt, 1996). Although the majority of words in a text is fixated, there are also words which are skipped during reading and are thus not processed foveally. In normal text reading, about 80% of the content words (nouns, verbs and adjectives) and only about 20% of the function words (articles, conjunctions, prepositions and pronouns) are fixated (Carpenter & Just, 1983; Rayner & Duffy, 1986). One reason that function words tend to be less often fixated than content words is that they are usually short. So, there is a relationship between the probability of fixating a word and its length. The longer a word, the higher the possibility that it receives fixation (Rayner & McConkie, 1976). Furthermore, Reichle et al. (1998) proposed that different variables influence fixation durations on words such as frequency, length and word predictability. Short, frequent and highly predictable words are often skipped in a text. Skipping of words is only possible if words are processed before being fixated (e.g., Henderson & Ferreira, 1990; Underwood & Batt, 1996).

The eye-movement – contingent display change technique is a widely-used method to investigate this so-called parafoveal preview effect. It is also referred to as the boundary technique (McConkie & Rayner, 1975), indicating that something in the display is changed contingent to where the eye is fixating. So for instance, a preview word, equal to or different from the target word, is presented before the reader fixates the target word. By crossing an invisible boundary during a saccade to the target word, the preview word changes into the target word. Fixation times on the target word are shorter when the preview word becomes identical to the target word (Reichle et al., 1998; for parafoveal on foveal effects see also Kennedy, Pynte, & Ducrot, 2002). But also the parafoveal-preview benefit has been investigated with this technique. This effect shows that orthographic or phonological information, already processed from the parafovea, facilitates subsequent foveal processings

(Balota & Rayner, 1983; Henderson & Ferreira, 1990; Rayner, 1998). Parafoveal on foveal effects and parafoveal preview benefit are also referred to as lag and successor effects (Kliegl, Nuthmann, & Engbert, 2006).

Concentrating on eye-movement research in reading, I will now provide a short overview of what eye movements can tell us about language processing. There are different hypotheses about the so-called eye-mind span (relationship between eye movements and linguistic processes). *Post-fixation theory* (Underwood & Batt, 1996) assumes that all processing occurs after a fixation is completed. All information is extracted after termination of fixation. If this is the case, the post-fixation theory cannot explain why low-frequency words receive more visual attention than high-frequency words (Rayner & Duffy, 1986). According to this theory, word information should not be able to manipulate our fixation pattern.

But there is evidence that processing during reading is not deferred. Fixation durations give an indication of on-line processing, given that they depend on the amount of information being processed (Just & Carpenter, 1980). So an opposite view is the *immediacy assumption* stating that each content word that the reader focuses on is immediately processed. Interpretation at all levels of processing occurs as soon as possible. The *eye-mind assumption* proposes that the eye is coupled with the mind in such a way that the reader's eyes remain on the word as long as it is being processed (Just & Carpenter, 1980; Rayner & Duffy, 1986; Underwood & Batt, 1996). This assumption is not supported by findings from Balota and Rayner (1983) and Henderson and Ferreira (1990) who found an influence of parafoveal processing on immediate fixations.

These different eye-mind span assumptions give an indication of how eye movements could reflect language processing. Thus, there seems to be a well-established relationship between eye-fixations and cognitive processes, e.g., low-frequency words provoke longer fixations (Hyönä, Niemi, Underwood, 1989; Rayner & Duffy, 1986; Underwood, Clews & Everatt, 1990). In sum, certain characteristics or information of words such as frequency, length, predictability. influence duration and location of fixations. After having clarified some points of how eye-tracking research "works", the next paragraph concentrates on a short description of the E-Z Reader model, a most influential approach to eye-movement research. Note that this model here serves as an example for an explanation of the close link between lexical access and eye movements in reading (Carpenter & Just, 1983; Just & Carpenter, 1980).

The E-Z Reader Model

The most important modelling approach, relating processes of lexical access to its effects on eye movements, is the E-Z Reader model (Reichle et al., 1998). Basic data on reading show that certain variables such as frequency, length or predictability of a word influence fixation times and the possibility of a word to be skipped (Inhoff & Rayner, 1986; Rayner & Duffy, 1986). The E-Z Reader model focusses on these variables, although they are not the only once influencing fixation times. The E-Z Reader model was developed because earlier models failed to explain the occurrence of, for instance, refixations and to account for processes of higher order than lexical access such as the reading of garden path sentences. The model also incorporates that information extracted from the parafovea depends on the difficulty of processing the word in the fovea, given that the parafoveal preview benefit decreases as foveal processing difficulty increases (see Henderson & Ferreira, 1990; Inhoff & Rayner, 1986).

There are five versions in the development of the E-Z Reader model. They account for details of eye-movement control in reading, more specifically for the relationship between aspects of lexical access and eye movements. E-Z Reader 1 and 2 attempt to explain the total fixation time spent on a word before moving forward and the probability of words to be fixated. E-Z Reader 3-5 explain the duration of individual fixation and the location and amount of individual fixations on individual words (including refixations). Thus, the final E-Z Reader model is a simulation model predicting fixations, their durations and locations by trying to relate processes of lexical access to eye movements in reading.

The E-Z Reader model assumes that the eyes are driven forward by certain lexical properties of individual words. A basic component of this model is the familiarity check, computed before lexical access. It is a product of different factors such as frequency, length, neighbourhood size effect and so on. The completion of lexical access (lc), induced by the level of familiarity (f), is the signal to shift covert attention, denoting that a saccade is planned to the subsequent word. The total time for lexical access of a word (n) is computed by $t\ (f_n) + t\ (lc_n)$. The model also explains that the parafoveal preview benefit decreases as lexical access time t (lc) increases by, for example, word frequency. The E-Z reader model also considers that certain top-down constraints or conceptually driven processes influence the predictability of a word, having an effect on both time of familiarity check and time of lexical access. Furthermore, the model accounts for multiple fixations on a word (refixations) and assumes an automatic refixation default mechanism. This prevents the eyes from staying indefinitely on one location. Maintaining a single viewing position for identifying an object is not optimal, especially in reading tasks where eyes move rapidly across words. Additionally, the E-Z Reader integrates a parameter which modulates the processing rates of f and lc depending on the eccentricity, being the distance between the word being processed and the word being fixated. Thus, the model proposes that the process of lexical completion slows down more than the familiarity check when the distance between the word being processed and the one currently being fixated increases. In general, the E-Z Reader model makes reliable predictions of fixation durations, fixation locations and the probability of words to be fixated by relating processes of lexical access to eye movements in reading. But none of the E-Z Reader model versions is perfect. Adding new parameters would improve data fitting, but this would contradict the minimalist intention of the model.

Since the first part of the thesis focuses on the comprehension of morphologically complex words during reading, the last paragraphs addressed some of the issues important for Chapter 2. Chapter 3 of this thesis is about morphologically complex word in language production. It is concerned with the production of compounds, taking different conditions into account, presumably involved in influencing lexical choice. For this reason, the following paragraph serves as an overview of approaches to language production and evidence for the existence of morphemic representations.

PART C: APPROACHES TO LANGUAGE PRODUCTION

Whereas Chapter 2 is concerned with reading morphologically complex words, Chapter 3 concentrates on producing complex words. There are various conceivable ways to explain how morphemes could play a role in language production. Models of language production often represent morphologically complex words as combinations of their constituent morphemes as well as they assume morphology as a distinct level of processing (Dell, 1986; Levelt, 1989). I will first focus on the model of Levelt, Roelofs and Meyer (1999) since it is the working model for most of our experimental research in the field of language production. Then, I will provide some evidence for morphologically structured representation in language production. Finally, I will give a detailed description of the factor perspective taking which is of particular importance in the Experiments of Chapter 3.

The production model of Levelt, Roelofs and Meyer (1999) consists of three strata. Each stratum produces its own output and activates the next level. At the "top", there is the conceptual stratum representing lexical concepts which denote the meaning of words. The next stratum contains the so called lemma nodes. They specify syntactic structure and syntactic properties such as the lexical category (nouns, verbs, etc.). Lemmas are linguistic units placed between the non-linguistic conceptual level and form representations. The form representation is the third stratum, specifying morphemes and their corresponding phonemic segments as well as syllable nodes. Lemma nodes activate the corresponding morphemes. Take, for instance, the compound *Weinflasche* (winebottle). The semantic information of this word is represented at the conceptual level. Since *winebottle* is a known word, it is assumed to have its own lemma, but it consists of two morphemes at the form level. In this model, it is easy to combine two lemmas and their corresponding morphemes to an unknown compound such as *Knoblauchschüssel* (garlich bowl). But contrary to existing compounds, two lemmas are needed here.

Thus, the model by Levelt et al. (1999) gives a structured explanation of how semantic, syntactic, morphological and phonological information are represented for speech production. Of course, experimental research has been conducted in order to test the assumptions of this model (Levelt et al., 1999), distinguishing between morphological, phonological and semantic processes. Here, I will focus on research on morphological processing.

Evidence for morphology in language production

The first experimental evidence for morphologically structured representations in speech production comes from Roelofs (1996). He used an implicit priming paradigm to investigate morphological processes. In this paradigm, participants learned to associate a certain response to a given prompt word, e.g., they had to say *bible* in response to *religion*. Responses occured in either homogeneous sets or heterogeneous sets. In homogeneous sets, the produced words shared a particular part of speech, for example, the first syllable, as in *bible*, *bypass*, *biker*. In heterogeneous sets response sets do not share a particular part of speech, as in *bible*, *organ*, *winter*. Roelofs compared these two sets and found that shared parts facilitate naming latencies. Shared morphology (e.g., *byline*, *bypass*, *byway*) lead to even larger facilitation than shared syllables (Roelofs, 1996, 1998). However, if the overlap was non-initial, there was no difference between homogeneous and heterogeneous sets. Roelofs interpreted this data as evidence for a left to right incrementality of morphological and phonological planning. Further evidence for morphological processes in language production comes from studies which used the picture-word interference paradigm.

In this paradigm, participants have to name pictures of objects which are accompanied by visually or auditorily presented distractor words. Studies using this paradigm (e.g., Dohmes et al., 2004; Gumnior et al., 2006; Zwitserlood, Bölte, & Dohmes, 2000, 2002) investigated the influence of morphologically but also phonologically (e.g., Schriefers, Meyer, & Levelt, 1990) and semantically related distractors on the naming of target pictures. Of course, target-distractor combinations which are morphologically related, are also often phonologically and semantically related. This natural-confound problem has mainly been attached by using an immediate and a delayed variant of the picture-word interference paradigm. This allows to investigate morphology independently from semantics and phonology. In those studies, the morphological complexity was only varied on the perception side. The influence of distractor words such as *flowery* or *flowerpot* on naming latencies of simple objects such as *flower* was examined. The data showed clear effects of morphological facilitation. Unlike semantic and phonological effects, morphological facilitation is found even for the delayed variant with seven or more intervening trials. In sum, the results were interpreted in the way that morphologically complex words are composed during production and decomposed during comprehension. Thus, most of these studies address questions concerning the lexical structure and access to, for instance, morphological representations during production. One of the core issues is to provide evidence for morphology as a distinct level organization.

Given that these studies focus on the exact role of morphology, lexical selection, which, in the model by Levelt et al. (1999), precedes morphological processing, is not an issue. This is different in the experiments reported in Chapter 3. Lexical selection is a fast process, implying the retrieval of a word or a lemma, from a number of activated lemmas in the mental lexicon. This is preceded by activating the concept to be expressed. The active concept passes activation to the lemma node. Note that there is always more than just one concept and therefore lemma active. The strongest activated lemma is then selected (lemma selection). Thus, the activation of a lexical concept is a prerequisite for lexical (lemma) selection. But what influences the choice of certain concepts, or more precisely in terms of Levelt et al.'s (1999) models, what influences conceptual preparation? Below, different approaches to how lexical choice is determined and how conceptual preparation is influenced will be given.

Lexical choice and reference taking

According to Levelt et al. (1999), the existence of lexical concepts is a precondition for every expression a speaker wants to utter. These lexical concepts are mostly expressible by words of the speaker's target language. Therefore, Levelt et al. refer to lexical concepts as the terminal vocabulary. However, this particular speech production model does not account well for the very early stage of conceptual preparation. There are only few assumptions formulated in this model about what might influence lexical choice and conceptual preparation as a preceding stage of lexical selection.

One approach to explain influences on expressions is perspective taking. Perspective taking includes the referring to any state of affairs. Levelt et al. (1999), for instance, differentiate between deictic perspective, being a three-term relation between the speaker, the relatum (e.g., *chair*) and the referent (e.g., *ball*) and intrinsic perspective, constituting a two-term relation with the relatum as the origin and the referent. Thus, perspective taking seems to be a major component when referring to objects, also for example in a picture naming task. There are many ways to refer to objects, e.g., as *piece of furniture*, *chair* or *office chair*. There are no fixed expression. But what issues are relevant for perspective taking when referring to objects? The following paragraph addresses these issue in particular, by introducing 1) the Gricean maxim of quantity, 2) the reference to objects in contextual alternatives, 3) the redundancy of expressions and 4) addressee orientation, i.e. for whom is the expression relevant.

In a conversation, the speaker assumes that the listener extracts information from his communicative expressions. This does not mean that the speaker's message has to include each and every detail. The speaker rather expects cooperative behaviour of the addressee. The interaction between information to be conveyed and information expressed is driven by, for instance, the Gricean principles (Grice, 1975). Grice's cooperative principles constitute the following maxims: maxim of quantity, maxim of quality, maxim of relation and the maxim of manner. One of the most relevant maxims, being essential in speakers' references, is the maxim of quantity. This maxim states that a speaker's contribution has to be as informative as required but not more informative than necessary. So, the speaker has to find a good intermediate solution between overinformative and meage expressions. This maxim should hold for discourse, where the listener infers information from the speaker's expression, and where both interlocutors often share a common ground (knowledge base). But how does this maxim hold for speakers' selections of information when making reference to objects?

A speaker's referring expression to a certain object is also highly dependent on what other objects are there in the same context as the reference object (Olson, 1970). For instance, if a speaker wants to refer to a *big black ball*, in the context of 1) a *small black ball* and 2) a *big white ball*, he might say *big ball* in the first case and *black ball* in the second. Consequently, speakers try to give distinctive references, so that a listener is able to uniquely identify the object from all other alternatives. According to the Gricean maxim of quantity, speakers avoid giving overspecified utterances which often go along with redundancy, as well as underspecified utterances which often result in ambiguity. Taking the example above, the expression *the big black ball* is redundant, whereas the expression *the ball* is ambiguous (since there are two balls).

Overall, speakers' utterances tend to be distinctive and non-ambiguous but are often redundant (Deutsch & Pechmann, 1982; Pechmann, 1984, 1989). Of course, this contradicts the Gricean maxim of quantity. In Pechmann's experiments, for instance, participants saw objects differing in colour, size or type. Subjects had to name the object marked by a star for an imagined listener. In an arrangement of, for example, a *white cup*, a *black cup* and a *white bird*, speakers refer to the bird with "*the white bird*" although "*bird*" would have been sufficient. These overspecifications are often referred to as exophoric redundancy, used for objects exhibiting salient features. One idea why speakers often use redundant expressions is that they want to help or support the listener to uniquely identify the target object. Studies have shown that listeners have less difficulty identifying an object when the referent is overspecified, or to put it differently, redundantly described (Sonnenschein, 1982).

The results represented so far show that there are more ways to refer to objects. In most of these studies, speakers had to imagine a listener when making their references. It is apparently of little influence in simple object naming whether the addressee is sitting next to the speaker or is imagined (for more details see Chapter 3, Ferreira, Slevc, & Rogers, 2005; Jescheniak, Hantsch, & Schriefers, 2005). When a speaker addresses an imagined or a real listener, speakers' expressions tend to be more descriptive, longer, and less diverse than when constructing messages for their own use (Fussell & Krauss, 1989; Krauss & Fussell, 1991). How reference-taking has been investigated in a conversational setting is addressed, for instance, by Brennan and Clark (1996). They pointed out that referring to objects in a conversation is more or less a cooperative action of the interlocutors, in order to achieve a common ground. Brennan and Clark interpreted their results such as that speakers often start with a provisional reference which is further specified in the ongoing conversation (see also Brennan, 1996; Clark & Krych, 2004). Thus, speakers try to establish reference in a collaborative process so that it is well understood by all interlocutors. The claims about provisional references serve as the theoretical background for the second part of this dissertation. There the focus is on: How do speakers refer to objects when there are categorically related contextual competitors (distractors) and they are allowed to use one word for discrimination? And what other manipulations such as time or addressee orientation influence the speakers' references?

After having described the relevant general background to Chapter 2 and 3, the following part serves as an outline of the experiments conducted in those Chapters.

OUTLINE OF CHAPTER 2 AND CHAPTER 3

The dissertation is divided into two empirical parts. The first deals with the receptive processing of compounds, whereas the second part concentrates on compounds in language production. Both parts draw on experimentally conducted studies investigating the role of compounds in both comprehension and production.

The basic aim of the first part of the dissertation (Chapter 2) is to investigate the role of several intercorrelated factors such as frequency, length or semantic transparency potentially influencing the processing of compounds during reading. This was studied in three separate experiments using 2154 German compound nouns, presented in isolation. All three experiments are based on a regression design. There are various processing theories (for detailed description see Chapter 1 Part A and Chapter 2) proposing different assumptions about the representation and lexical retrieval of multimorphemic words (Baayen & Schreuder, 1999; Baayen et al., 1997; Butterworth, 1983; Bybee, 1985; Caramazza, 1997; Caramazza et al., 1988; Chialant & Caramazza, 1995; Fowler et al., 1985; Laudanna et al., 1997; Schreuder & Baayen, 1995; Taft, 1986, 1994, 2004; Taft & Forster, 1975, 1976).
The different models are supported by studies in which certain factors, like frequency, semantic transparency or length, are manipulated. These manipulations are supposed to be indicative as to whether or not morphologically complex words are decomposed. Research of compound processing was so far restricted to manipulations of only one predictor variable, e.g., either frequency (Hyönä et al., 2004; Pollatsek, Hyönä, & Bertram, 2000) or semantic transparency (Pollatsek & Hyönä, 2005; Marslen-Wilson et al., 1994; Zwitserlood, 1994). Given that most studies use factorial designs, accompanied with small item sets, compound word processing has been seen too restrictive. I tested the processing of compounds by covering nearly all noun-noun compounds provided by the CELEX lexical database (Baayen, Piepenbrock, & Gulikers, 1995) including a large range of predictor variables such as frequency, length, semantic transparency, onset complexity, family size and family frequency. In short, the first experiment explores the lexical access of compounds by measuring gaze durations on the whole compound and its constituents using a variant of the boundary technique (Rayner, 1975). In order to confirm that gaze durations are a sensitive measurement for effects of momentary processing since they are also guided by visual principles, I tested the same compounds in a lexical decision experiment. If lexical decision times reveal no effects of word length but effects of word frequency or semantic transparency, evidence for

lexical decision as a more global measure than gaze durations is provided. In order to test Taft's (2004) assumption that the type of frequency effect depends on the manipulation of the pseudo-word distractors, I investigated, in a third experiment, the same compounds with the same task as in Experiment 2 but with different pseudo-word distractors.

Results from this chapter support the notion that compounds are processed via two routes, a whole-word and a decompositional route. Effects of predictors concerning both whole compounds and constituents showed that there is holistic as well as constituent processing of compounds. Furthermore, the type of frequency effect in a lexical decision task depends on the manipulation of pseudo-word distractors (Taft, 2004). These issues will be addressed in the second chapter of this thesis.

The basic aim of the second part of the dissertation (Chapter 3) is to investigate under which conditions speakers use morphologically complex words (more specifically, compounds) instead of morphologically simple words to refer to objects. According to the Gricean maxim of quantity (1975), speakers provide sufficient information but not more information than necessary. There are various studies investigating factors determining the lexical choice when referring to objects (e.g., Ferreira et al., 2005; Jescheniak et al., 2005; Jolicouer, Gluck, & Kosslyn, 1984). When investigating influences on lexical choice in an object naming task, one also has to take into consideration the situational context. For lexical choice it seems to matter whether there are other unrelated or related objects presented within the same context with the referred object. Accordingly, one has to distinguish between non-lexical and lexical ambiguities. Speakers tend to use, for instance, exophoric overspecifications, especially for non-lexical ambiguities (objects showing salient features) such as *the big white bird* (Pechmann, 1984, 1989). Instead, linguistic ambiguities are not easily avoided. They mainly occur in a context of categorically related objects (for homophones see Ferreira et al., 2005). Usually, the first provisional reference to objects is clarified within a conversation (Brennan & Clark, 1996). In the experiments presented in Chapter 3, participants are not situated within a conversational background. Therefore, the focus in these experiments is on the provisional references.

Five experiments investigated under which conditions speakers use a morphologically complex word when referring to an object (*Wassereimer*, water bucket), although the preferred naming for this object is morphologically simple (*Eimer*, bucket). In the critical condition, the distractors belonged to the same semantic category as the targets (*Mülleimer* - waste basket). In this case, the production of a complex word would be an unambiguous naming of the object. Certain manipulations such as same-category distractors or a referential communication task should encourage the speakers to unambiguously describe one of two pictures in a picture-picture paradigm. The results showed that speakers had difficulties to produce unambiguous answers. With a final relaxation of time pressure, there were more unambiguous (complex) answers than ambiguous answers. But referential ambiguity was completely resolved when both pictures had to be named. This indicates that sufficient time for conceptualization and formulation is required in order to produce an informationally adequate utterance. This issue will be addressed in Chapter 3.

EFFECTS OF INTERCORRELATED VARIABLES ON COMPOUND WORD PROCESSING IN READING: EVIDENCE FROM FIXATION DURATIONS AND LEXICAL DECISION TIMES

CHAPTER 2

Abstract

The processing of 2154 German compounds was investigated with a semantic relatedness judgement task and eye movement measures (Experiment 1) and with lexical decision tasks, using different pseudowords, and reaction time measures (Experiment 2 & Experiment 3). The data were analysed by means of multiple regression analyses using word frequency, word length, semantic transparency, onset complexity, family size and family frequency as predictors. Gaze durations measured in Experiment 1, with a boundary technique, were affected by frequency, length and family frequency. Lexical decision times from Experiment 2 were mainly influenced by frequency, semantic transparency and onset complexity. Experiment 3 showed significant results of frequency and semantic transparency. Both lexical decision experiments differ with respect to their type of frequency effects, depending on the pseudowords. Thus, the data suggest that different factors influence compound processing using different dependent measures, for instance, eye movements are also guided by visual principles. Our results show effects of the compounds as well as their constituents which supports assumptions of a whole-word and a decompositional processing.

Introduction

In language comprehension, the breaking down of words into their constituent morphemes is apparently relatively straightforward. The morphologically complex word *antidisestablishmentarianism* can rapidly be broken down into its smallest meaningful elements, the morphemes, because they follow a clear sequence. Such long complex words are uncommon in English, but users of agglutinating languages, for instance Turkish or Finnish, frequently encounter such long words. Regardless of the number of morphemes, the question arises as to how we process words comprising more than one morpheme? In particular, how does lexical access take place? Is it comparable to lexical access of morphologically simple words? How are morphologically complex words stored in the mental lexicon (for an overview, see Schriefers, 1998)?

The present research focusses on the processing of written compounds. Compounds, words that consist of more than one free morpheme, are common in German and are formed productively. Compounds are written as one word in German without intervening spaces (e.g., *Wein+flasche* - wine bottle[1]). We attempt to answer the above questions by presenting a large number of items to our participants. Research on compound processing has often employed factorial designs (Radach & Kennedy, 2004; Rayner, 1998; Rayner & Juhasz, 2004). In this approach, a significant influence by one factor is regarded as supporting the validity of a particular model. It is certainly a promising approach, but it also has some flaws.

The manipulation of a small number of independent factors while simultaneously controlling the influence of intervening variables often limits substantially the number of items (Cutler, 1981). A more promising approach, rarely used, can be to select items from a larger set of words that accomplish the targeted characteristics (Forster, 2000). Furthermore, usually researchers categorise a continuous variable, for instance, into low and high frequent words while ignoring that word frequency is a continuous variable. Especially if "extreme" groups are used, one faces the problem of regression to mean phenomenon. Thus the observed effect might result, at least in part, from a regression artefact. But already the categorisation itself influences reliability and statistical power (Cohen, 1983; Maxwell & Delaney, 1993). Furthermore, it is rather difficult to find German compounds which have a higher word frequency than their constituents (see Table 1). In the overwhelming number of cases (96%)

---

[1] A "+" serves to indicate a morpheme boundary.

the constituents are more frequent than the compound. Given this, and the observation that word frequency is the most reliable predictor to word recognition times, it seems probable that the lexical access system has taken advantage of this distribution in language. Constituent frequency might have an advantage over compound frequency to influence lexical access.

Table 1: Frequency distribution of noun-noun compounds

		ln frequency compound	ln frequency modifier	ln frequency head
compound > modifier & compound > head	mean	8.8	7.3	8.3
	sd	2.8	2.5	3.1
	max	11.7	10.4	11.6
	min	4.9	6.0	4.8
	n	6		
compound > modifier & compound < head	mean	6.7	5.5	10.1
	sd	2.3	2.7	1.3
	max	11.6	11.3	12.4
	min	2.2	.01	6.9
	n	55		
compound < modifier & compound > head	mean	6.4	8.8	5.3
	sd	1.5	1.6	1.9
	max	9.5	11.2	8.7
	min	2.8	5.1	.01
	n	28		
compound < modifier & compound < head	mean	4.7	8.7	9.1
	sd	1.7	1.7	1.6
	max	11.7	11.5	13.3
	min	.01	2.7	2.8
	n	2064		

These limitations might constrain the inferences one can draw. Therefore, our study takes a different approach. It circumvents this limitation by using a regression design looking simultaneously into various predictors suggested to influence lexical access. This informs us about the influence of intercorrelated predictors on compound processing. Furthermore, we employed two different dependent variables, gaze durations[2] and lexical decision times. We are interested in predictors that influence compound processing independent of a particular task or measurement. We use gaze durations and lexical decision times, both of which supposedly reflect lexical access processes (Rayner, 1998).

A similar approach was taken by Balota, Cortese, Sergent-Marshall, Spieler, & Yap (2004) investigating over 2000 monomorphemic words with lexical decision and naming. They assessed effects of a whole range of variables and observed task-dependent influences of most variables. Frequency-based information had a larger impact in lexical decision than in naming, and the same held for semantic predictor variables. Naming latencies were considerably more influenced by phonological onset variables and by word length than lexical decision latencies (see also Balota & Chumbley, 1984).

We extend this kind of research at two levels: 1) eye-tracking was employed and gaze durations were compared to lexical decision latencies; 2) morphologically complex words were presented instead of morphologically simple words. We commence with a brief description of models which suggest predictors influencing the processing of complex words. This is followed by the presentation of our data and conclusions.

Models of morphological processing

We restrict our discussion to models describing the lexical access of morphologically complex words; lexical access being the process(es) needed to locate a form description or an address of a target entry in the mental lexicon. It is comparable to looking up a word in a dictionary. One feature which discriminates between the models is the look-up procedure. Three classes of models can be distinguished: Full-listing models (Butterworth, 1983; Bybee, 1985; Fowler, Napps & Feldman, 1985), full-parsing or obligatory parsing models (Taft & Forster, 1975, 1976; Taft, 1986, 1994, 2004), and dual-route models which combine listing and decomposition (Baayen & Schreuder, 1999; Baayen, Dijkstra & Schreuder, 1997; Caramazza, 1997; Caramazza, Laudanna, & Romani, 1988; Chialant & Caramazza, 1995; Laudanna, Cermele, & Caramazza, 1997; Schreuder & Baayen, 1995).

---

[2] Gaze durations are the sum of all fixations made to a region prior to a saccade to another region.

Full-listing models

Full-listing models suggests that all word forms regardless of their morphological complexity are lexically represented and are accessed via whole-word forms (Butterworth, 1983; Bybee, 1985; Fowler et al., 1985). Butterworth, for instance, proposed a grouping of morphologically-related forms in lexical memory but disputes that such group centres around some base form. Thus, there is some morphological structure, but this does not derive from the decomposition of morphologically complex forms into their constituents. Notice that Butterworth (1983) suggested decomposition as a fall-back procedure for items not accessible as whole-word forms.

Obligatory decomposition

In contrast to full-listing models, full-parsing models decompose morphologically complex words into their constituents, by extracting the stem and permissible affixes (Taft & Forster, 1975, 1976; Taft, 1986, 1994, 2004). It is assumed that regularities in word formation and lexical representation based on rules serve to decompose a complex word into its constituents. In its strongest form, decomposition is obligatorily taking place at early processing stages. This type of processing can account for base-frequency (cumulative frequency of a base form: *love, loves, loving, loved*), surface (frequency of a particular morphologically complex words: *loved*) and reverse base-frequency effects. Which type of frequency effect influences the dependent measure depends on the amount of involvement of a combinatorial stage and affix type (Taft, 1994, 2004; Taft & Ardasinki, 2006).

Dual-route models

Dual-route models propose that lexical access to morphologically complex words can be gained by two routes, either whole-word forms or decomposed word constituents. The Augmented Addressed Morphology Model (AAM; Caramazza et al., 1988; Caramazza, 1997; Chialant & Caramazza, 1995; Laudanna et al., 1997) assumes that whole-word units and morphemic access units are activated in parallel. The access units activate a morphologically decomposed lexical representation. Given that activation via morphemic access units requires an additional process, parsing the input into the proper access units, access via theses units is slower than access via the whole-word route. The speed with which a lexical access reaches its threshold is also influenced by word and constituent frequency, semantic transparency and other factors (Notice that this addition makes the model nearly indistinguishable from the Morphological Race Model, see below). When a novel morphologically complex word is presented to the lexical access system, it is processed via the decompositional route because there is no whole-word access form (Laudanna et al., 1997).

An alternative to the AAM is the Morphological Race Model (Baayen & Schreuder, 1999; Baayen et al., 1997; Schreuder & Baayen, 1995). Similarly as the AAM, this model proposes a simultaneous processing via a whole-word and a decompositional route. Which of the two routes achieves lexical access depends on properties such as word frequency, neighbourhood size, semantic and phonological transparency (Baayen & Dijkstra, 2003; Bertram, Baayen, & Schreuder, 2000). The proponents of this model postulate also a learning mechanism. The access unit which achieves lexical access is strengthened by increasing its resting level. Semantically non-compositional words can only be access via the whole-word form. Consequently, only constituents which are part of many semantically transparent words will achieve high resting levels.

These models differ with respect to the potential impact that certain variables may have on the processing of complex words. Whereas full-listing allows whole-word variables such as full-form frequency to affect processing, the Morphological Race Model would predict far more variables, such as constituent frequency, to have an impact. A whole range of such variables have been shown to affect the processing of complex words in reading. Given that we assessed the impact of many such variables in our experiments, we will briefly review them here.

Word frequency. Word frequency manipulations are a primary tool for investigating morphological processing. For instance, the two compounds *Priesteramt* (priesthood) and *Zollamt* (custom office) which have the same whole-word frequency, but their respective modifiers differ in word frequency. *Priester* (priest) occurs more often than *Zoll* (custom). Frequency manipulation of the whole-word form or the constituents supposedly indicates which route is used for lexical access. If compounds of equal whole-word frequency but different constituent frequency are recognized equally fast, one would suggest that this recognition took place via a whole-word access route. If, however, constituent frequency affected word recognition performance, one would suggest that the compounds had been decomposed for lexical access (e.g., Baayen et al., 1997). There is no doubt that various combinations of frequency effects are conceivable and have been observed (Taft, 2004).

Semantic transparency. Another factor influencing complex word processing is semantic transparency (Giraudo & Grainger, 2000, Libben, Gibson, Yoon, & Sandra, 2003; Longtin, Segui, & Hallé, 2003; Marslen-Wilson, Tyler, Waksler, & Older, 1994; Schreuder & Baayen, 1995, Zwitserlood, 1994). The meaning of a semantically transparent complex word is a predictable function of the meaning of its components. *Butterfly*, however, is an intransparent compound, the meaning of which can not be derived from the meaning of its components *butter* and *fly*. The question whether semantically intransparent words are stored as whole-word forms or are morphologically structured as semantically transparent words has often been addressed. Morphological priming effects have been observed for semantically transparent but not for semantically intransparent words, suggesting a storage of intransparent words as a whole (Longtin et al., 2003; Marslen-Wilson et al., 1989). Zwitserlood (1994) and Libben et al. (2003), however, do not exclude opaque words from decomposition. In their studies, semantically transparent as well as intransparent compounds primed their morphological constituents. Taft (2004) also does not exclude semantically opaque words from decomposition. He suggests that decomposition takes place at the access level and that the constituents are subsequently recombined at a later level providing the link between *butter* and *fly* to the semantic representation of *butterfly* (see also Giraudo & Grainger, 2000). Frequent morphologically complex words and/or semantically opaque words are supposedly accessed via the whole-word route, whereas the decompositional route is responsible for transparent words and/or low frequent words. Thus, properties such as frequency or semantic transparency determine which route is chosen (Koester, Gunter, Wagner, & Friederici, 2004). The different data patterns obtained with transparent and intransparent words have been attributed to differences in experimental setup and language in question (see Feldman, 2000).

Word length. A further variable, that influences compound processing, is word length. Compound length determines how many fixations are needed for its processing. Long compounds (12-18 letters) are supposedly processed via the decompositional route, because its constituents cannot be processed within one fixation. Short compounds (7-9 letters) can be accessed via the whole-word form because they usually cover one foveal area (Hyönä, Bertram, & Pollatsek, 2004; Hyönä, Bertram, & Pollatsek, 2005).

Word length and word frequency. If length determines which access route is chosen, there should be interactions between length and other factors such as frequency. Hyönä and Pollatsek (1998) observed first-constituent length effects on fixation location and duration when first-constituent length of long compounds was manipulated and whole-word length was held constant. When first-constituent frequency was manipulated while keeping second constituent and whole-word frequency constant, first-fixation time (duration of initial fixation on the word) and gaze duration (first-pass reading time, regressions excluded) were influenced by first-constituent frequency (Hyönä & Pollatsek, 1998). Second-constituent frequency also had an impact on gaze duration (Pollatsek, Hyönä, & Bertram, 2000). These results clearly support the assumption that long compounds are accessed via their constituents and that the initial constituent is accessed first (see also Andrews, Miller, & Rayner, 2004; Beauvillain, 1996; Niswander, Pollatsek, & Rayner, 2000). Hyönä, Bertram and Pollatsek (2004) replicated these findings with an eye-movement – contingent display change technique (based on the boundary technique developed by Rayner, 1975). Long compounds with either high or low frequent first constituents were embedded in a sentence frame. Fixation durations on the first constituent and gaze duration on the whole-compound were affected by first-constituent frequency. Thus, long compounds again show serial access of constituents (Hyönä & Pollatsek, 1998; Pollatsek et al., 2000).

Short compounds, on the other hand, showed effects of whole-word frequency on gaze duration and no effect of first-constituent frequency, indicating whole-word form access (Bertram & Hyönä, 2003). The fact that semantically transparent and intransparent words showed comparable first-constituent frequency effects suggests decomposition irrespective of semantic transparency (Pollatsek & Hyönä, 2005). Thus, the effects of variables such as frequency, length or semantic transparency depend on other factors controlled during the experiments, e.g., constituent-frequency effects are observed particularly with respect to long compounds (see also Inhoff & Rayner, 1986; Rayner & Duffy, 1986).

Family size and family frequency. Two further variables that are found to affect the processing of words are family size and family frequency. Derivation and compounds formed from a base word make up a morphological family. The summed frequency of all family members forms the family frequency. In visual lexical decision, response latencies to simplex or complex words are shorter to words of a large morphological family than to words of a small morphological family (Bertram et al., 2000; de Jong, Schreuder, & Baayen, 2000; Krott & Nicoladis, 2005; Moscoso del Prado Martin, Deutsch, Frost, Schreuder, de Jong, & Baayen, 2005; Schreuder & Baayen, 1997). Effects of family frequency are less clear. Colé, Beauvillain and Segui (1989) found an effect of family frequency on response latencies; high family frequency results in faster responses (Burani & Caramazza, 1987; Colé et al., 1989). Other studies showed that family frequency does not affect response latencies at all (Baayen, Lieber, & Schreuder, 1997; Giraudo & Grainger, 2000; Schreuder & Baayen, 1997). Pykkänen, Feintuch, Hopkins and Marantz (2004) observed even inhibitory effects of high family frequency on the M350.

Onset complexity. Onset complexity, that is whether a word onset consists of one or two and more consonants, effects have mostly been obtained in naming experiments. Frederiksen and Kroll (1976) were among the first to show that words with simple onsets are named faster than words with complex onsets. Burani, Barca and Ellis (2000) showed that not just the number of graphemes at word onset influences naming speed but rather the complexity of the grapheme-to-phoneme rule that needs to be applied for pronunciation. Low frequent, complex words are pronounced slower than low frequent simple words. No such difference was found for high frequent words. Kawamoto and Kello (1999) obtained a pattern opposite from that of Frederiksen and Kroll. Rastle and Davis (2002) attribute the different results to differences in reaction time registration. The effect of onset complexity disappears in lexical decision (Frederiksen & Kroll, 1976). Lexical decision, in general, seems to be less sensitive to phonological effects than naming which has been attributed to the need to articulate in naming (Balota et al., 2004).

The above review summarizes data from different methods, tasks, stimuli and languages. It is obvious that various methods and tasks differ in sensitivity. Take for instance, Inhoff, Brihl and Schwartz (1996), who reported longer fixation durations but shorter naming latencies for compounds. In single word presentation, Hyönä, Vaino and Laine (2002) observed longer lexical decision times to inflected targets than to monomorphemic targets. This morphological complexity effect disappeared in a lexical decision and in a reading task when the target was embedded in a sentence context. A result which supports the idea that, at least inflected Finish nouns are processed via a time-consuming decompositional route. Sometimes however, effects are stable across different tasks. Juhasz, Starr, Inhoff and Placke (2003) found shorter lexical decision times, naming latencies and gaze durations during reading with high frequent second compound constituents. It is often not evident what brings about the different effects: presentation mode, embedding in a sentential context or task? A sentence context, for instance, provides semantic and syntactic cues about the target word which are absent in single word presentation (Zwitserlood, 1989). Furthermore, people read words more often in a sentence context than in a single-word presentation mode. However, using a sentence context often limits the number of potential target words making it difficult to find enough material. Despite the various and contradictory outcomes of the reported studies, some variables influence lexical access in a reliable manner. Word frequency and word length are probably the most important variables. Additional, but less important variables are semantic transparency and family size. Family frequency and onset complexity seem to influence lexical access only under certain circumstances such as a specific task (e.g., naming for onset complexity). This set of variables served as predictors for RTs observed in the following experiments (Balota et al., 2004; Juhasz & Rayner, 2003; Lemhöfer, Dijkstra, Schriefer, Grainger, & Zwitserlood, subm.).

In short, our experiments assessed the impact of a whole range of predictors such as frequency, length, semantic transparency, onset complexity, family size and family frequency on the processing of 2154 German compound nouns, nearly all noun-noun compounds in the CELEX lexical database (Baayen, Piepenbrock, & Gulikers, 1995). In Experiment 1, a boundary technique was used which suggests a natural reading process (Rayner, 1975). Gaze durations served as dependent variable. In Experiment 2 and Experiment 3, the dependent measure was lexical decision latency. The pseudoword type was varied between Experiments 2 and 3. The following issues were addressed: 1) the influence of compound and constituent frequency on gaze durations and lexical decision times; 2) the additive impact of word frequency and length and 3) the influence of the remaining predictors on gaze durations and lexical decision times. As word frequency and length are the best-documented and most robust variables in language processing (Andrews et al., 2004; Bertram & Hyönä, 2003; Hyönä et al., 2004; Hyönä & Pollatsek, 1998; Juhasz et al., 2003), they were given priority in our analyses. Predictors such as semantic transparency, onset complexity, family size and family frequency are entered as additional predictors. The analyses will be restricted to durations of eye fixations on the target compounds and on their constituents, and to response times to assess how compounds are processed.

Experiment 1: Eye tracking with the boundary technique

Method

Participants.

Eight students of the University of Münster, Germany, took part in the experiment. They received course credit for participation. All participants had normal or corrected-to-normal vision and were native speakers of German.

Material.

The stimuli consisted of 2154 compounds selected from the German CELEX lexical database (Baayen et al., 1995). Only bimorphemic, compositional compounds, consisting of two nouns were chosen as targets (e.g., *Weinflasche*, wine bottle). A typical semantically transparent German noun-noun compound is right-headed. The modifier forms the first constituent (*Wein*, wine) and the head the second (*Flasche*, bottle). There are no spaces between German compound constituents, so orthographically, a compound is one word.

Twelve predictor variables for the selected compounds: word frequency and word length, available for the whole compound as well as its constituents, semantic transparency and onset complexity for the compound and family size and family frequency for the modifier and the head, were available from the CELEX database (Baayen et al., 1995). Additional frequency information was obtained from the corpus provided by the department of computer science of the University of Leipzig (Leipziger Wortschatzlexikon). In order to test compound familiarity, 247 words of lowest frequency were presented to 10 students (native speakers of German). They had to indicate whether they knew a word, did not know it or weren't sure. Compounds unknown to two or more participants (181 out of 247 words, 73%) were excluded from the stimulus list.

Frequency estimates of CELEX and the Leipziger Wortschatzlexikon were positively correlated (whole compound: $r = 0.885$, $p < 0.01$; first constituent: $r = 0.377$, $p < 0.01$; second constituent: $r = 0.765$, $p < 0.01$). Because the Leipziger Wortschatzlexikon provided frequency counts for more compounds (and constituents) than CELEX, frequency measures from the Leipziger Wortschatzlexikon (June '05) were used in our regression analysis. The actual corpus size is 500 million words and 35 million sentences. Furthermore, whole-compound frequency, constituent frequency and family frequency for modifier and head were logarithmized (ln), to reduce skewness of frequency distributions. The word length of the stimulus words ranges from 6-18 letters for the whole compound, 2-11 letters for the first constituent and 2-12 letters for the second constituent. Onset complexity (singleton vs. complex word onset) was not coded dichotomously but varied from 0-3. The number indicates the number of consonants which form the compound onset. The morphological family size for modifier and head ranges from 1-137 (see Table 2).[3] Given that CELEX's semantic transparency information could not be used (only 36 out of 2154 compounds were marked as intransparent in CELEX), a separate semantic transparency rating was carried out. All 2154 compounds were rated by 26 participants on a scale from 1 for semantically transparent to 5 for semantically intransparent (mean: 2.52, sd: 0.97, range: 1-5). The mean of each item's semantic transparency rating was adopted as a predictor in the regression analyses.

---

[3] Note that the CELEX database does not provide family size and family frequency information for 290 words which can be modifiers and heads of our stimulus compounds.

Table 2: Characteristics of stimulus material

predictor variables	Mean (SD)	min - max
Compound frequency (ln)	4.76 (1.72)	0 – 11.7
1st constituent frequency (ln)	8.69 (1.75)	0 – 11.5
2nd constituent frequency (ln)	9.06 (1.69)	0 – 13.34
Length of compound (in letters)	10.14 (1.94)	6 – 18
Length of 1st constituent	5.08 (1.32)	2 – 11
Length of 2nd constituent	5.13 (1.35)	2 – 12
Semantic transparency	2.52 (.97)	1 – 5
Onset complexity compound	1.15 (.53)	0 – 3
Morphological family size modifier	25.86 (27.96)	1 – 137
Family frequency modifier (ln)	4.44 (2.47)	0 – 9.26
Morphological family size head	26.94 (29.35)	1 – 137
Family frequency head (ln)	4.37 (2.58)	0 – 9.26

The contribution of these twelve variables to compound-word processing was assessed in a multiple-regression analysis. A perfect situation for multiple regression analyses entails that the predictors are highly correlated with the dependent variable, but are uncorrelated with each other, a situation which is very rare in practice. Intercorrelations are unavoidable when investigating natural language. Therefore, intercorrelations among the predictors were calculated (see Table 3). Whole-compound frequency is highly correlated with first and second-constituent frequency. This also holds for length measures. Note that these high intercorrelations are within one predictor variable class. More importantly, the correlations between length of the whole compound and its constituents, and frequency of the whole compound and its constituents are smaller than 0.2 (see Table 3). So the influence of one predictor on the other predictor will be rather small.

Table 3: Correlations among predictor variables

variable	2	3	4	5	6	7	8	9	10	11	12
1. lnfreqcomp	.347**	.367**	-.105**	-.080**	-.056**	.001	-.034	.234**	.317**	.271**	.271**
2. lnfreqconst1	1	.224**	-.054*	-.115**	.041	-.017	-.025	.540**	.609**	.142**	.156**
3. lnfreqconst2		1	-.093**	.059**	-.186**	-.021	.024	.132**	.159**	.647**	.611**
4. lengthcomp			1	.696**	.733**	-.062**	.138**	-.118**	-.208**	-.159**	-.272**
5. lengthconst1				1	.044*	-.034	.203**	-.174**	-.270**	.044	-.022
6. lengthconst2					1	-.051*	-.017	.004	-.014	-.277**	-.366**
7. semantrans						1	.073**	.043	.037	-.002	.004
8. onscomp							1	.054*	-.024	.000	.007
9. famsizem								1	.757**	.087**	.125**
10. lnfamfreqm									1	.124**	.142**
11. famsizeh										1	.773**
12. lnfamfreqh											1

Note: lnfreqcomp = logarithmized frequency of whole compound; lnfreqconst1 = logarithmized frequency of first constituent; lnfreqconst2 = logarithmized frequency of second constituent; lengthcomp = word length of whole compound (number of letters); lengthconst1 = word length of first constituent (number of letters); lengthconst2 = word length of second constituent (number of letters); semantrans = semantic transparency of compound; onscomp = onset complexity of compound; famsizem = family size of modifier; lnfamfreqm = logarithmized family frequency of modifier; famsizeh = family size of head; lnfamfreqh = logarithmized family frequency of head. ** $p < .01$, * $p < .05$.

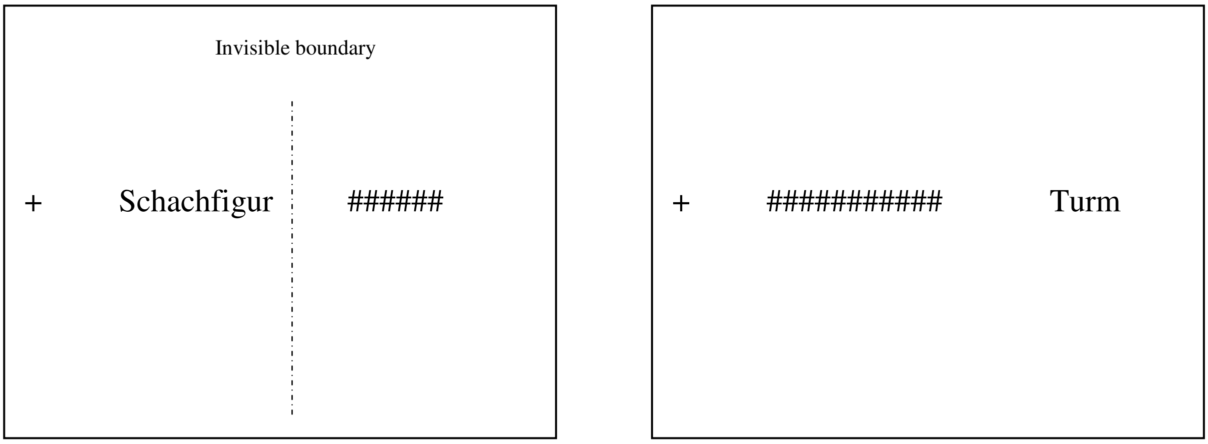
Apparatus.

Words were presented on the centre line of a 21-inch Samsung SyncMaster 1100p plus monitor (1024 x 768 pixel, frame rate: 85 Hz) controlled by a Dell-Dimension 4200 IBM-compatible PC. Participants were seated approximately 80 cm in front of the monitor. Eye movements were recorded with the help of an Eyelink II eye-tracker (SR Research), with a sampling rate of 500 Hz and an eye-position resolution of less than 0.5°. The eye-tracker was controlled by a Dell-OptiPlex 280 computer.

Procedure.

The 2154 compounds were distributed over sixteen separate lists, and four lists were presented within one session (four sessions per participant). Participants received twenty warm-up trials at session start. Additionally, each list started with two warming-up trials. To ensure that participants read all compounds carefully, a second word appeared on the screen after the compound was read. The participants had to decide whether the two stimuli were semantically related or not. There were 40% related trials. These semantically related words could be nouns, verbs or adjectives. All stimuli were presented in Courier (font size 26) which ensured that each character was of equal width. Before the experiment proper, the eye-tracker was calibrated and validated. At the start of each trial, a fixation point was presented at the left margin of the screen (centred 100 pixels to the right of the left margin). Participants had to fixate the fixation point before the trial started. A compound appeared 100 pixels right (2.2°) of the fixation point. The second word was presented simultaneously with the compound but was masked with hash marks. As soon as the participants made a saccade across an invisible boundary, programmed between the target and the second word, the mask on the second word vanished and the target compound was masked until trial end (see Figure 1). Participants decided whether the target compound and the second word were semantically related or not (640 ms, SD: 177; measured from invisible boundary; for this procedure see Beauvillain, 1996). With this task, we wanted to ensure reading for meaning.

Figure 1: Example for screen arrangement in Experiment 1



Data handling and analysis

The data analysis procedure used for this experiment is as follows. The calculation of fixations or reaction times for each item averaged over participants is inadequate for exploring factors in multiple regression designs, because it disregards interparticpants' variability. Therefore, we used the method suggested by Lorch and Myers (1990). We first performed a separate regression analysis for each participant. With a particular analytical model defining the order of entry of predictor variables in mind, each individual regression equation was performed according to this prescribed order. As the influence of frequency and length are the most robust findings in eye-tracking, we predicted their effects on fixation durations in compound reading. Therefore, they entered the regression equation first. Afterwards, a cross validation was carried out, by dividing the data set into half, to confirm the reliability of the predictors. Only predictors that were still significant after cross validation will be reported here. We then calculated a one-sample *t* test on the resulting regression coefficients for each predictor variable to establish whether the mean unstandardized coefficients were significantly different from zero.

We report results from gaze duration on the whole compound and on its constituents. Gaze duration is the sum of the durations of all fixations made on a target. For the gaze durations on the compounds' constituents, we adopted the term subgaze (e.g., Hyönä et al., 2004). Subgaze$_1$ is the gaze duration on first constituent, whereas subgaze$_2$ is the gaze duration on second constituent. Note that total fixation durations are not addressed because refixations on the compound were suppressed by the appearance of hash marks after participants had crossed the invisible boundary.

Gaze durations on the whole compound were calculated from subgaze_1 and subgaze_2 measures. We removed wrong responses (10.8%) and gaze durations on the whole compound smaller than 200 ms (1.8%) and larger than 1600 ms (0.3%) from the data set. If the gaze duration on the whole compound were below or above these values, the corresponding subgaze_1 and subgaze_2 durations were also discarded. Furthermore, we used standardized residuals (done separately for whole-compound gaze duration, subgaze_1 and subgaze_2 analysis) to examine data of participants who did not fit the model well. Residuals greater than 3 in absolute value were also eliminated from the data set (Stevens, 2002). No additional outliers were removed as according to Lorch and Myers (1990), the analysis is more effective with full data sets.

Results

The influence of frequency and length of the compound and each constituent, semantic transparency and onset complexity of the compound, family size and family frequency of the modifier and the head on gaze duration of the whole compound (419 ms, SD: 138), first (288 ms, SD: 112) and second constituent (217 ms, SD: 105) was examined[4]. The unstandardized coefficient means, standard errors and *t*-values for this analysis can be found in Table 4. Results will be reported in the order gaze duration whole compound, subgaze_1 and subgaze_2. There were five variables that significantly predicted gaze duration of the whole compound: whole-compound frequency, $t(7) = -6.7$, $p < .001$; first-constituent frequency, $t(7) = -3.7$, $p = .008$; whole-compound length, $t(7) = 3.9$, $p = .006$; family frequency of the modifier, $t(7) = -2.6$, $p = .037$ and family frequency of the head, $t(7) = -3.9$, $p = .006$. The negative *t*-values for frequency indicate shorter gaze durations with increasing frequency. First-constituent and second-constituent length, second-constituent frequency, semantic transparency, onset complexity and family size of the modifier and the head did not significantly influence gaze duration of the whole compound. In order to test the assumption of a non-additive impact of frequency and length (Hyönä & Pollatsek, 1998; Hyönä et al., 2004), we computed a second regression analysis in which we added interaction terms of whole-compound frequency and whole-compound length, first-constituent frequency and first-constituent length as well as second-constituent frequency and second-constituent length to the set of significant

---

[4] Note: subgaze_1 and subgaze_2 do not add up to gaze duration, because the second constituent was sometimes skipped.

predictors. The interaction was significant for whole-compound frequency and length (*t*(7) = -3.6, *p* = .009), indicating that whole-compound frequency affects the processing of long and/or short compounds. There were no significant effects for the interaction terms first-constituent frequency and length (*t*(7) = 1.5, *p* = .174) and second-constituent frequency and length (*t*(7) = -1.69, *p* = .135).

For subgaze$_1$, the significant predictors were whole-compound frequency, *t*(7) = -2.9, *p* = .024; first-constituent frequency, *t*(7) = -12.1, *p* < .001; whole-compound length, *t*(7) = 4.5, *p* = .003 and second-constituent length, *t*(7) = -5.4, *p* = .001. Interestingly, second-constituent length influences subgaze$_1$ in a reverse manner: The longer the second constituent, the shorter the durations on the first constituent. There were significant interactions for whole-compound frequency and length (*t*(7) = -2.9, *p* = .022), first-constituent frequency and length (*t*(7) = -2.4, *p* = .045) and second-constituent frequency and length (*t*(7) = 3.2, *p* = .015), supporting parafoveal and foveal processing during subgaze$_1$.

Finally, for subgaze$_2$, the significant predictors were whole-compound frequency, *t*(7) = -7.4, *p* < .001 and second-constituent length, *t*(7) = 6.1 *p* < .001. The cross validation analysis (see data handling) did not confirm the effects of whole-compound length (*t*(7) = -1, *p* = .358), first-constituent length (*t*(7) = .1, *p* = .939), family size of the modifier (*t*(7) = -1.6, *p* = .155) and family frequency of the head (*t*(7) = -.3, *p* = .784). A significant interaction was observed for second-constituent frequency and length (*t*(7) = -5.6, *p* = .001) but not for the other two interaction terms (whole-compound, *t*(7) = -1.7, *p* = .139; first constituent, *t*(7) = -1.7, *p* = .135). Note that second constituents were skipped in 34.7% of the cases, whereas first constituents were not fixated in only 4% of the cases. This is consistent with results from first-fixation location. Participants' eyes landed on the first constituent in 88.3% of the cases. First-fixation locations on the second constituent occur most often (68.8%) when the compounds' first constituents are very short (2 letters), as for instance *Ei* (egg) in *Eidotter* (egg yolk). First-constituent length, second-constituent frequency, semantic transparency, onset complexity and family size of modifier and head were not significant predictors throughout all analyses.

Table 4: Estimates of mean unstandardized regression coefficients (B), standard errors (SE) and t – values of the predictors for gaze duration, subgaze1, subgaze2

	GD			**subgaze$_1$**			**subgaze$_2$**		
predictor variable	B	SE	*T*	B	SE	*t*	B	SE	*t*
lnfreqcomp	-7.4*	1.1	-6.7	-2.2*	.8	-2.9	-5.3*	.7	-7.4
lnfreqconst1	-4.2*	1.1	-3.7	-3.4*	.3	-12.1	-2.3	1.1	-2.1
lnfreqconst2	.2	.7	.2	.03	1.1	.03	-.02	.9	.02
lengthcomp	13*	3.3	3.9	30.4*	6.7	4.5	-17.1	5.4	-3.2
lengthconst1	8.9	4.1	2.2	-3.6	4.7	-.8	9.7	2.8	3.5
lengthconst2	3	4.1	.7	-46*	8.6	-5.4	33.4*	5.5	6.1
semantrans	.7	.9	.8	.1	.5	.2	1.3	.6	2
onscomp	2.3	1.6	1.5	-.9	1.4	-.7	-1.9	3.1	-.6
famsizem	.04	.1	.5	.02	.05	.5	-.2	.1	-2.9
lnfamfreqm	-1.5*	.6	-2.6	-2.4	1.2	-2	2.5	1.1	2.2
famsizeh	.08	.05	1.8	.03	.1	.5	-.04	.03	-1.6
lnfamfreqh	-3.3*	.9	-3.9	-.2	1.1	-.2	-2.1	.6	-3.4

Note. GD = gaze duration; subgaze$_1$ = duration on first constituent; subgaze$_2$ = duration on second constituent; lnfreqcomp = logarithmized frequency of whole compound; lnfreqconst1 = logarithmized frequency of first constituent; lnfreqconst2 = logarithmized frequency of second constituent; lengthcomp = length of whole compound (no. of letters); lengthconst1 = length of first constituent (no. of letters); lengthconst2 = length of second constituent (no. of letters); semantrans = semantic transparency; onscomp = onset complexity of compound; famsizem = family size of modifier; lnfamfreqm = logarithmized family frequency of modifier; famsizeh = family size of head; lnfamfreqh = logarithmized family frequency of head.

* $p < .05$.

Discussion

In Experiment 1, we investigated the influence of twelve variables, partly intercorrelating, on gaze durations: frequency and length of the whole compound and of its constituents, semantic transparency, onset complexity of the compound and family size and family frequency of the modifier and the head. Not all variables had a significant impact on gaze durations. We find, consistent with our expectation, that frequency and length significantly influenced gaze duration. Gaze durations on the whole compound and its constituents were affected by whole-compound and constituent variables as one would expect from dual route models (Caramazza et al., 1988; Chialant & Caramazza, 1995; Schreuder & Baayen, 1995) but not from the full-listing approach (Butterworth, 1983; Bybee, 1985).

Gaze durations on the whole compound revealed effects of whole-compound frequency, indicating holistic processing. It is astonishing to observe whole-compound frequency effects at all. Remember that there are hardly any German compounds which are of higher frequency than their constituents. Thus, words which supposedly take a whole-word route, are hardly ever encountered in everyday German language. Still finding an effect of whole-word frequency suggests that the whole-word form is, despite its unfavourable frequency distribution relative to the frequency distribution of constituents, of special importance for the lexical access process. Simultaneously, effects of first-constituent frequency, family frequency of modifier and head on gaze durations of whole compound are observed. These effects imply a decompositional processing via the constituents. In sum, frequency effects suggest an involvement of both whole-word form and constituent access units.

Interestingly, gaze duration on the whole compound is affected by whole-compound length. However, constituent length does not matter. This confirms previous results that the sum of both constituents influences compound processing but not each constituent individually (Hyönä & Pollatsek, 1998). Such observation is in favour of a whole-word access route and implies that dual-route models need to consider word length as a factor influencing lexical access (see also Bertram & Hyönä, 2003).

The frequency and length effects on gaze duration for the first constituent (subgaze_1) replicate the gaze-duration findings for the whole compound. This conforms well to approaches which predict constituent and whole-word form effects. An outstanding result, at first sight, is that subgaze_1 is influenced by second constituent length in a reverse manner: the longer the second constituent, the shorter the subgaze_1, and vice versa. We assume that parafoveal-on-foveal effects occurred here during initial-constituent reading. The foveal processing of the first constituent is influenced by parafoveal preview of the second constituent (for parafoveal-on-foveal effects see Kennedy, Pynte, & Ducrot, 2002; Kliegl, Nuthmann, & Engbert, 2006). Subgaze$_1$ is also affected by whole-compound length. Findings of whole-compound and constituent length effects fit well into the dual-route framework.

Although we did not focus on parafoveal processing, our findings confirm both parafoveal-on-foveal and parafoveal preview benefit effects. Subgaze$_1$ measures provide evidence for parafoveal-on-foveal effects; effects of second-constituent length on gaze duration of the second constituent (subgaze$_2$) provide evidence for a parafoveal-preview benefit (see Rayner, 1998; Balota & Rayner, 1983; Henderson & Ferreira, 1990). Orthographic or phonological information is “picked up” from processing based on parafoveally acquired information and thus facilitates subsequent foveal processing (Rayner, 1998). In this case, the acquired information may not just be processed at a visual level, but also at a lexical level, as suggested by the significant interaction between second-constituent frequency and second-constituent length.

An important question is how much these results depend on the type of the dependent variable and the task. In this experiment, participants decided on the semantic relationship between the target compound and the second word. It was our intention that participants read the stimuli for meaning, avoiding superficial reading influenced mainly by visual factors. However, word length was a significant predictor for the eye-tracking data. In order to investigate the relevance and generality of the determined predictors, we employed lexical decision times as the dependent measure in Experiments 2 and 3. Lexical decision times often show frequency effects. The task forces participants to strongly rely on lexical representations to figure out if they have encountered the presented stimulus before. Therefore, we hypothesized that visual effects such as length, should have less influence than lexical effects such as frequency.

Experiment 2: Lexical decision

Experiment 1 showed that gaze duration is also affected by low-level, visual factors, although a decision on semantic relatedness was required. Experiment 2, with lexical decision task, should predominantly show an impact of lexical factors such as frequency. Comparing the patterns of effects between Experiments 1 and 2 should reveal whether the type of dependent variable influences the predictors involved in compound processing.

Method

Participants.

Sixteen students of the Westfälische Wilhelms-University took part in the experiment. They received course credit or 10 € for participation. All participants had normal or corrected-to-normal vision and were native speakers of German.

Material and Procedure.

The same material as in Experiment 1 was used. We constructed 2154 pseudowords from the original compounds by changing the initial, medial or final phoneme in the first or second constituent (e.g., *Eidotter*, egg yolk → *Eudotter*). Compound words and pseudowords were equally distributed over two lists (pseudowords of list 1 were words in list 2; words in list 1 were pseudowords in list 2). So each list consisted of 2154 stimuli, half of them were compound words and half of them pseudowords. Each participant received one list which was further divided into eight blocks consisting of about 269 trials. The eight blocks were distributed over two sessions. Before each block started, the participants received 15 warming-up trials. Before the experiment proper, the eye-tracker was calibrated and validated. The fixation point had to be fixated before each trial started. After successful fixation the target compound appeared in the centre of the screen, 100 pixels (2.2°) to the right of the fixation point. Stimuli had the same font size as in Experiment 1. Participants made a lexical decision by pressing either the right button if the compound is a word or the left button if the stimulus is a pseudoword. Eye movements were recorded simultaneously.

Results

Data analysis procedure was the same as in Experiment 1. Wrong responses (9.2%) and reaction times longer than 1600 ms were removed from the data set. We examined the influence of the same set of predictors as previously: frequency and length of whole compound and constituents, semantic transparency and onset complexity of whole compound, family size and family frequency of modifier and head on lexical decision time. The average lexical decision time was 762 ms (SD: 185). The unstandardized coefficient means, standard errors and *t*-values for this analysis can be found in Table 5. In this analysis, five variables predicted significantly lexical decision times: whole-compound frequency, $t(15) = -15.2$, $p < .001$; first-constituent frequency, $t(15) = -4.4$, $p = .001$; first-constituent length, $t(15) = -2.3$, $p = .037$; semantic transparency, $t(15) = 4.9$, $p < .001$ and onset complexity, $t(15) = 4.2$, $p =$

.001. As before, higher frequency goes along with shorter lexical decision times. Interestingly, there are effects of semantic transparency, implying that lexical decision times on compounds increase with their semantic opacity. The more complex the onset of a stimulus compound, the larger the latencies. Factors such as length of compound and second constituent, second-constituent frequency or family size and family frequency of modifier and head had no significant impact in the lexical decision task. Simultaneously recorded eye movements show that participants looked at both constituents in 75.6% of the cases (first constituent only: 14.2%; second constituent only: 3.5%; no fixations: 6.6%). Participants always reacted after the compound or one of its constituent had been fixated.

Table 5: Estimates of mean unstandardized regression coefficients (B), standard errors (SE) and t – values of the predictors for lexical decision times (Exp. 2)

predictor variable	B	SE	*t*
lnfreqcomp	-16.7*	1.1	-15.2
lnfreqconst1	-6.1*	1.4	-4.4
lnfreqconst2	-1.1	.9	-1.3
lengthcomp	1.7	10.5	.2
lengthconst1	20.6*	9	2.3
lengthconst2	11.7	10.6	1.1
semantrans	7.3*	1.5	4.9
onscomp	12*	2.9	4.2
famsizem	-.1	.1	-.6
lnfamfreqm	1.3	1.5	.9
famsizeh	-.2	.1	-1.8
lnfamfreqh	-.2	1.8	-.1

Note. lnfreqcomp = logarithmized frequency of whole compound; lnfreqconst1 = logarithmized frequency of first constituent; lnfreqconst2 = logarithmized frequency of second constituent; lengthcomp = length of whole compound (no. of letters); lengthconst1 = length of first constituent (no. of letters); lengthconst2 = length of second constituent (no. of letters); semantrans = semantic transparency; onscomp = onset complexity of compound; famsizem = family size of modifier; lnfamfreqm = logarithmized family frequency of modifier; famsizeh = family size of head; lnfamfreqh = logarithmized family frequency of head.

* $p < .05$.

Discussion

In Experiment 2 we examined the influence of frequency and length of whole compound and its constituents, semantic transparency and onset complexity of the compound and family size and family frequency of modifier and head on lexical decision times. In contrast to Experiment 1, this experiment demonstrated that compound processing is sensitive to frequency, semantic transparency and onset complexity. Effects of word length were observed only for the first constituent.

Both a whole-compound frequency effect and a constituent-frequency effect on lexical decision times are arguments in favour of the dual route model, indicating a processing of compounds via their constituents and their whole-word form (Baayen et al. 1997; Baayen & Schreuder, 1999; Caramazza et al., 1988; Chialant & Caramazza, 1995; Schreuder & Baayen, 1997). As Experiment 1, these results can not be reconciled with the full-listing approach (Butterworth, 1983; Bybee, 1985).

The relationship between semantic opacity and lexical decision shows that an increasing opacity slows down lexical decision times. This indicates that compound processing is not independent from the semantic status. So, one may draw the conclusion that semantically opaque complex words are processed differently than semantically transparent complex words. At first sight, this seems to be consistent with findings from Marslen-Wilson et al.'s (1994). They suggest a processing of opaque complex words as whole-word forms, proposing that composition is restricted to semantically transparent words (Schreuder & Baayen, 1995). This interpretation is not supported by our data. Semantically opaque compounds provoke slower latencies. This does not support their processing as whole-word forms (Marslen-Wilson et al., 1994) because direct access to whole-word forms is proposed to be fast. Our data are consistent with the assumption that semantically transparent compounds and their constituents overlap in the set of (semantic) representations while no such overlap exists for opaque compounds (Schreuder & Baayen, 1995). These semantic representations feed back activation to lexical levels facilitating processing in case of a semantically transparent compound.

It is often found that onset complexity affects naming latencies (Balota et al., 2004; Kessler, Treiman, Mullenix, 2002, subm.; Spieler & Balota, 1997) and, to a smaller extent also lexical decision times (Balota et al., 2004). We observed that the more complex the onset, the longer the lexical decision time suggesting that phonological (and articulatory) processes are involved in lexical decision. Even the gaze durations registered during the lexical task ($t(15) = 3.186$, $p = .006$, B = 12.56, SE = 3.94) showed an influence of onset complexity. A phonologically complex word is often also orthographically (and visually) complex in German. Despite the sensitivity of the first experiment to visual factors (e.g., word length), no influence of onset complexity was evident in the first experiment. Either onset complexity was of no relevance for this task or there was no variance left for this predictor when it entered the regression analysis. Both options are possible. Length measures are correlated with onset complexity. So, when one of these intercorrelated predictors enters the regression equation no variance is left for the remaining. On the other hand, it is known that gaze durations are influenced by top-down mechanisms such as task requirements (see Underwood, Foulsham, van Loon, Humphreys, & Bloyce, 2006). At the moment, we do not have the means to tease these two options apart.

In sum, this experiment again supports assumptions as they have been formulated in dual-route models. Frequency effects of the whole-word as well as of the constituents, the main indicator of dual-route models, were observed. However, these results can also be reconciled with Taft's approach (2004), suggesting mandatory decomposition with the finding of base-frequency effects. Taft (2004) proposes that base-frequency effects arise at early processing stages whereas surface frequency effects emerge at the subsequent lemma level where stems and affixes are recombined. He suggests that surface (i.e. whole-compound) frequency or base (i.e. constituent) frequency effects in a lexical decision task are influenced by the type of pseudoword distractors. Taft observed standard base-frequency effects when using affixed pseudoword distractors having a pseudoword stem (e.g., *milphs*, *juxing*), whereas he found a surface frequency and a reverse base-frequency effect when using affixed pseudoword distractors having a real-word stem (e.g., *mirths*, *joying*). In Experiment 2, participants could quickly figure out if the presented compound is an existing word or not because one of the constituents was always a pseudoword. According to Taft, our effects results from our pseudowords. So, if we change our pseudoword distractors to non-existing compounds with existing constituents, one would expect effects of whole-word frequency and an absence of the standard base-frequency effect because the subsequent combinatorial stage is included. If a base frequency effect occurs, this will be reversed since the advantage of high-base frequency is counterbalanced by a disadvantage encountered at this subsequent combinatorial stage (Taft, 2004). This is going to be tested in Experiment 3. Keep in mind that we used German compounds which are right-headed and not affixed words as Taft did. Following Taft's argumentation, we assume that participants have to process the second constituent (the head) and combine it with the first constituent (the modifier) to determine whether a certain compound combination exists in German. So, if Taft's assumptions are valid we should observe a reversed second-constituent frequency effect. Taft and Ardasinski (2006) restrict this proposal to semantically transparent stimuli. Opaque words have a lemma representation of their own. They are not recombined at this level.

Experiment 3: Lexical decision with different pseudowords

Similar to Experiment 2, participants also had to decide whether a compound is an existing word or not. The data of Experiment 2 showed that lexical decision times are influenced by whole-compound and first-constituent frequency. The next experiment was set up to test the hypothesis whether the type of pseudoword distractors influences the effects of whole-compound or constituent frequency (Taft, 2004). We presented non-existing pseudo-compound distractors consisting of two existing constituents.

Method

Participants.

Sixteen students of the Westfälische Wilhelms-University took part in the experiment. They received course credit for participation. All participants had normal or corrected-to-normal vision and were native speakers of German.

Procedure.

The same material and apparatus as in Experiments 1 and 2 were used. Similar to Experiment 2 all 2154 compounds were transformed into pseudowords. The only difference to Experiment 2 was that the pseudowords were non-existing compounds consisting of two existing constituents, e.g., *Sahnetisch* (cream table). The procedure was the same as in Experiment 2.

Results

Data analysis procedure was the same as in Experiments 1 and 2. Reaction times longer than 1600 ms were removed from the data set. The amount of wrong responses was 23.8%, probably implying the difficulty of deciding whether the presented compound is an existing one or not. We examined the influence of the predictors: frequency and length of whole compound and its constituents, semantic transparency, onset complexity and family size and family frequency of modifier and head on lexical decision times. Based on the results of

Taft's study (2004), we predicted whole-compound frequency to be a significant frequency predictor. Standard-constituent frequency effects are supposedly not relevant because pseudoword compounds cause a decision on the subsequent combinatorial stage.

The average lexical decision time was 894 ms (SD: 220), about 130 ms longer than in Experiment 2. The unstandardized coefficient means, standard errors and *t*-values for this analysis can be found in Table 6. In this analysis, there were three variables that significantly predicted lexical decision time. These were whole-compound frequency, $t(15) = -13$, $p < .001$; second-constituent frequency, $t(15) = 4.9$, $p < .001$ and semantic transparency, $t(15) = 8.2$, $p < .001$. Again, higher compound frequency results in shorter lexical decision latencies. Interestingly, second-constituent frequency was also significant but in a reverse manner. The more frequent the second constituent, the longer the lexical decision times.

In order to test the proposal put forward by Taft and Ardasinski (2006) we computed a second regression analysis in which we added an interaction term of second-constituent frequency and semantic transparency to the set of significant predictors. However, the interaction did not prove to be significant ($t(15) < 1$).

The difference to Experiment 2 is that there are no significant effects of first-constituent frequency and no effect of onset complexity. Simultaneously recorded eye movements show that participants looked at both constituents in 82.7% of the cases (first constituent: 10.6%; second constituent: 5.4%; nothing: 1.4%). Again, participants always reacted after the compound or one of its constituent had been fixated.

Table 6: Estimates of mean unstandardized regression coefficients (B), standard errors (SE) and t – values of the predictors for lexical decision times (Exp.3)

predictor variable	B	SE	*t*
lnfreqcomp	-32.9*	2.6	-12.9
lnfreqconst1	1.4	2.5	.6
lnfreqconst2	9.7*	2	4.9
lengthcomp	13.1	10	1.3
lengthconst1	7.7	9.8	.8
lengthconst2	-.6	9.9	-.1
semantrans	13.3*	1.6	8.2
onscomp	-.9	4.6	-.2
famsizem	-.01	.1	-.1
lnfamfreqm	.9	2.8	.3
famsizeh	-.2	.1	-2.1
lnfamfreqh	-.6	2	-.3

Note. lnfreqcomp = logarithmized frequency of whole compound; lnfreqconst1 = logarithmized frequency of first constituent; lnfreqconst2 = logarithmized frequency of second constituent; lengthcomp = length of whole compound (no. of letters); lengthconst1 = length of first constituent (no. of letters); lengthconst2 = length of second constituent (no. of letters); semantrans = semantic transparency; onscomp = onset complexity of compound; famsizem = family size of modifier; lnfamfreqm = logarithmized family frequency of modifier; famsizeh = family size of head; lnfamfreqh = logarithmized family frequency of head.

* $p < .05$.

Discussion

In Experiment 3 we examined the influence of the variables frequency and length for whole compound and constituents, semantic transparency, onset complexity, family size and family frequency for modifier and head on lexical decision times. We designed our pseudowords so that the subsequent combinatorial stage is involved in deciding about the lexical status of the stimulus. Consistent with our expectations, lexical decision times were influenced by whole-compound frequency and second-constituent frequency in a reversed manner. Thus, the type of pseudoword distractors has an impact on the type of frequency effect (Taft, 2004). We assumed, along the lines of Taft (2004) that the whole-compound frequency effect originates from an involvement of the subsequent combinatorial stage, where the two pseudoword constituents, e.g., *Sahne* (cream) and *Tisch* (table), have to be recombined. It is a reversed head-frequency effect because we used German right-headed compounds and not suffixed words in which an affix is attached to a base. The underlying principle is, however, the same. So, when the combinatorial stage is important for discriminating words from the pseudowords, the advantage and therefore easier access of high frequency words is counterbalanced (Taft, 2004).

Taft and Ardasinski (2006) limit the reversed base frequency effect to semantically transparent words. Semantically opaque words have a lemma of their own, thus they do not require any additional combinatorial processing. They should not show reversed base frequency effects as Taft and Ardasinski observed. Thus, semantic transparency and second-constituent frequency should interact which they did not. We observed only a main effect of semantic transparency and frequency. We can therefore not support this proposal, but rather suggest that all complex words are decomposed irrespective of their degree of semantic transparency.

General Discussion

The article reports three experiments exploring the impact of twelve intercorrelated variables, i.e. frequency and length of whole compound and its constituents, semantic transparency and onset complexity of the compound, family size and family frequency of the modifier and the head, on compound word processing. The following key questions are addressed: 1) Which predictors have an impact on gaze durations and lexical decision times? 2) How does the type of task influence the relevance of the predictors? 3) Are there effects of the whole compound, the constituents or both?

1) All three experiments have been designed to investigate the influence of different predictors on the processing of 2154 German noun-noun compounds. In Experiment 1, we used a boundary technique and measured gaze durations on the compound and its constituents. When the participants crossed an invisible boundary, the compound was masked and the distractor appeared. Participants decided whether the target compound and the distractor word were semantically related or not. Results showed that gaze durations on the whole compound and each constituent were influenced by frequency, length and family frequency.

In Experiment 2 and Experiment 3, lexical decision times were employed as the dependent measure. In Experiment 2, pseudowords were constructed by altering one phoneme in the first or second constituent of a compound (e.g., *Kaffeetisch*, coffee table → *Kaffeemisch*, coffee *mable*). In Experiment 3, pseudowords were constructed by combing existing compound constituents into a new compound (e.g., *Sahnetisch*, cream table). This was done to trigger two different processing strategies: 1) the whole compound or 2) a compound constituent has to be considered for the lexical decision.

Results of Experiment 2 revealed that lexical decision times were influenced mainly by frequency, semantic transparency and onset complexity. Experiment 3 roughly replicated the results of Experiment 2. But the two experiments differed in the type of the frequency effects. There was a reverse second-constituent frequency effect in Experiment 3 which was induced by the different make-up of the pseudoword-compound (Taft, 2004). In addition, the role of predictors such as constituent frequency, length of whole compound and its constituents, semantic transparency and onset complexity of the compound, family size and family frequency of the modifier and the head, varied in the different experiments. Summarizing, gaze durations and lexical decision latencies were explained by different combinations of predictors. This suggests that theses measures reflect various lexical access processes to different proportions.

One predictor outshines the others. Word frequency is the predictor which was significant across tasks supporting the importance of this factor for compound processing. In particular, whole-compound frequency predicted gaze durations (Exp. 1) as well as lexical decision times (Exp. 2 & Exp. 3), presumably demonstrating that both tasks, eye-tracking and lexical decision, respond to a processing stage where word frequency is of high relevance. We will address the role of this particular predictor below after discussing the differences of gaze durations and lexical decisions.

2) Gaze durations in eye-tracking and reaction times in lexical decision are explained by different sets of predictors, apparently reflecting different proportions of the lexical access process. One reason could be the manner in which the two dependent measures are registered. Gaze durations are measured while the compound is being read. So, eye-tracking addresses the reading process itself and may be a sensitive measurement for effects of momentary processing (Rayner, 1998) thereby reflecting mainly early processes of compound processing. This interpretation is supported by significant word length effects that showed up in gaze durations but not in lexical decision latencies. These effects were evident despite a semantic relatedness decision task, which was intended to enforce encoding up to the conceptual level. So, compound processing registered with gaze durations is sensitive to visual principles such as length and not just lexical principles such as frequency. Later effects such as semantic transparency do not yet show up despite the requested semantic decision.

Gaze durations are too fast to be influenced by semantic transparency effects. This corroborates previous findings from other eye-tracking studies (e.g., Pollatsek & Hyönä, 2005; for lexical decision Zwitserlood, 1994). So, if we use semantic transparency effects as a reflection of semantic processing, early processing stages are uninfluenced by semantics. This suggests that semantically transparent and intransparent compounds are treated equally during early processing. We will see below that semantic transparency comes into play in later processes.

Our findings are consistent with assumptions of a combinatorial impact of frequency and length in eye-tracking research (Hyönä et al., 2004; Hyönä & Pollatsek, 1998). Bertram and Hyönä (2003) suggested that long compounds are decomposed for lexical access while short compounds are processed as a whole. Thus, length is one of the factors influencing the parsing into morphemic units and needs to be controlled in investigations on compound processing. Unfortunately, neither our data nor Bertram and Hyönä (2003) propose a critical word length at which a compound is decomposed.

We could also show that frequency and length are not simply additive effects but rather interact with each other. This implies that short (long) words with a low (high) word frequency are looked at longer (shorter) than one could expect from adding their length and frequency effects. It seems to be the case that one looks longer at a short word than at a long word if the long word's frequency is high. Again, we can not propose a critical boundary at which one could observe faster processing of long words compared to short words. At least one observation we made will facilitate further experiments. Experiment 1 showed that length and frequency effects can be observed using single word presentation. A sentence context, that was often implemented, is not needed. Thus, not only material selection is easier, but also sentence context effects must not be controlled.

In addition to the length factor, support for eye-tracking as a measurement of early processes results from our reliable effects of family frequency of modifier and head on gaze durations. These effects imply that access to the lexical representations occurs via the modifier and the head morpheme (Burani & Caramazza, 1987; Colé et al., 1989), arguing for morphological decomposition. These predictors represent morphological access effects, apparently reflecting even earlier access variables than word frequency. This is supported by no influences of family frequency of head and modifier in lexical decision. Access variables such as length, except a small effect of first-constituent length, and family frequency are no longer visible in the lexical decision latencies. Notice that lexical decision latencies (Exp. 2: 762 ms; Exp. 3: 894 ms) are longer than gaze durations (Exp. 1: 419 ms; Lima & Pollatsek, 1983; Taft, 2004). Thus, they might be influenced to a greater degree by later processes than gaze durations. Lexical decision times are not tracked online as gaze duration while the compound is being read. Participants read the target compound (which simultaneously recorded eye movements show) before they reacted. So, lexical decision times represent a mixture of processes which took place before the participant decided on the lexical status. In this sense, lexical decision is rather a global, "late" measure. This does not imply that a factor, such as length, was not involved in the lexical access process. Rather, lexical decision emphasizes processing stages where frequency-based information of the whole compound and each constituent becomes evident. Early effects are "washed" out.

In contrast to gaze durations, we observe semantic transparency effects in lexical decision. This suggests an involvement of semantic information, which is assumed to be available after lexical access has taken place. We could show that an increasing semantic opacity slows down lexical decision latencies (Exp. 2 & Exp. 3). Although this indicates that the semantic status of compounds is involved during processing, it does not necessarily indicate that semantically opaque words are processed as whole-word forms (Marslen-Wilson et al., 1994; Schreuder & Baayen, 1995) and that only semantically transparent words are decomposed. Considering semantic transparency as a semantic information available after lexical access, our data are consistent with assumptions of an additional conceptual "boost" for transparent words than for intransparent words (Schreuder & Baayen, 1995). So, hardly any activation from the semantic representation of the concept of an intransparent compound as for instance *butterfly* flows back to its constituents *butter* and *fly*, which in turn have no connections to the semantic representation of *butterfly*. Thus, due to this lack of additional activation, the processing of compounds with an increasing semantic opacity is slowed down relative to transparent compounds.

A further variable that slows down lexical decision latencies is onset complexity which is only relevant for lexical decision latencies of Experiment 2. According to our argumentation so far, one would consider onset complexity as a rather early process, implying grapheme to phoneme assignment as, for instance, in a naming task (Balota et al., 2004; Kessler et al., 2002, subm.; Spieler & Balota, 1997). However, if onset complexity indicates early processes, why can this effect not be observed in gaze durations? It is also not specific for lexical decision. Onset complexity does not predict lexical decision latencies in Experiment 3. It is only relevant for manipulations of Experiment 2. Thus, we propose that this lexical decision in combination with the type of pseudowords in Experiment 2, where phonemes of either the first or second constituent are changed, seems to induce participants to search for phonological irregularities in the stimulus material in order to make their decision. In this case, phonological variables influence this decision. Since onset complexity is the only phonological variable we use, this significantly predicts lexical decision in Experiment 2. Furthermore, it seems plausible that both semantic transparency (also occuring at the even longer decision latencies of Experiment 3) and onset complexity (only Exp. 2) are relevant for the lexical decision task of each experiment. But alternatively, since length, a variable of high importance in eye-tracking, is not an issue in lexical decision, more variance is left for semantic transparency and onset complexity.

However, word frequency is the most robust finding in all of our experiments (e.g., Monsell, Doyle, & Haggard, 1989), showing that both gaze durations and lexical decision latencies reflect processes of lexical access, where frequency information is involved. There is no question that both tasks reflect lexical access processes, but they present different proportions of this process from different time perspectives as they explain different sets of predictors. As mentioned above, whole-compound frequency predicts gaze durations (Exp. 1) and lexical decision latencies (Exp. 2 & Exp. 3), supporting assumptions of a holistic processing. Given that there are only 6 cases (0.3%) of our material where the whole-compound's frequency is higher than its constituents' frequency, it seems surprisingly unconvincing that the whole-word form is of such major importance for the lexical access of compounds. Thus, we propose that every compound, irrespective of the frequency relationship between the whole compound and its constituents, is tried to be accessed first via whole-word access units. Still, the finding of constituent-frequency effects favours the assumption of a decompositional processing. Thus, on the basis of these results we are able to support models which propose the processing of compounds via whole-word access units prior to morphemic ones (Baayen & Schreuder, 1999; Baayen et al., 1997; Caramazza et al., 1988; Caramazza, 1997; Chialant & Caramazza, 1995; Laudanna et al., 1997; Schreuder & Baayen, 1995; Taft, 1994, 2004; Taft & Ardasinski, 2006).

3) If compounds were treated similar to monomorphemic words, gaze duration and lexical decision times should reveal whole-compound effects only which is not the case in any of our experiments. Our data clearly contradict the full-listing approach (Butterworth, 1983; Bybee, 1985). The results of all experiments show that compound processing is sensitive to whole-word and constituent effects (e.g., frequency or length), which proposes a processing of compounds via a whole-word and a decompositional route as assumed by the dual-route models, AAM (Caramazza et al., 1988; Chialant & Caramazza, 1995; Laudanna et al., 1997) and MRM (Baayen & Schreuder, 1999; Baayen et al., 1997; Schreuder & Baayen, 1995). Other predictors such as semantic transparency (Laudanna et al., 1997) are also proposed by both models to influence the processing of complex words. While the models seemed to be different in their descriptions at first, the differences disappeared in later formulations. This makes it difficult to distinguish between and to refuse any of these models.

Furthermore, although our data are conform with assumptions of the dual-route approach, they also seem to be consistent with Taft's (2004) obligatory decompositional model (Taft & Ardasinski, 2006). He argues for both surface, base and reversed base frequency effects in lexical decision (Exp. 2 and Exp. 3) depending on the type of pseudoword distractors. However, although Taft (2004) does not exclude opaque words from decomposition, Taft and Ardasinski (2006) restrict the reverse base frequency effect to semantically transparent words. An interaction between semantic transparency and second constituent frequency would have indicated the difference between transparent and opaque words. However, there was no interaction. Semantically opaque words also showed a reversed second-constituent frequency effect, proposing that these words also necessitate a combinatorial processing. This implies that semantically opaque words behave as semantically transparent words (Zwitserlood, 1994; Libben et al., 2003) and are decomposed as semantically transparent words. Based on our results, we favour the assumptions of a whole word and a decompositional processing as embedded in the dual-route framework so far.

Proposing a processing via the decompositional route, one would expect effects of both first and second constituents at the same time. This is not the case in any of our experiments. In the eye-tracking experiment (Exp. 1) as well as the lexical decision experiment (Exp. 2), we find effects of first-constituent frequency on gaze duration of the whole compound and the first constituent and lexical decision latencies. Effects of second-constituent frequency (but reversed) were only significant for lexical decision times in Experiment 3. The importance of a morphemic constituent in the first position has been emphasized in various eye-tracking (Beauvillain, 1996; Bertram & Hyönä, 2003; Hyönä et al., 2004; Niswander et al., 2000) and lexical decision studies (Kehayia, Jarema, Tsapkini, Perlak, Ralli, & Kadzielawa, 1999; Lima & Pollatsek, 1983; Taft & Forster, 1976; for auditory processing see Isel, Gunter, & Friederici, 2003), implying that fixation durations and lexical decision times are affected by the frequency of the first morphological element. Effects of the second morphemic unit are not so well-established. To our knowledge, only the study from Pollatsek et al. (2000) could show effects of second-constituent frequency on gaze duration. This effect was yielded in very late processing stages, proved by a clear effect on a third fixation probability (for second constituent effects in lexical decision see Juhasz et al., 2003).

In sum, the major intention of the present article is to point out that 1) there are several predictors involved in the processing of compounds, 2) these predictors are influenced by task settings and 3) whole-word as well as constituent morphemes are involved in the lexical processing of compounds. The employment of both eye-tracking and lexical decision allows for an appropriate testing of models of morphological processing as well as showing different proportions of the lexical access process. Despite some differences, our research shows a consistent effect of the factor frequency irrespective of the type of measurement, stressing again its importance in processes of lexical access.

EFFECTS OF REFERENTIAL AMBIGUITY, TIME CONSTRAINTS AND ADDRESSEE ORIENTATION ON THE PRODUCTION OF MORPHOLOGICALLY COMPLEX WORDS

CHAPTER 3

Abstract

In five experiments, participants were asked to describe unambiguously a target picture in a picture-picture paradigm. In the same-category condition, targets (e.g., water bucket), and distractors (e.g., ice bucket) had identical names if named morphologically simple, creating lexical ambiguity which could be resolved by compound use (e.g., water bucket). The preferred name for the target and distractor picture was morphologically simple (e.g., bucket). Simple names sufficed as specification means in other conditions, with distractors identical to the target, completely unrelated, or geometric figures. If the principles formulated by Levelt (1989) are obeyed, compound answers should be predominant when a same-category distractor is present. Results showed that the principles are violated in the majority of cases. Additional processing time and a referential communication instruction increased the number of compound responses, but morphologically simple answers still prevailed. Further relaxation of time pressure, as well as naming both objects, resulted in ambiguity resolution.

Introduction

How do we refer to objects in our surroundings in an adequate way? Consider a request to pass a bottle of red wine when two types are available, red and white. For cooperative communication, speakers should refer to the desired bottle in a sufficiently distinctive manner, but with no more detail than is necessary. The request, “could you please pass me the red wine?”, definitely suffices, while “could you please pass me the 1996 Ghemme?” is, arguably, more informative than necessary. On the other hand, “could you please pass me the wine?” is underspecified. In the first case, the speaker provides sufficient information to identify the object uniquely (cf. Maxim of Quantity, Grice, 1975) while in the second, more information is given than needed. The third request is underspecified; there is not enough information to uniquely identify what is requested. In the best of all worlds, a speaker’s lexical choice should be guided by the principles of informational adequacy (Engelhardt, Bailey & Ferreira, 2006).

The focus of this research is on one aspect of informational adequacy, namely how lexical choice is accomplished when naming one of two objects. We were interested in compounding, a means of lexical specification which is quite common in German. German is a morphologically rich language, replete with compounds, and novel ones (e.g., *Parkschwein*, lit: parking pig, i.e. someone whose parking hinders others) can frequently be encountered. We selected our target and distractor pictures such that the morphologically simple name was the preferred one. By this, we created an ambiguity when target and distractor objects were from the same category: two buckets, or two flutes. This lexical ambiguity in situations of conceptual similarity can be resolved by using compound words (e.g., saying “*milk bucket*” in the presence of an ice bucket). In control conditions, target objects could be differentiated from the distractor objects by use of their preferred morphologically simple names (e.g., naming the object milk bucket “*bucket*” when presented next to an image of a flute). In other cases, target and distractor objects could be unambiguously differentiated by using compound words (e.g., naming it “*milk bucket*” in the presence of an ice bucket).

We thus investigated under which conditions lexical choice might result in lexical ambiguity, how this lexical ambiguity is detected and avoided by specification through compound use. If lexical ambiguity is indeed detected, compounds should be used whenever same-category distractors are present. Because the detection of lexical ambiguity requires the linguistic encoding of both pictures down to the word-form level, a process that might take time, we also manipulated the temporal availability of the objects on the display, as well as the arrival time of the cue as to which picture serves as target on a given trial. Finally, given that the degree of specification may well depend on the outside pressure, we varied the communicative context, by means of the absence or presence of an addressee.

To anticipate, despite timing manipulations and referential communication instructions, participants were quite reluctant to use names other than the preferred ones, even at the cost of being referentially ambiguous. Before describing the details of our experiments, we provide some background with respect to theory and data concerning factors influencing the explicitness of reference and lexical choice relevant to the issues addressed here. Note that there is no unitary theoretical approach to explicitness of reference in language production. This is because the topic straddles a number of fields, ranging from perspective taking, conversation, (referential) communication, to language production.

Explicitness of reference and lexical choice

Speakers show an enormous variability in their lexical choice. Furnass, Landauer, Gomez, and Dumais (1983, 1987) denote this variability as the *vocabulary problem.* They report that people use *remove, delete, erase, kill, omit, destroy, lose, change* or *trash* as a command for removing a file (see Hermann & Deutsch, 1976 for similar observations with object descriptions). Speakers often provide more information than necessary (Dale & Reiter, 1995; Eikmeyer & Ahlsén, 1998; Hermann & Deutsch, 1976; Hermann & Grabowski, 1994; Mangold & Pobel,1988; Pechmann, 1984; Sonnenschein, 1982; Zhu, 1995). Still, not all alternatives are chosen equally often. Factors influencing the choice of names for objects are (1) the category typicality of objects, (2) the situational context (which other objects are present?), (3) the type of ambiguity (conceptual or lexical), and (4) the communicative context in which a description is given.

With respect to typicality, Rosch, Mervis, Gray, Johnson and Boyes-Braem (1976) showed that speakers prefer basic-level terms in neutral contexts (e.g., *bird, dog, tree*). This is different for atypical category objects. The subordinate-level term *penguin* will be preferred over *bird* even in the context of unrelated objects, in which *bird* would be sufficiently specific (Jolicoeur, Gluck & Kosslyn, 1984). Note that our stimuli were preferably named with the basic-level terms.

Speakers also use exophoric overspecifications, such as referring to a small green cup with "*small green cup"* in the presence of a small blue and a large red cup. This type of overspecification involves salient features (such as colour or size), taking into account the distribution of these features in the situational context (Hermann & Deutsch, 1976; Hermann & Grabowski, 1994). Another means of overspecification is the use of a superfluous prepositional phrase (e.g., "*the apple that is on the towel*", Engelhardt et al., 2006; Pechmann, 1984). Mangold and Pobel (1988) suggest that speakers use referential overspecifications in order to help listeners with object identification (this interpretation may also hold for the subordinate-level names). It was indeed shown that listeners can identify objects more easily when the referent is overspecified (Sonnenschein, 1982).

The situational context - also manipulated in our study - is another important factor influencing lexical choice, given that "*a word specifies a perceived referent relative to a set of alternatives*" (Olson, 1970, p. 265). Speakers might refer to a *BMW Mini Cooper* with *vehicle*, *car,* or *Mini*, depending on the situational context. In the presence of unrelated objects such as a house and a tree, all three terms uniquely identify the object. If a car of a different brand is present, speakers should use the subordinate-level name *Mini* (or the brand name *BMW*). Jescheniak, Hantsch, and Schriefers (2005) showed an effect of constraining situational context on lexical choice, competing category members served as context (e.g., target = rose, distractors = tulip) on lexical choice. Subordinate-level naming, which was preferred for these items, occurred more often when another category member was present than with unrelated objects. Note that the ambiguity - for the speaker and the potential listener - arising in such situational contexts is at a conceptual level, and that the appropriate lexical choice serves to disambiguate the objects present.

Ferreira, Slevc and Rogers (2005) found similar effects in conditions of conceptual ambiguity (distinguishing small and large bats). A completely different pattern arose for linguistic or lexical ambiguity, when two objects - one of which was the target - had a homophonic reference (e.g., flying mammal *bat*, baseball *bat*). Interestingly, speakers produced many bare homophones in this condition, where disambiguation could only be achieved by using a specific term (*baseball bat*). Ferreira et al. thus observed underspecification in object naming, for which there is far less empirical evidence than for overspecification.

It thus seems much easier to detect conceptual ambiguity than lexical ambiguity. When objects are conceptually ambiguous, commonalities between distractor and target, be it in terms of perceptual similarities, semantic or featural overlap, are easily noted. Consequently, this conceptual information arrives early enough to guide lexical choice and thereby prevent ambiguous answers. This is not so for lexical ambiguity. Probably, speakers notice the ambiguity through monitoring, so that it can only be "repaired" at a later stage. This might explain why so many underspecified utterances were observed for homophones. We also investigated lexical ambiguity, but contrary to the homophonic cases used by Ferreira et al., our objects are subordinate members (milk bucket, ice bucket) of the same basic-level category (bucket), and both are preferably named at this basic level.

A final factor important to lexical choice is the communicative context of the utterance. Is there an addressee present, and if so, who? When speakers address an imagined or a real listener, expressions are usually longer, less figurative and less diverse than when generating messages for their own use (Fussell & Krauss, 1989; Krauss & Fussell, 1991). Ferreira et al. (2005) obtained overall fewer ambiguous answers with a real listener than with an imagined one. Speakers try to adapt their message to their listeners' knowledge level (Bromme, Jucks, & Wagner, 2005), and together with their addressees, they achieve a common understanding, and an agreement on object reference, by a process of "negotiation" (Brennan & Clark, 1996; Clark & Clark, 1979; Lockridge & Brennan, 2002). Clark and colleagues view language use as a collaborative action, aiming at achieving a common ground. In their view, speakers often opt for a provisional reference to an object, which is subsequently negotiated and decided upon in the ongoing communication with their interlocutors. It is assumed that speakers make " … a choice of categories because we have some reason for focusing on certain properties and downplaying other" (Lakoff & Johnson, 1989, p. 163). Speakers adopt various perspectives on the same object and use multiple words for the same referent. Consequently, perspectives are goal-driven (Clark, 1997). Especially, the degree of detail that a speaker uses determines what a listener considers as acceptable object reference (Jörg & Hörmann, 1978; Dubois & Dennis, 1988).

Negotiation of referential expressions between interlocutors was not an option for participants in the above-mentioned studies on lexical choice. The communicative context was manipulated by including real or imagined addressees - as is the case in our experiments reported below. These studies - and our own - thus all focus on provisional reference, which can, however, be more or less explicit depending on the referential context, and on whether or not there is an addressee.

Principles of specificity

What kind of provisional reference can or will the participants in our experiments provide? It is "… a convenient illusion in the picture naming literature that an object has a fixed name" (Levelt et al. 1999, pp. 9). In most picture-word interference experiments a fixed name is established by training the participants to elicit a specific response to a picture. So, the problem of lexical choice is circumvented by use of a learning procedure. But how is lexical choice achieved in other circumstances? The most articulated theoretical view on this issue comes from Levelt (1989). His starting point is the hyperonym problem. “When lemma A’s meaning entails lemma B’s meaning, B is a hyperonym of A. If A’s conceptual conditions are met, then B’s are necessarily also satisfied” (Levelt, 1989, pp. 201). If a speaker wants to express the concept BMW, all conceptual conditions of CAR are met simultaneously and CAR could be produced just as well. However, speakers do not use hyperonyms (Levelt et al., 1999) but rather the more specific term. Roelofs (1996) proposes a solution in terms of concept activation and thus delegates the problem of lexical choice to the conceptual level (cf. Stede, 1993, 2000).

Levelt (1989) describes three principles that help determining the proper lexical entry: 1) the uniqueness principle (no two lexical items have the exact same meaning, separating superordinate, basic-level, and subordinate terms), 2) the core principle (lexical retrieval only if the core meaning is satisfied) and 3) the specificity principle. The latter entails that of all items whose core conditions are satisfied by the concept, the most specific one is retrieved. This principle prevents the retrieval of CAR, when BMW is the concept. Levelt regards his principles as a specification of Grice’s maxim of quantity and concludes that “Lexical access, then, involves essentially recognizing the most entailing predicates in the concept and finding unique lemmas that have these as their core conditions” (Levelt, 1989, p. 214).

If Levelt’s principles apply in all situations, we should expect our participants to always produce the more specific term. We believe that providing a unique reference will be problematic in our special situation of subordinate-level concepts (e.g., a table spoon and a tea spoon) that are both preferably referred to with the basic-level term, *spoon*. To detect the ambiguity, both concepts, specified by means of pictures, have to be coded down to the lexical level. That both concepts activate the same word form as preferred reference will only become evident at the lexeme level. We thus expect that time will play an important role. Relaxing time pressure and providing addressee orientations might be necessary for unambiguous reference by means of compound words.

Note that our lexical ambiguity is of a different type than the ambiguity caused by homophones. With “morphological” ambiguity, the same word form is used to denote two subordinates of the same basic level, *spoon*, in the above example. The ambiguous word form thus maps onto shared meaning, and the ambiguity is resolved when a compound (*teaspoon*) is used to specify the target. Even then, the preferred simple name (*spoon*) as well as the compound names for both the target (*tea spoon*) and the distractor (*table spoon*) share the head morpheme. Again, this type of ambiguity, in terms of shared morphemes, is clearly different from the homophonic case (e.g., *bat*) tested by Ferreira et al. (2005). Homophonic ambiguity is detrimental for referential success, because a single word form maps onto semantically completely unrelated concepts. With morphological ambiguity, the shared morpheme maps onto shared meaning, which facilitates name retrieval in picture-word interference (cf. Gumnior, Bölte, & Zwitserlood, 2006; Roelofs, 1996; Zwitserlood, Bölte & Dohmes, 2002).

Experimental considerations

Given that virtually nothing is known about the factors influencing lexical choice in situations of shared semantics and form, we set out to explore the conditions under which correct specification can be achieved. In the five experiments reported below, we varied (1) the time available before a cue signals the target, (2) the total time available for stimulus processing, (3) addressee orientation, and (4) the number of objects to be named. We started in Experiment 1 with timing parameter typical for picture-word interference experiments trying to stay as close as possible to the standard experimental situation usually established in language production research. If Levelt's principles generally apply, we expected that participants use more morphologically complex words in the categorical distractor condition than in the control conditions. Inspection time increased from Experiment 1 to Experiment 2. This additional time should provide more opportunity to inspect the display and to encode both concepts down to the lexeme level and thus to detect the ambiguity. From Experiment 3 onwards, we introduced an imagined addressee who was dependent on unambiguous reference. Given that perspective taking influences our lexical choice (Bromme et al., 2005; Fussell & Krauss, 1989; Krauss & Fussell, 1991), the number of morphologically complex answers should increase relative to that of Experiments 1 and 2. In Experiment 5, with lax timing, the distractor picture was named before the target, thus creating optimal opportunities for referential specificity. The main dependent measure was the percentage of compound use in critical and control conditions. Moreover, we measured eye-movements in all experiments, to assess the extent to which participants looked at one or both objects.

Experiment 1: Cue onset 200 ms

Method

Participants.

Forty-eight participants, mainly students of the University of Münster, took part in the experiment. They were either paid 3.00 € for their participation or received course-credits. All participants had normal or correct-to-normal vision and were native speakers of German.

Material.

Materials were selected in multi-phased procedure. First, we collected as many depictable noun-noun compounds as possible. We then searched for pairs of compounds that share the same head (e.g., *Mülleimer - trash can, Wassereimer - bucket*). Coloured photos for these 271 noun-noun compounds were taken from the Hemera Photo-Objects Vol I, II, & III collection, or from the internet (max. size 190 x 245 pixels). Picture background was white.

Three pre-tests served to select the final materials for the main experiment: name agreement offline, name agreement online, and category naming. There were 33 participants in the offline name agreement test, another 15 in both the online test and the category naming test. All participants were from the same population as in the main experiment(s).

In the offline name agreement test, participants were asked to write down the word that described best the depicted object. This test served as an index of whether or not all pictures could be identified. Name agreement was acceptable for 254 pictures (mean agreement: 77%, SD: 21, range: 51%-100%). These 254 photos were further evaluated in the online name agreement test. Pictures were presented as follows. A fixation cross appeared for 250 ms on a computer screen, directly followed by the picture, which was presented for 400 ms. Time-out was set to 1500 ms. Participants were asked to name the picture as quickly as possible. The category-naming test was administered subsequently with target-distractors pairs appearing on the computer screen. The rationale for this test was to validate our intuitions about the shared category membership. Participants were asked to produce the shared basic-level term (coinciding with the category name) using the same procedure as in the online name agreement task. This turned out not to hold for some pairs, e.g., *fish hook - coat hook*[5].

---

[5] These are English translations of the German material. Please notice that sometimes the morphological relatedness is lost in the English translation.

Based on the results of the latter two pre-tests, we selected 40 pictures as targets such that the preferred names for the target pictures were predominantly morphologically simple (mean: 77%, SD: 13) and that the target-distractor pairs belonged to the same category (mean: 95%, SD: 7, range: 73% - 100%). The preferred name for the distractor objects was also morphologically simple (mean 71%, SD: 23), creating referential ambiguity in target naming that can be solved by compound use.

The 40 target pictures (e.g., *Wassereimer - bucket*) were combined with four distractor types: same-category distractors (*Mülleimer - trash can*) in the ambiguous condition, unrelated distractor pictures with monomorphemic names (*Flöte* - flute*)*, geometric figures (*triangle, rectangle, square, circle, pentagon, hexagon, ellipsis,* or *trapezium*), or the identical pictures (*Wassereimer - bucket*). The latter three conditions did not create ambiguity and thus served as baselines. We expected that participants would predominantly use morphologically simple names to refer to the target object in these conditions. If ambiguity is detected, morphologically complex answers should occur more often with a same-category distractor.

Target-distractor pairs were distributed over four lists such that each participant saw each target once, ten targets in each of the four distractor conditions. Across lists, each target appeared with each of its four distractors.

We added 98 filler trials to equally boost the production of both morphologically simple as well as morphologically complex responses. In order to diversify the type of naming, we added 8 geometric figures as targets with identical distractors (e.g., *triangle - triangle*), 10 targets with morphologically simple names, with identical distractors (e.g., *snake - snake*), 10 geometric figures as targets, paired with distractors with preferred morphologically complex names (e.g., *triangle - beer coaster*), 10 targets with morphologically simple names, with related distractors with preferred morphologically complex names (e.g., *cigarette -fridge*). We also added 20 targets with morphologically complex names, coupled with unrelated distractors with morphologically complex names (e.g., *ashtray - lady bird*), and 40 targets with preferred morphologically complex names, combined with unrelated, morphologically simple distractors (e.g., *slot machine - lens*) to boost the production of morphologically complex answers. Ten warm-up trials preceded the experimental trials proper.

Apparatus.

Pictures were presented centered on a 21-inch Samsung SyncMaster 1100p plus monitor (1024 x 768 pixel, frame rate: 85 Hz) controlled by a Dell-Dimension 4200 IBM-compatible PC. Participants were seated approximately 60 cm from the monitor. Eye-movements were recorded with the help of an Eyelink II eyetracker (SR Research), with a sampling rate of 500 Hz and an eye position resolution of less than 0.5°. The eye-tracker was controlled by a Dell-OptiPlex 280. Naming latencies were recorded with a voice key.

Procedure.

Participants were tested individually in a quiet room and assigned randomly to one of four lists. They were given a written instruction explaining the trial structure and the task: name the target picture as quickly and accurately as possible with one word. By the instruction, speakers knew that “the left bucket” or “the grey bucket” were not allowed as responses. We did not place emphasis on using morphologically complex words.

The trial structure was as follows: A fixation point, centred in the middle of the screen, indicated a new trial. Successful fixation (measured by the eye-tracker) of this fixation point started the trial and two pictures replaced the fixation point, either one left and one right of the fixation point (160 pixels left or right of the screen centre) or one above and one below the fixation point (150 pixels above or below the screen centre). The four target positions made it more difficult to predict the target. An arrow appeared 200 ms after picture onset, indicating the picture the participants had to name. Pictures and arrow remained visible for 400 ms. Then a blank screen was presented for 1100 ms. Reaction times were measured for 1600 ms from picture onset.

The eye-tracker was calibrated and validated before the experiment proper, using a nine-point calibration type (HV9). Drift correction was performed at the beginning of each trial, using the fixation point presented in screen centre at trial begin.

Results

Wrong answers and voice-key triggers by non-speech sounds were excluded from the statistical analyses. The total number of morphologically complex answers was very low (see Table 1). There were only 148 or 8.8% morphologically complex answers overall. However, as expected, most of these morphologically complex answers (3.7% overall) occurred in the same-category condition (*Wassereimer - Mülleimer*). The number of complex answers in this condition (62 or 15% of the within-condition responses) differed reliably from that of the three baseline conditions ($\chi^2(3) = 25.5$, $p < .001$; standardized residuals: geometric figure: -.9, identical: -1.4, unrelated: -1.9, same-category: 4.1)[6]. Note that some complex answers were expected in all conditions, since the simple-name preference was not 100%. In the identical condition participants were allowed to make "ambiguous" responses, since they have no choice to make unambiguous responses (such as "the left ice bucket"). We did not analyse naming latencies, due to the low number of morphologically complex answers (for means see Table 3).

---

[6] Paired t-tests confirmed the chi²-results that there were more morphologically complex answers in the categorically related distractor condition than in any other condition ($t(47) = -3.2$, $p = .002$; $t(47) = -3.7$, $p = .001$; $t(47) = -3.5$, $p = .001$; geometric figure, identical, unrelated respectively). We used arcsin transformed proportions as dependent variable.

Table 1: Experiment 1 – 5: Percentages and frequency (in parentheses) of morphologically complex and simple naming responses as a function of Distractor Type

		morphologically simple response	morphologically complex response
Experiment 1			
	geometric figure	23.4 (392)	1.9 (32)
	identical	23.6 (396)	1.7 (29)
	unrelated	23.0 (385)	1.5 (25)
	same-category	21.2 (356)	3.7 (62)
Experiment 2			
	geometric figure	22.5 (389)	2.3 (39)
	identical	22.6 (390)	2.8 (49)
	unrelated	22.3 (385)	2.3 (40)
	same-category	20.2 (350)	5.0 (87)
Experiment 3			
	geometric figure	22.8 (381)	2.8 (47)
	identical	22.2 (371)	3.3 (55)
	unrelated	22.2 (371)	3.2 (53)
	same-category	13.3 (223)	10.2 (170)
Experiment 4			
	unrelated	48.7 (333)	3.4 (23)
	same-category	16.4 (112)	31.6 (216)
Experiment 5			
	unrelated	39.6 (247)	8.7 (54)
	same-category	10.6 (66)	41.2 (257)

We checked whether the pattern of eye fixations gave some indication as to why such a low number of morphologically complex answers was observed (see Table 2). Morphologically complex answers were given independently of whether participants looked at one or both objects, but on most trials, participants looked at one object only (57%). If participants need to fixate both objects to detect and resolve the ambiguity, and to overcome subsequently the preferred, morphologically simple name, they had little chance to do so in about half of the trials.

Notice that participants did not avoid morphologically complex answers per se. They predominantly produced them in the filler conditions where the preferred target names were compounds: morphologically complex - simple (*slot machine* - *lens*: 87.4%) and morphologically complex - complex (*ashtray* - *lady bird*: 84.3%).

Table 2: Experiment 1 – 5: Frequency of object fixations in the same-category condition, broken down by morphological complexity of target naming response

		morphologically simple response	morphologically complex response	
Experiment 1				
	one object	199	32	231 (56.8%)
	two objects	146	30	176 (43.2%)
		345 (84.8%)	62 (15.2%)	
Experiment 2				
	one object	131	27	158 (36.5%)
	two objects	216	59	275 (63.5%)
		347 (80.1%)	86 (19.9%)	
Experiment 3				
	one object	89	33	122 (32.3%)
	two objects	124	132	256 (67.7%)
		213 (56.3%)	165 (43.7%)	
Experiment 4				
	one object	22	39	61 (18.7%)
	two objects	88	177	265 (81.3%)
		110 (33.7%)	216 (66.3%)	
Experiment 5				
	one object	2	12	14 (4.4%)
	two objects	64	243	307 (95.6%)
		66 (20.6%)	255 (79.4%)	

Note: The frequencies given here do not add up to the cell frequencies in Table 1. Sometimes participants did not fixate an object although they named it.

Table 3: Experiment 1 – 4: Mean naming latencies in ms (measured from cue-onset) for morphologically complex and simple responses, and standard-deviations (in parentheses), by Distractor Type

		morphologically simple response	morphologically complex response
Experiment 1			
	geometric figure	856 (235)	963 (245)
	identical	713 (233)	931 (265)
	unrelated	873 (227)	1016 (222)
	same-category	836 (240)	909 (242)
Experiment 2			
	geometric figure	738 (242)	871 (296)
	identical	539 (235)	713 (286)
	unrelated	746 (234)	870 (274)
	same-category	695 (243)	872 (293)
Experiment 3			
	geometric figure	790 (258)	863 (213)
	identical	672 (283)	753 (305)
	unrelated	820 (258)	862 (299)
	same-category	838 (282)	958 (302)
Experiment 4			
	unrelated	869 (298)	1042 (448)
	same-category	921 (451)	1203 (420)

Discussion

Contrary to the predictions by the principles summarised above, there were no more than 15% morphologically complex answers in the same-category condition. Participants still did describe many targets ambiguously, so clearly, there is little referential specificity here. Against the principle of specificity, participants predominately used hyperonyms contradicting Levelt et al.'s claim (1999). It is also in contrast with data suggesting that words with more complex features (more specific terms) are as easy to access as words with simple feature sets (Levelt, Schreuder, & Hoenkamp, 1978). Although more compounds were produced when same-category distractors are present than in all other conditions, it still holds that the object descriptions were underspecified in the vast majority of cases, given the situational context. It was not the case that participants avoided morphologically complex answers, because compounds were produced abundantly in filler conditions in which compound names were preferred over simple names. Note that in the identical condition participants were allowed to make "ambiguous" responses, since is does not matter which of the two identical objects is referred to.

Our results seem to be at odds with those by Jescheniak et al. (2005). The main reason for this discrepancy is that the name which disambiguated between the objects in their study was the preferred, subordinate name. A second important difference concerns the level of ambiguity, which was solely conceptual in Jescheniak et al.'s study (between two different objects with different names) and lexical – with conceptual similarity between the two objects – in Experiment 1. We surmise that conceptual ambiguity can be detected and remedied early during processing. Detecting a lexical ambiguity requires processing of target and distractor down to the level of lexical form. Most probably, the timing parameters used in Experiment 1, which are standard in picture naming with distractors, do not allow deep lexical processing of both pictures.

The eye fixations indicated that the time constraints induced by the procedure might have prevented participants from naming the target unambiguously. Of course, we know from our own and other data that it is not necessary to fixate a stimulus to identify it or even to retrieve its name (Dobel, Gumnior, Bölte, & Zwitserlood; 2007; Griffin, 2001; Morgan & Meyer, 2005). However, the particular processing and timing details under which a distractor object influences target processing, are still undetermined (Henderson & Ferreira, 2004; Irwin, 2004). To allow for deeper processing of both stimuli, we increased the SOA between cue and picture onset in Experiment 2.

Experiment 2: Cue onset 600 ms

We changed the SOA between picture onset and cue onset, increasing it from 200 ms to 600 ms. The prolonged SOA should enable the participants to process both pictures before naming the target. We hoped that the additional time would help the participants to detect the lexical ambiguity and to derive an unambiguous, and thus morphologically complex answer in the same-category condition.

Method

Participants.
A total of 48 participants selected from the same population as in Experiment 1 was tested. None had participated in Experiment 1.

Procedure.
The same material, apparatus and procedure as in Experiment 1 was used. The only difference to the previous experiment was that the cue signalling the target appeared 600 ms after picture onset instead of 200 ms.

Results

Data treatment was the same as in Experiment 1. We now registered overall 215 or 12.4% complex answer (see Table 1). As expected, most of the compound answers were observed in the same-category condition (87 or 5%; $\chi^2(3) = 30.9$, $p < .001$, standardized residuals: geometric figure: -1.9, identical: -.8, unrelated: -1.8, related: 4.4).[7] As before the number of complex answers in the category distractor condition is larger than that of the other conditions. We further calculated a one-way ANOVA using arcsin-transformed proportions as dependent variable and Experiment (1-5) as independent variable. Following this ANOVA, between-experiment contrasts of the number of responses in the category-distractor condition were calculated by means of Tukey’s HSD. This showed that the number of complex answers

---

[7] Paired t-tests with arcsin transformed proportions confirmed the chi²-results. There were more morphologically complex answers in the categorically related distractor condition than in any other condition ($t(47) = -3.8$, $p \leq .001$; $t(47) = -4.3$, $p \leq .001$; $t(47) = -4.1$, $p \leq .001$; geometric figure, identical, unrelated respectively).

of Experiment 1 and Experiment 2 did not differ from each other in this condition. Naming latencies were not analysed due to the low number of morphologically complex answers (the condition means are provided in Table 3).

The pattern of eye fixations in the same-category condition was different from Experiment 1. Participants used the extra time to make additional fixations. Now, they looked at both objects (64%) more often than at one object (36%). Thus, the additional time was often sufficient to fixate more than one object, however, it was not sufficient to detect and resolve the lexical ambiguity. When fixating both objects, no more than 21% of the answers were morphologically complex. This was just an increase of 4% compared to Experiment 1 (17%), an insignificant increase (see above Tukey HSD). So, even with more time to process both pictures before the cue appeared, participants still predominantly produced underspecified, ambiguous answers. A large number of morphologically complex answers was again found in the filler conditions, in which the preferred response was morphologically complex (*slot machine - lens*: 90.0%; *ashtray - lady bird*: 90.9%).

Discussion

Again, there is a small but reliable influence of a same-category distractor on the naming of the target picture. These distractors, sharing their preferred, simple name with the target, provoke more morphologically complex answers than identical and unrelated pictures or geometric figures. Compound answers were almost always observed when they constituted the preferred picture name (in the two relevant filler conditions). Thus, the additional time to inspect the pictures resulted in some increase of morphologically complex answers. But morphologically simple answers still outweigh complex ones. A possible reason is that time still does not suffice to detect and repair the ambiguity before the morphologically simple name is well on its way - a possibility that will be investigated in Experiments 4 and 5. Another possibility is that speakers' first reference is just not specific, even if they do detect the ambiguity. The fact that participants stick to their preferred descriptions even if this creates an ambiguity fits with the proposal made by Brennan and Clark (1996), who suggest that speakers initially often provide a provisional reference. Provisional references are subsequently developed and negotiated in an ongoing conversation.

There was no addressee, not even an imagined one, in our experiments so far (aside from the experimenter). Even if there is no ongoing conversation, speakers take into account whether their utterance is relevant to an addressee (Krauss & Fussell, 1991). It is apparently of little influence in object naming whether the addressee is sitting next to the speaker or is imagined

(Ferreira et al., 2005). We therefore introduced a fictive listener in Experiment 3. This manipulation should increase the number of unambiguous answers, reflected in an increase in morphologically complex answers in the related condition.

Experiment 3: Cue onset 600 ms + addressee perspective

Different from Experiment 1 and Experiment 2, participants now had to imagine an addressee, who had no cue information and had to select the target object from the display on the basis of their descriptions. This instruction implies that the speaker has to adopt the addressees' perspective to produce an appropriate answer, which was not required in the previous experiments. Taking the addressees' perspective should prime the speaker to the presence of an ambiguity and to resolve it. If the speaker uses the preferred, morphologically simple description in the same-category condition, the listener would not be able to identify the correct target object. Consequently, speakers should preferably use compound names instead of simple ones in this condition - at least, they should use more compounds than in Experiment 1 or Experiment 2.

Method

Participants.

A total of 48 participants, selected from the same population as before, took part in this experiment. None had participated in Experiment 1 or 2. Reward was the same as before.

Procedure.

We used the same timing and set-up as in Experiment 2. The instruction now included a referential communication task. Participants were told to name the target object as quickly and accurately as possible but in such a way that other participants, who had no arrow present on the display, could correctly identify the target object. Again, we did not explicitly stress the use of morphologically complex words. But we used morphologically complex examples in the written instruction (pictures of a beer glass and a wine glass → correct answer *beer gla*ss; pictures of a beer glass and a triangle → correct answer either *beer glass* or *glass*).

Results

Data treatment was the same as in Experiments 1 and 2. The number of compound answers was still too low to allow RT-analyses (means are provided in Table 3). Table 1 shows the number of morphologically complex and simple answers as a function of distractor type. In order to fully comply with the instruction, participants should have used compound descriptions throughout in the same-category condition, to allow the listener to unambiguously differentiate the two objects. Participants did so in 43.3% of these trials, which is the largest number obtained so far. Compared to Experiment 1 and Experiment 2, this was an increase of approximately 28% or 23%, respectively. This increase was significant ($p \leq .001$) as revealed by a Tukey HSD post-hoc test (see also Result Experiment 2). Thus, altering the instruction had the intended effect, although participants still produced more ambiguous than unambiguous answers in the critical condition.

The difference in the amount of complex answers between the same-category condition and all other conditions was significant ($\chi^2(3) = 186.47$, $p < .001$; standardized residuals: geometric figure: -4.0, identical: -3.1, unrelated: -3.2, related: 10.7)[8]. The number of complex answers in the relevant filler conditions was as before (*slot machine - len*s: 90.7%; *ashtray - lady bird*: 91.1%).

Overall, participants fixated both objects in 68% of the same-category trials. If they fixated both objects, they used morphologically complex names in 52% of the cases. Remember that in Experiment 2 participants fixated both objects in about 64% of the trials but produced morphologically complex answers only in 21% of these cases. Thus, although the overall number of morphologically complex answers in Experiment 3 might not seem impressive, the effect of the same-category distractors becomes clear when eye fixations are taken into consideration. Participants produce more complex answers.

Discussion

Our referential communication instruction clearly increased the number of complex answers in the same-category condition, although participants still produced more ambiguous than

---

[8] Paired t-tests with arcsin transformed proportions confirmed the chi²-results. There were more morphologically complex answers in the categorically related distractor condition than in any other condition ($t(47) = -8.6$, $p \leq .001$; $t(47) = -8.3$, $p \leq .001$; $t(47) = -8.9$, $p \leq .001$; geometric figure, identical, unrelated respectively).

unambiguous answers. The increase in the number of complex answers is particularly obvious if eye fixations are taken into account. But still, some processing limitations hinder participants from producing unambiguous answers in all relevant cases. One indication for such limitations concerns the fact that participants did not always fixate both objects. Even though fixations are not obligatory for object recognition (Dobel, Gumnior, Bölte & Zwitserlood, in press), the processing of both objects, all the way down to the lexical level at which the ambiguity can be detected, is a prerequisite for producing an unambiguous answer. The eye-fixation data indicate that if participants succeed in taking the whole scenario into account, they provide slightly more complex than simple answers. This also shows that the referential communication instruction was operative but that, perhaps, time pressure on processing was still too high to code both objects at a word-form level. Data from Meyer and colleagues (cf. Meyer, 2004, for an overview) and from Griffin (2001) indicate that speakers encode objects for naming in a highly incremental fashion. That is, the lexical information about a second object which - contrary to our situation - has to be named after the first is not available by the time the first name is sent on its way. We had hoped to change this incremental pattern by means of the addressee instruction. But it is possible that the incremental nature of processing cannot be changed by an explicit instruction such as addressee orientation. Meyer and collaborators also showed that it takes quite some time to fully process only one object, let alone to lexically encode a second one, to detect word-form ambiguity and to subsequently “repair” the initial, morphologically simple and preferred word-form choice for the target. We therefore tested the idea that time constraints prevented our participants from detecting the lexical ambiguity and overcoming their naming preference in favour of unambiguous, morphologically complex answers in Experiment 4.

Experiment 4: Cue onset 600 ms + addressee perspective + processing time

This experiment tested the hypothesis that time constraints hindered our participants from coming up with the appropriate name. We presented the stimulus display for maximally 5 seconds, instead of 400 ms after cue onset as it was implemented in the earlier experiments. The 5 sec. presentation time was similar to the timing parameters used in experiments on multiple-object naming (cf. Morgan & Meyer, 2005).

Method

Participants.

There were 20 new participants in this experiment, from the same population as before.

Material.

The number of distractor conditions and the timing of stimulus presentation were changed relative to Experiment 3. The first change reduced the number of distractor conditions to two. We only used the unrelated condition as a baseline, because none of the previous experiments showed any difference between the unrelated, identical, and geometric figure conditions with respect to the number of morphologically complex answers. The forty target pictures used in all previous experiments (e.g., *Wassereimer - bucket*) were combined with their same-category picture (*Mülleimer - trash can*) and an unrelated picture (*Flöte - flute*). The target pictures were distributed over two lists such that each target appeared only once on each list. Across lists, each target appeared with each distractor. We added 40 target-distractor fillers to each list: 20 targets with preferred simple names combined with complex distractors (e.g., *cassette - bicycle tyre*) and 20 complex - complex pairs (e.g., *airplane - ashtray*) with preferred compound names. Thus, each participant saw one list consisting of 80 trials; each target appearing only once. A set of 10 warm-up trials preceded the experimental trials.

Procedure.

We used the same referential communication instruction as in Experiment 3. To reduce the time pressure for picture naming, picture presentation duration was prolonged to a maximum of 5000 ms. As in the previous experiments, pictures disappeared with the participants' voice-onsets.

Results

Data handling was the same as in all other experiments. There were 77% morphologically complex answers in the complex - complex filler condition, while there were only 1.8% complex answers in the simple - complex filler condition. Table 1 lists the distribution of complex and simple answers in the two test conditions. For the first time, we observe more complex answers (216 or 65.9%) than simple answers (112 or 34.1%) in the same-category condition ($\chi^2(1) = 264.91$, $p < .001$; $t(19) = 13.543$, $p \leq .001$). Reducing the time pressure thus resulted in a significant increase in the number of compound answers relative to Experiment 3 as revealed by a Tukey HSD test (*p* ≤ .001; see above Experiment 2 Results). This number is still smaller than that of the morphologically complex filler condition for which the preferred name is morphologically complex. This is not so for the test pictures and the small number of complex answers to the target objects in the unrelated control condition (6.5%) nicely demonstrates this.

As with all previous experiments, latencies were not analysed in a formal way. Note, however, that Experiment 4 had the longest latencies of all experiments, when the production of morphologically complex descriptions is concerned. Latencies in the same-category condition are some 200 - 300 ms slower than in all other experiments. This indicates that relaxation of time constraints was indeed useful to process both object stimuli down to the lexical level. Of course, we are somewhat reluctant to put much weight on this observation, because the comparison involves few data points in some experiments, and different populations between experiments.

The pattern of eye fixations revealed that participants looked at both objects in 81% of the same-category trials. When participants look at both objects, they produce a complex answers in 177 of 265 cases (67%). If only one object is fixated, the number of morphologically complex answers drops only slightly (64%) and non-significantly as shown by a paired t-test with arcsin-transformed proportions ($t(19) = 1.123$, $p = .275$). This again demonstrates that fixations are not a prerequisite for deep processing.

Discussion

Experiment 4 investigated whether relaxation of time pressure, implemented by the temporal availability of the objects, allows participants to produce more unambiguous, morphologically complex answers. For the first time, the number of complex answers exceeded the number of simple answers when a same-category distractor was present. Interestingly, it is not so much the need to actually look at both objects to derive an unambiguous answer but rather a "sufficiently long" presentation of both objects. For the first time, the proportion of complex and simple answers did not vary with number of fixations. Apparently, objects can be identified without fixations, as we already knew from other work (cf. Dobel et al., in press; Meyer, 2004).

But how long is "sufficiently long"? We increased the presentation duration from 600 ms in Experiment 1 to 1000 ms in Experiments 2 and 3, while it was maximally 5000 ms in Experiment 4. Whereas 1000 ms in Experiment 3 leads to 43% compound answers when the critical distractor is present, this increases by some 25% in Experiment 4, when more time was available. We selected the timing for Experiment 4 on the basis of procedures used for multiple-object naming (cf. Morgan & Meyer, 2005). Apparently this timing allows for a coding, at the lexical level, of both target and distractor, and, as a consequence, for a larger impact of situational and communicative context. Thus, the pattern of results from Experiment 4 supports the hypothesis that time pressure prevented processing, down to the word-form level, of both objects necessary to note the lexical ambiguity and to repair the selection of an ambiguous, morphologically simple name.

So, processing time is a prerequisite for deep lexical processing, but the clearest situation in which speakers can notice the ambiguity explicitly is when they have to name both objects in the display. Ferreira et al. (2005) observed that participants are aware of the ambiguity of their responses when they name the distractor first. The last experiment tests this option. We asked our participants to name the distractor first, and to name the target subsequently. Naming both objects should result in more unambiguous answers than in all other experiments, because participants can notice the ambiguity in the same-category condition based on their own responses. Hence, we expected at least one of the two objects to be named with a compound word.

Experiment 5: Naming distractors and targets

Method

Participants.

Twenty speakers from the same population as before in this experiment participated for course credit or cash payment.

Procedure.

We used the same material, apparatus and timing as in Experiment 4. The difference to the previous experiments was that the direction of the cue was changed. It now pointed to the distractor. Participants were told to name the first object, signalled by the cue, and then name the second object. Pictures disappeared with the participants' voice-onsets to the second object. All subjects' responses were recorded. The instruction included a referential communication task, as in Experiment 3 and 4.

Results

Data handling was the same as in all other experiments. We observed an overall increase of morphologically complex answers, compared to Experiment 4 which, however, failed significance as revealed by a non-significant Tukey HSD test ($p = .093$). Table 1 shows the number of morphologically complex and simple answers as a function of distractor conditions. We observed more complex answers (257 or 79.6%) than simple answers (66 or 20.4%) for the targets in the same-category condition ($\chi^2(1) = 236.691$, $p < .001$; $t(19) = 16.268$, $p \leq .001$). Naming the distractor first thus clearly increased the number of compound answers, but there were still 20.4% morphologically simple answers to targets in the same-category condition. As expected, participants resolved the ambiguity in these cases by referring to the first object (the distractor) with a compound (in 91% of the cases). There were only some 6 cases of ambiguous reference left in the same-category condition, so that ambiguity was efficiently resolved (see Table 4).

Table 4: Experiment 5: Percentages and frequency (in parentheses) of morphologically complex and simple answers for target and preceding distractor object in the same-category condition

			Distractor	
			simple	complex
Target	Simple	20.4% (66)	9.1% (6)	90.9% (60)
	Complex	79.6% (257)	7.0% (18)	93.0% (239)

The effect of name preference, however, is still quite visible. There are some 83% of simple descriptions of the critical targets in the unrelated control condition, demonstrating that the preference for using the simple name is still very strong and has not been abolished by the double-object naming situation. As in all earlier experiments, there were 86.8% morphologically complex answers in the complex - complex filler condition, where the complex name was the preferred one. Finally, the pattern of eye fixations demonstrates that participants looked at both objects in 95.6%. This does not come as a surprise, since they had to name both objects.

Discussion

Experiment 5 investigated whether naming both, the distractor and the target, results in unambiguous, morphologically complex answers. The results clearly showed that a required reference to both objects effectively abolishes ambiguous references which is in line with Ferreira et al.'s (2005) observations. When participants named the second object with a morphologically simple name, they had described the first object unambiguously. Speakers thus fully resolved the ambiguity of reference.

General Discussion

We reported five experiments exploring the consequences of time pressure and addressee orientation on lexical choice, in situations of a combined conceptual and lexical ambiguity. Participants had to name (one of) two objects on display, and were not allowed to use noun phrases ("the blue bucket") or prepositional phrases ("the bucket on the right") as descriptions. They had to name the target picture with a single spoken word, which, in German, includes compounds. In critical conditions, target and distractor pictures came from the same basic level category (two types of dress, knife, glass, nut, etc.) and shared their – preferred - morphologically simple name. This created lexical ambiguity in a situation of conceptual similarity, which can be resolved by using compound words as a means of specification (e.g., saying "*wine glass*" in the presence of a water glass). In control conditions, the preferred simple names were sufficiently specific.

We thus investigated under which conditions lexical ambiguity is detected and avoided by specification through compound use. Given that the detection of lexical ambiguity requires the linguistic encoding of both pictures down to the word-form level, and is thus time-consuming, we manipulated the temporal availability of the objects on the display, and the arrival time of the cue to the target. We also varied the communicative context, by means of the absence or presence of an addressee. With this, we investigated if outside pressure to be specific, a manipulation that is more conscious to the speaker than processing time, affects lexical specification.

In Experiment 1, with time parameters that allow picture-name retrieval in picture naming, we observed only few morphologically complex answers in the ambiguous condition. Morphologically complex answers were given in filler conditions in which the preferred name of the target was a compound. Thus, it was not the production of compounds per se which proved to be difficult, but rather to overcome the preference for a morphologically simple name in situations of referential ambiguity. Clearly then, the time parameters traditionally used for picture naming did not suffice to detect and repair the ambiguity created by the use of the preferred name. Lexical choice is determined mainly by preferred naming. Additional processing time for both objects, provided by a later cue onset, gave rise to only a small, insignificant, increase in the number of compound answers (Experiment 2). In Experiment 3, participants were asked to optimise their descriptions for an imagined addressee which led to an increase in the number of complex answers. Presentation time of the complete display was considerably lengthened in Experiment 4. For the first time, participants produced more complex answers than simple ones in the ambiguous situation. We interpret this boost in unambiguous answers as being due to the time available for the lexical processing of both objects, which is necessary to detect and remedy the ambiguity.

Our results fit well with the results by Ferreira et al. (2005) who also observed a large number of lexically ambiguous descriptions with homophonic objects. They suggested that speakers “repair” these lexical ambiguities when mentioning a second object. As our participants only named one object in Experiments 1-4, we expected that naming both objects should drastically reduce ambiguous responding. This is exactly what was observed in Experiment 5, in which ambiguity was resolved almost completely.

Before turning to the implications of our results for theories of lexical choice (specification), a word about the eye-tracking data. Not surprisingly, the eye-tracking data which were simultaneously recorded showed that participants looked more often at both objects as presentation time increased. This does not imply that participants needed to fixate both objects in order to produce compound answers as the relative proportion of complex and simple answers was the same for fixated and non-fixated objects (see Experiment 3 and 4). Our data thus confirm that overt attention shifts, as reflected by fixations, are no prerequisite for name retrieval and for distractor effects on lexical choice (cf. Dobel et al., 2007; Morgan & Meyer, 2005).

Ambiguity and principles of specificity

Apparently, the principles guiding appropriate lexical choice formulated by Levelt (1989) did not prevent ambiguity of expression in situations of lexical choice assessed in our experiments. How does the uniqueness principle, stating that no two lexical items have the exact same meaning, apply? Of course, hand bags are conceptually different from shopping bags, wine glasses are different from water glasses, and they can be lexically differentiated by compound use in German. So, the principle can apply, but speakers prefer to refer to them with their superordinate, basic-level, name: bag, or glass. Similarly, the core principle (lexical retrieval only if the core meaning is satisfied) applies. The crucial principle, which prevents the retrieval of a hypernym (such as *glass* for a *wine glass*), is the specificity principle, stating that of all items whose core conditions are satisfied by the concept, the most specific one is retrieved. This principle apparently failed in our situation of lexical ambiguity.

The crucial issue, in our view, is not whether such principles apply, but under which conditions and at which level they are operative. Since the principles serve to guide lexical choice, their implementation must be at the interface between conceptualisation and lexicalisation. We argue here that these principles, originally formulated to guide lexical choice when formulating "internal states of affairs", operate in a context-sensitive way, and that they are fallible under time pressure and other constraints. Imagine a display with two glasses, a tumbler and a champagne flute. There is potential referential ambiguity at a conceptual level: Referring to the tumbler with "glass", which is fine in the presence of a book, a bottle, or a plate, is clearly problematic when two glasses are present, and the specific name is needed. When "tumbler" is the preferred reference, it suffices to use this name to solve the ambiguity (cf. Jescheniak et al., 2005). But imagine a wine glass and a water glass, both of which are preferentially referred to with "glass". The same conceptual ambiguity arises; one cannot use "glass" as reference. But this happens to be the preferred specific name for both, and this can only be detected at the word-form level – as is the case for homophones, and for the critical object names in our experiments. So, one constraint is the outside world, which is crucial for the unique linguistic specification of particular things in it.

A second constraint is time. Speaking is often characterized as an incremental process (Kempen & Hoenkamp, 1987) and it is known that speakers often begin to speak before having visually inspected other objects in the situational context (Meyer, 2004; Pechmann, 1989). This might well have happened in our first experiments, where we put our speakers under time pressure by presenting targets and their relevant context for a few hundreds of milliseconds only. Such timing parameters suffice for single-object naming, and essentially provided us with a baseline measure of morphologically simple and referentially ambiguous answers. Even with relatively short presentation durations, unambiguous reference can to some extent be enforced by external pressure to be specific – as the addressee manipulation showed. Moving to presentation durations that are sufficient for multiple-object naming (cf. Morgan & Meyer, 2005), we saw a clear increase in unambiguous name use. As we know, name retrieval for both objects, target and distractor, is a prerequisite for discovering the ambiguity. This double name retrieval, the actual discovery and subsequent resolution of ambiguity take time.

How is ambiguity discovered and resolved? One potential mechanism is a context-sensitive lexical competition process, in which the activation of some word forms (the appropriate compounds in our study) is boosted in a top-down manner, and the inappropriate morphologically simple form is inhibited. Such a mechanism could be subserved by interactive models of speech production such as Dell's (e.g., Dell, Chang & Griffin, 1999). Another means could be the monitor, a system that is part of Levelt's language model to detect and intercept potential speech errors (e.g., Hartsuikers, Kolk, & Martensen, 2005). If the monitoring system is sensitive to the contextual adequacy of certain expressions, these can be intercepted and an adequate word form can be selected instead. The explanation would certainly require adequate amounts of time for ambiguity detection, monitoring and repair. In a sense, it is supported by the fact that ambiguity was fully resolved when both objects on display had to be named - an ideal situation for the monitor (and observed by Ferreira et al. 2005). If the first utterance was morphologically simple and ambiguous, this was repaired on naming the second object. If the first was already specific enough, the second could be morphologically simple. It remains an empirical issue to decide between these two potential implementations of successful ambiguity resolution in speaking.

CONCLUSIONS

CHAPTER 4

The fluent comprehension and production of speech is a complex human skill. In language comprehension, there is mapping from word form to word meaning. Instead, in language production information flows from meaning to form. However, both processes are assumed to use shared representations such as the information about the form of words, e.g., morphemes (Zwitserlood, 1994). The focus in this thesis is on the comprehension and production of morphologically complex words, more precisely compounds. Many linguistic accounts of how complex words are stored, accessed and processed, propose that the mental lexicon is morphemically organized. In models of language comprehension, for instance, there is typically a processing stage included in which complex words are separated into their constituent morphemes before meaning based representations are accessed. In sum, most of the results of past research were interpreted such that morphologically complex words are decomposed during comprehension and composed during production.

The aim of the first empirical part of the thesis (Chapter 2) was to investigate which predictors influence the comprehension of morphologically complex words during reading. The processing of complex words was studied in three experiments using 2154 compounds, presented in isolation. Data were analysed by means of multiple regression analyses using frequency, length, semantic transparency, onset complexity, family size and family frequency as predictors. In the first experiment, eye movements were recorded and gaze durations were the dependent variable. Gaze durations were affected by frequency, length and family frequency. Results of this experiment also support the prediction of a combinatorial impact of frequency and length. The second experiment included a lexical decision task and reaction times were the dependent measure. Here, the results showed an impact of frequency, semantic transparency and onset complexity. In the third experiment, also a lexical decision experiment, different pseudo-word distractors were used. The results showed that the type of frequency effect depends on the manipulation of the pseudo-word distractors.

The aim of the second part of the thesis (Chapter 3) was to investigate in five experiments under which conditions speakers produce compounds (e.g., *Wassereimer*, water bucket) as references to objects although the preferred naming for those objects is morphologically simple (*Eimer*, bucket). Different manipulations such as contextual alternatives, i.e. category related distractors, or a referential communication task were realized to encourage the speakers to unambiguously describe one of two pictures. Participants had to produce compounds in order to avoid ambiguity. The results showed that speakers were not very ambitious to overcome their preferred naming, even for the cost of being ambiguous. But, with the use of a referential communication task and an increase of processing time, participants produced more compounds and therefore unambiguous answers than simple, ambiguous answers. This suggests that sufficient time is needed to detect and remedy ambiguity.

The results of Chapter 2 show that the factor frequency is an overall robust factor predicting the processing of compounds in reading, irrespective of the type of task. (For additional predictors involved in the processing of compounds see Chapter 2.) In general, frequency is a factor which supports many assumptions on the role of decompositionality and full-form access for models of lexical representation of morphologically complex words. As it was mentioned in Chapter 1 and 2 there are different assumptions about how morphologically complex words are stored in the mental lexicon. There is the full-listing approach (Butterworth, 1983; Bybee, 1985; Fowler et al., 1985), the full-parsing model (Taft & Forster, 1975, 1976; Taft, 1986, 1994, 2004) and an intermediate solution such as dual-route models (e.g., Baayen & Schreuder, 1999; Baayen et al., 1997; Caramazza et al., 1988; Schreuder & Baayen, 1995). Support for the different models comes from studies in which the frequency of the whole-word form or the constituents was manipulated. These manipulations showed that the factor frequency is a reliable indicator for determining the way the processing of complex words takes place. So, if there were effects of whole-word frequency, one would suggest that lexical access proceeded via the whole-word access route. But if constituent frequency affects recognition performance, one would assume that the complex word had been decomposed. In recent research, observations of both whole-word frequency and constituent frequency on fixation durations (Bertram & Hyönä, 2003; Hyönä et al., 2004) and on lexical decision times (Baayen et al., 1997; Juhasz et al., 2003; Inhoff et al., 1996) have been arguments in favour of the dual-route models which suggest a processing via both the whole-word route and the decompositional route (Caramazza et al., 1988; Baayen & Schreuder, 1999). The data of Chapter 2 also revealed that the processing of compounds is sensitive to both whole-word frequency and constituent-frequency effects. The results are discussed in favour of dual-route models since the absence of either the whole-word frequency or the constituent-frequency effect would propose a processing via one route only.

Thus, frequency seems to be one of the most important factors influencing the processing of complex words. However, frequency has been established to be a major factor not only in language comprehension but also in language production. One of the very first approaches concerning this issue was addressed by Oldfield and Wingfield (1965). They showed that naming latencies for objects are closely related to the frequency of the object name in language use. Pictures with high-frequency names are named faster than pictures with low-frequency names (Huttenlocher & Kubicek, 1983). In a study by Jescheniak and Levelt (1994) subjects had to translate words that produced homophones. Homophones share the lexeme but not the lemma. The results showed that the production of low-frequency homophones was as fast as the production of the high-frequency controls, giving evidence for an inheritance of the accessing speed of high-frequency partner homophones. Therefore, Jescheniak and Levelt suggested that the effect of frequency arises at the level of lexemes (Jescheniak & Levelt, 1994). In sum, word frequency is rather attributed to the level of word forms than to the lemma level (Levelt et al., 1999). Recent language production studies also showed an influence of the factor frequency. Frequency manipulation of the first and second constituent of a compound as well as the compound itself revealed a significant effect of constituent frequency on production latencies (Bien et al., 2005). This is in favour of decompositional approaches to models of speech production. In sum, the factor frequency has been investigated and used extensively as an indicator for certain processes in language comprehension and production.

But what does the factor frequency reflect? There are different copora such as the CELEX lexical database for English, German and Dutch (Baayen et al., 1995) or the “Leipziger Wortschatzlexikon” for German (department of computer science of the university of Leipzig), providing frequency information for a large amount of words. Most of these frequency measures have been estimated by assessing how often words are used in written or spoken language. Thus, the factor frequency simply reflects the frequency of words in use. With regard to Chapter 3 of this thesis, one could assume that the frequency of use is accompanied by or confounded with the choice of utterances. What is the preferred naming for certain objects? If a word is often chosen, this word might also be very frequent. Speakers often “rely to a great extent on their store of frequently used words and idioms” (Levelt, 1989, pp. 233). Therefore, the preferred naming for objects can be traced back to their frequency of use. So, frequency may not just be located at the lexical level but may also occur on a much higher level like the conceptual semantic level where the preferred naming is chosen. Chapter 3 encompasses the topic under which circumstances speakers overcome their preferred simple naming which could possibly be the most frequent one. Of course, experiments in this Chapter did not control for the factor frequency but however, one could imagine that the preferred simple naming is very frequent in use. Take for instance the morphologically simple word *Glas* (glass) which has a higher frequency (frequency: 13799; frequency class: 10) than the morphologically complex word *Weinglas* (wine glass) (frequency: 199 frequency class: 16). The data showed that it is very hard for speakers to change the preferred and probably the more frequent naming for objects. In sum, frequency effects might not only arise at the level of lexemes (e.g., Jescheniak & Levelt, 1994). They might also be attributed to a higher conceptual level since it seems to influence lexical choice and consequently the production of, in this case, compounds as unambiguous references to objects.

Further Research

According to Chapter 2 of this thesis, evidence is given that the processing of compounds is in favour of dual-route models. Findings of both whole-compound and constituent effects support the assumption of compound processing via whole-word forms and constituents. The experiments conducted in Chapter 2 provide evidence that the main factors involved in compound processing are frequency (Exp.1, Exp.2 & Exp.3), length (Exp.1) and semantic transparency (Exp.2 & Exp.3). Thus, there is a difference in the outcome of predictors influenced by type of task. The difference in data was interpreted with respect to a reflection of different proportions of the lexical access process from different time perspectives. Eye movements (Exp.1) are recorded while the compound is being read whereas lexical decision times reflect to some extent a global measure. Similarily, Balota et al. (2004) also found task-dependent influences of most of their variables. They observed, for instance, that frequency-based information had a larger impact on lexical decision than on naming (Balota & Chumbley, 1984). Considering our arguments (Chapter 2) of an influence of the type of task on predictors involved in compound processing, further evidence from a naming task should be provided. The compounds investigated here with eye-tracking and lexical decision have not been explored with a naming task so far.

Which predictors will be involved in compound processing when conducting a naming task?
In Balota et al.'s study (2004), the influence of predictor variables such as phonological onset, length, frequency, meaningfulness, number of associates etc., on lexical decision and naming was tested. Their predictors were categorized in phonological onset variables, lexical variables and semantic variables. The basic findings demonstrated that phonological onset variables predicted considerably more variance in naming than in lexical decision (Frederiksen & Kroll, 1976). At the lexical level, lexical decision was more dependent on the frequency-based information than naming. Interestingly, spelling-to-sound consistency

predicted both naming and lexical decision. The influence of word length was much larger on naming than on lexical decision. Finally, the semantic predictor influenced lexical decision more than naming.

In a further naming task, participants would be asked to name the word aloud as quickly and as accurately as possible. Considering Balota et al.'s (2004) assumption that naming tasks address the onset of the appropriate articulation, the predictor variable that should produce stable influence is onset complexity (phonological onset). Including spelling-to-sound consistency as a new predictor variable seems uneffective when investigating German compounds because the grapheme-to-phoneme correspondence is quite regular (Coltheart et al., 1993). Regarding Balota et al.'s findings, there will also be predictive power of the factor length in naming performance. The results will again highlight the impact of the type of task. Because of the importance of the impact of different factors on compound processing depending on the type of task, it is necessary to extend these observations to another measure of lexical processing, namely naming.

With regard to Chapter 3 of this thesis, evidence is given that the preferred morphologically simple and therefore ambiguous naming of objects in a context of same-category objects is hard to overcome. Of course, certain manipulations such as addressee orientation or time pressure relaxation increase the production of complex, unambiguous answers to differentiate between two categorically related pictures. Remember that, according to Grice´s maxim of quantity (1975), speakers provide sufficient information for referent identification but no more. Quite a few studies showed that speakers even tend to produce overspecified utterances (Deutsch & Pechmann, 1982; Pechmann, 1984, 1989). In a recent study of Engelhardt, Baily and Ferreira (2006), it was investigated how sensitive speakers are to the Gricean maxim of quantity. In a production study, they investigated the type of utterances speakers produce when instructing other people to move a target object to a certain location. They realized the following conditions: 1) a matching condition, where the target object had to be moved from a location to another of the same type, e.g., an apple on the towel moved to another towel 2) a different condition, where the target object had to be moved to a different type of location, e.g., the apple on the towel into a basket. In each of these conditions there was either one referent, i.e. only one picture of the same type (e.g., one apple and a cloth) or two referents, i.e. two pictures of the same type (e.g., two apples). Specified target utterances should occur more often in the two referent condition but not in the one-referent condition. Conform with the Gricean maxim of quantity, speakers produced more specified target utterance (e.g., put the apple that's on the towel in the box) in the two-referent condition (98%) than in the one-referent condition (30%). Indeed, speakers avoided under-determined and therefore ambiguous descriptions in the two-referent condition as expected by the Gricean maxim. But in one-third of the cases they also produced over-descriptive utterances where it is not necessary (see Deutsch & Pechmann, 1982; Pechmann, 1984, 1989).

On the basis of this study (Engelhardt et al., 2006), it is a further challenge, to examine speakers' type of utterances with the material used in Chapter 3. Speakers should also instruct other people, who do not necessarily have the objects in the same configuration, to move the target object (e.g., *Wassereimer* – water bucket) from one location to another. There will also be a matching location (e.g., *from a towel to another towel*) and a different location condition (e.g., *from a towel into a box*). Speakers shall be at ease in producing their utterances. We will not put emphasis on the production of compounds. But, in order to encourage speakers to produce a compound, target objects will not always be located on an object but will also occur 'alone' (with no object underneath). The two-referent condition will be realized with the objects belonging to the same category (e.g., *Mülleimer* – waste basket). The one-referent condition will be realized with the unrelated condition (e.g., *Flöte* – flute) (see Chapter 3). Considering Engelhardt et al.'s study, speakers will produce unambiguous answers in the two-referent condition. Note: In their two-referent condition, they used the same two objects. Therefore, those objects could 'only' be specified by using the location. This will probably be different in this follow-up experiment. Targets may also be specified by using a compound, especially in the conditions where the target occurs alone. In contrast to Engelhardt et al., we predict that it will still be very difficult for speakers to overcome the preferred morphologically simple naming. So, compounds will not be produced very often. Instead, if specification takes place, speakers rather tend to specify the object with regard to its location. This study will give potential further evidence of how and when speakers use unambiguous utterances, especially for addressees, as references to objects.

REFERENCES

Andrews, S., Miller, B., & Rayner, K. (2004). Eye movements and morphological segmentation of compound words: There is a mouse in mousetrap. *European Journal of Cognitive Psychology, 16,* 285-311.

Baayen, R.H., & Dijkstra, T. (2003). Frequency effects in regular inflectional morphology: revisiting Dutch plurals. In: H. Baayen & R. Schreuder, (eds.), *Morphological structure in language processing,* (pp. 355-390). Berlin: Mouton de Gruyter.

Baayen, R.H., Dijkstra, T., & Schreuder, R. (1997). Singulars and Plurals in Dutch: Evidence for a parallel dual-route model. *Journal of Memory and Language, 37,* 94-117.

Baayen, R.H., Lieber, R., & Schreuder, R. (1997). The morphological complexity of simplex nouns. *Linguistics, 35,* 861-877.

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). The CELEX lexical database (CD-ROM). Linguistic Data Consortium, University of Pennsylvania, Philadelphia, PA.

Baayen, R.H., & Schreuder, R. (1999). War and peace: Morphemes and full forms in a noninteractive activation parallel dual-route model. *Brain and Language, 68,* 27-32.

Balota, D.A., & Chumbley, J.I. (1984). Are lexical decisions a good measure of lexical access? The role of word frequency in the neglected decision stage. *Journal of Experimental Psychology: Human Perception and Performance, 10,* 340-357.

Balota, D.A., Cortese, M.J., Sergent-Marshall, S.D., & Yap, M.J. (2004). Visual word recognition of single-syllable words. *Journal of Experimental Psychology: General*, *133,* 283-316.

Balota, D., & Rayner, K. (1983). Parafoveal visual information and semantic contextual constraints. *Journal of Experimental Psychology: Human Perception and Performance, 9,* 726-738.

Beauvillain, C. (1996). The integration of morphological and whole-word information during eye-fixations on prefixed and suffixed words. *Journal of Memory and Language, 35,* 801-820.

Bertram, R., Baayen, H., & Schreuder, R. (2000). Effects of family size for complex words. *Journal of Memory and Language, 42,* 390-405.

Bertram, R., & Hyönä, J. (2003). The length of a complex word modifies the role of morphological structure: Evidence from eye movements when reading short and long Finnish compounds. *Journal of Memory and Language, 48,* 615-634.

Besner, D. & Humphreys, G. W. (1991). Basic Processes in Word Recognition and Identification: An Overview. In D. Besner & Humphreys, G.W. (Eds.), *Basic Processes in Reading – Visual Word Recognition, (pp. 1-9)*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Bien, H., Levelt, W.J.M., & Baayen, H.R. (2005). Frequency effects in compound production. *PNAS, 102,* 17876-17881.

Brennan, S.E. (1996). Lexical Entrainment in spontaneous dialog. *International Symposium on Spoken Dialogue*. 41-44.

Brennan, S. E. & Clark, H. (1996). Conceptual pacts and lexical choice in conversation. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 22,* 1482-1493.

Bromme, R., Jucks, I. & Wagner, T. (2005). How to Refer to 'Diabetes'? Language in Online Health Advice. *Applied Cognitive Psychology, 19,* 569-586.

Burani, C., & Caramazza, A. (1987). Representation and processing of derived words. *Language and Cognitive Processes, 2,* 217-227.

Burani, C., Barca, L. & Ellis. A. (2006). Orthographic complexity and word naming in Italian: Some words are more transparent than others. *Psychonomic Bulletin & Review, 13,.* 346-352.

Butterworth, B. (1983). Lexical Representation. In B. Butterworth (Ed.), *Language Production,* (pp. 257-294). London: Academic Press.

Bybee, Joan L. (1985). *Morphology: A Study of the Relation between Meaning and Form.* Philadelphia: Benjamins.

Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology, 14,* 177-208.

Caramazza, A., Laudanna, A., & Romani, C. (1988). Lexical access and inflectional morphology. *Cognition, 28,* 297-332.

Carpenter, P.A., & Just, M.A. (1983). What your eyes do while your mind is reading. In K. Rayner (Ed.), *Eye Movements in Reading: Perceptual and Language Processes*. New York: Academic Press.

Chialant, D., & Caramazza, A. (1995). Where is morphology and how is it represented? The case of written word recognition. In L.B. Feldman (Ed.), *Morphological aspects of language processing, (pp. 55-76)*. Hillsdale, NJ: Erlbaum.

Clark, E.V. (1997). Conceptual perspective and lexical choice in acquisition. *Cognition, 64,* 1-37.

Clark, E.V. & Clark, H.H. (1979). When nouns surface as verbs? *Language,* 5, 430-477.

Clark, H.H., & Krych, M.A. (2004). Speaking while monitoring addressees for understanding. *Journal of Memory and Language, 50,* 62-81.

Cohen, J. (1983). The cost of dichotomization. *Applied Psychological Measurement, 7,* 249–253.

Colé, P., Beauvillain, C., & Segui, J. (1989). On the representation and processing of prefixed and suffixed derived words: A differential frequency effect. *Journal of Memory and Language, 28,* 1-13.

Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). Models of reading aloud: dual-route and parallel-distributed-processing approaches. *Psychological Review, 100,* 589-608.

Cutler, A. (1981). Making up materials is a confounded nuisance: or Will be able to run any psycholinguistic experiments at all in 1990? *Cognition, 10,* 65-70.

Dale, R. & Reiter, E. (1995). Computational interpretations of the Gricean Maxims in the generation of referring expressions. *Cognitive Science, 18,* 233-263.

de Jong, N., Schreuder, R., & Baayen, R.H. (2000). The morphological family size effect and morphology. *Language and Cognitive Processes, 15,* 329-365.

Dell, G.S. (1986). A spreading activation theory of retrieval in language production. *Psychological Review, 93*, 283-321.

Dell, G., Chang, F., & Griffin, Z. M. (1999). Connectionist models of language production: Lexical access and grammatical encoding. *Cognitive Science, 23,* 517-542.

Deutsch, W. & Pechmann, T. (1982). Social interaction and the development of definite descriptions. *Cognition, 11*, 159-184.

Dobel, C., Gumnior, H., Bölte, J., & Zwitserlood, P. (in press). Describing scenes hardly seen. *Acta Psychologica.*

Dohmes, P., Zwitserlood, P., & Bölte, J. (2004). The impact of semantic transparency of morphologically complex words on picture naming. *Brain and Language, 90,* 203-212.

Dubois, D. & Denis, M. (1988). Knowledge organization and instantiation of general terms in sentence comprehension. *Journal of Experimental Psychology: Learning, Memory and Cognition, 14,* 606-611.

Eikmeyer, H.-J. & Ahlsen (1998). The cognitive process of referring to an object: A comparative study of German Swedish. In T. Haukioja (Ed.), *Papers from the 16th Scandinavian Conference of Linguistics.* (Publications of the Department of Finish and General Linguistics of the University of Turku, Vol. 60, pp. 75-86).

Engelhardt P.E., Bailey, K.G.D. & Ferreira, F. (2006). Do speakers and listeners observe the Gricean Maxim of Quantity? *Journal of Memory and Language, 54,* 554-573.

Feldman, L.B. (2000). Are morphological effects distinguishable from the effects of shared meaning and shared form? *Journal of Experimental psychology: Learning, Memory and Cognition, 26,* 1431-1444.

Ferreira, V., Slevc, L.R. & Rogers, E.S. (2005). How do speakers avoid ambiguous linguistic expressions? *Cognition, 96,* 263-284.

Frederiksen, J. R. & Kroll, J. F. (1976). Speeling and sound: Approaches to the internal lexicon. *Journal of Experimental Psychology: Human Perception and Performance, 2,* 361-379.

Forster, K.I. (2000). The potential for experimenter bias effects in word recognition experiments. *Memory & Cognition, 28,* 1109-1115.

Fowler, C.A., Napps, S., & Feldman, L. (1985). Relations among regular and irregular morphologically related words in the lexicon as revealed by repetition priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 241-255.

Furnas, G.W., Landauer, T.K., Gomez, L.M. & Dumais, S.T. (1983). Statistical semantics: Analysis of the potential performance of keyword information systems. *Bell Systems Technical Journal, 62,* 1753-1806.

Furnas, G.W., Landauer, T.K., Gomez, L.M. & Dumais, S.T. (1987). The vocabulary problem in human-system communications. *Communications of the ACM, 30,* 964-971.

Fussell, S.R. & Krauss, R.M. (1989). The effects of intended audience on message production and comprehension: Reference in a common ground framework. *Journal of Experimental Social Psychology, 25,* 203-219.

Giraudo, H. & Grainger, J. (2000). Effects of prime word frequency and cumulative root frequency in masked morphological priming. *Language and Cognitive Processes, 15,* 421-444.

Goodman, K. (1976). Behind the Eye: What Happens in Reading? In H. Singer and R.B. Ruddell (Eds.), *Theoretical models and processes of reading (2nd edition), (pp. 470-496).* Newark, DE: International Reading Association.

Goodman, K. (1976). Reading: A psycholinguistic guessing game. In H. Singer and R.B. Ruddell (Eds.), *Theoretical models and processes of reading (2nd edition), (pp. 497-508).* Newark, DE: International Reading Association.

Gough, P.B. (1976). One second of reading. In H. Singer and R.B. Ruddell (Eds.), *Theoretical models and processes of reading (2nd edition), (pp. 509-535).* Newark, DE: International Reading Association.

Grice, H.P. (1975). Logic and conversation (from the William James lectures, Harvard University, 1967). In P. Cole & J. Morgan (Hrsg.), *Syntax and Semantics 3: Speech acts (pp. 41-58).* New York: Academic press.

Griffin, Z.M. (2001). Gaze durations during speech reflect word selection and phonological encoding. *Cognition, 82*, B1-B14.

Gumnior H., Bölte J. & Zwitserlood P. (2006). A chatterbox is a box: Morphology in German word production. *Language and Cognitive Processes, 21,* 920-944.

Haberlandt, K. (1994). *Cognitive Psychology*. Boston: Allyn & Bacon.

Hartsuikers, R. J., Kolk, H. J. & Martensen, H. (2005). Division of labor between internal and external speech monitoring. In Hartsuiker, R. J., Bastiaanse, R., Postma, A., & Wijnen, F. (Eds), *Phonological encoding and monitoring in normal and pathological speech* (pp. 187-205). New York, NY: Psychology Press.

Hemera Photo-Objects. [Computer software] Hemera Technologies Inc. Gatineau, Quebec, Canada.

Henderson, J.M., & Ferreira, F. (1990). Effects of foveal processing difficulty on the perceptual span in reading: Implications for attention and eye movements control. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 417-429.

Henderson, J. M. & Ferrerira, F. (2004). Scene perception for psycholinguists. In J. M. Henderson & F. Ferreira (Eds.), *The interface between of language, vision, and action: Eye movements and the visual world* (1-58). New York, NY: Psychology Press.

Hermann, T. & Deutsch, W. (1976). *Psychologie der Objektbenennung* [Psychology of object naming] Bern, Switzerland: Huber.

Hermann, T. & Grabowski, J. (1994). *Sprechen: Psychologie der Sprachproduktion.* [Speaking: The psychology of speech production]. Heidelberg, Germany: Spektrum Verlag.

Huttenlocher, J. & Kubicek, L.F. (1983). The source of relatedness effects on naming latency. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9,* 486-496.

Hyönä, J., Bertram, R., & Pollatsek, A. (2004). Are long compounds identified serially via their constituents? Evidence from an eye-movement – contingent display change study. *Memory & Cognition, 32,* 523-532.

Hyönä, J., Bertram, R., & Pollatsek, A. (2005). Identifying compound words in reading: an overview and a model. In G. Underwood (Ed.), *Cognitive Processes in Eye Guidance,* (pp. 79-103). New York: Oxford University Press.

Hyönä, J., Niemi, P., & Underwood, G. (1989). Reading long words embedded in sentences: informativeness of word parts affects eye movement. *Journal of Experimental Psychology: Human Perception and Performance, 21,* 68-81.

Hyönä, J., & Pollatsek, A. (1998). Reading Finnish compound words: Eye fixations are affected by component morphemes. *Journal of Experimental Psychology: Human Perception & Performance, 24,* 1612-1627.

Hyönä, J., Vainio, S., & Laine, M. (2002). A morphological effect obtains for isolated words but not for words in sentence context. *European Journal of Cognitive Psychology, 14,* 417-433.

Inhoff, A.W., Brihl, D., & Schwartz, J. (1996). Compound word effects differ in reading, on-line naming, and delayed naming tasks. *Memory & Cognition, 24,* 466-476.

Inhoff, A.W., & Rayner, K. (1986). Parafoveal word processing during eye fixations in reading:Effects of word frequency. *Perception & Psychophysics, 40,* 431-439.

Irwin, D. E. (2004). Fixation location and fixation duration as indices of cognitive processing. In J. M. Henderson & F. Ferreira (Eds.), *The interface between of language, vision, and action: Eye movements and the visual world* (105-133). New York, NY: Psychology Press.

Isel, F., Gunter, T.C., & Friederici, A.D. (2003). Prosody-assisted head-driven access to spoken German compounds. *Journal of Experimental Psychology: Learning, Memory and Cognition, 29,* 277-288.

Janssen, N., Bi, Y., & Caramazza, A. (subm.). A tale of two frequencies: determining the speed of lexical access for English and Mandarin Chinese compounds.

Jescheniak, J. & Levelt, W.J.M. (1994). Word frequency effects in speech production: retrieval of syntactic information and of phonological form. *Journal of Experimental Psychology, 20,* 824-843.

Jescheniak, J., Hantsch, A. & Schriefers, H. (2005). Context effects on lexical choice and lexical activation. *Journal of Experimental Psychology: Language, Memory, and Cognition, 31,* 905-920.

Jolicoeur, P., Gluck, M.A. & Kosslyn, S.M. (1984). Pictures and names: Making the connection. *Cognitive Psychology, 16,* 243-275.

Jörg, S. & Hörmann, H. (1978). The influence of general and specific verbal lables on the recognition of labeled and unlabeld parts of pictures. *Journal of Verbal Learning and Verbal Behavior. 17,* 445-454.

Juhasz, B.J., & Rayner, K. (2003). Investigating the effects of a set of intercorrelated variables on eye fixation durations in reading. *Journal of Experimental Psychology, 29,* 1312-1318.

Juhasz, B.J., Starr, M.S., Inhoff, A.W., & Placke, L. (2003). The effects of morphology on the processing of compound words: Evidence from naming, lexical decision and eye fixations. *British Journal of Psychology, 94,* 223-244.

Just, M.A., & Carpenter, P.A. (1980). A theory of reading: from eye-fixations to comprehension. *Psychological Review, 87,* 329-354.

Kawamoto, A. H., & Kello, C. T. (1999). Effect of onset cluster complexity in speeded naming: A test of rule-based approaches. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 361–375.

Kehayia, E., Jarema, G., Tsapkini, K., Perlak, D., Ralli, A., & Kadzielawa, D. (1999). The role of morphological structure in the processing of compounds: The interface between linguistics and psycholinguistics. *Brain and Language, 68,* 370-377.

Kessler, B., Treiman, R., & Mullennix, J. (2002). Phonetic biases in voice key response time measurements. *Journal of Memeory and Language, 47,* 145-171.

Kessler, B., Treiman, R., & Mullennix, J. (subm.). A new look at the factors that affect oral word reading.

Kempen, G. & Hoenkamp, E. (1987). An incremental procedural grammar for sentence formulation. *Cognitive Science, 11,* 201-258.

Kennedy, A., Pynte, J., & Ducrot, S. (2002). Parafoveal-on-foveal interactions in word recognition. *Quarterly Journal of Experimental Psychology, 55,* 1307-1337.

Kliegl, R., Grabner, E., Rolfs, M., & Engbert, R. (2004). Length, frequency, and predictability effects of words on eye-movements in reading. *European Journal of Cognitive Psychology, 16,* 262-284.

Kliegl, R., Nuthmann, A., & Engbert, R. (2006). Tracking the mind during reading: The influence of past, present, and future words on fixation durations. *Journal of Experimental Psychology: General, 135*, 12-35.

Koester, D., Gunter, Th.C., Wagner, S., & Friederici, A.D. (2004). Morphosyntax, prosody, and linking elements: The auditory processing of German nominal compounds. *Journal of Cognitive Neuroscience, 16*, 1647-1668.

Krauss, R.M., & Fussell, S.R. (1991). Perspective-taking in communication: Representations of others' knowledge in reference. *Social Cognition, 9,* 2-24.

Krott, A. & Nicoladis, E. (2005). Large constituent families help children parse compounds. *Journal of Child Language, 32,* 139-158.

LaBerge, D., & Samuels, S.J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology, 6,* 293-323.

Lakoff, G. & Johnson, M. (1980). *Metaphors we live by.* University of Chicago Press, Chicago, IL.

Laudanna, A., Cermele, A., & Caramazza, A. (1997). Morpho-lexical representations in naming. *Language and Cognitive Processes, 12,* 49-66.

Lemhöfer, K., Dijkstra, T., Grainger, J., & Zwitserlood, P. (accepted pending revision). Native language influences on word recognition in a second language: A mega-study. *Journal of Experimental Psychology: Learning, Memory and Cognition.*

Levelt, W.J.M. (1983). Monitoring and self-repair in speech. *Cognition, 14,* 41-104.

Levelt, W.J.M. (1989). *Speaking: From intention to articulation.* Cambridge, MA: MIT Press.

Levelt, W.J.M., Schreuder, R. & Hoenkamp, E. (1978). Structure and use of verbs of motion. In R.N. Campbell & P.T. Smith (eds.) *Recent advances in the psychology of language* (pp. 137-162). New York, NY: Plenum.

Levelt, W.J.M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22,* 1-75.

Libben, G. (1998). Semantic transparency in the processing of compounds: Consequences forrepresentation, processing, and impairment. *Brain and Language, 61,* 30-44.

Libben, G., Gibson, M., Yoon, Y-B., & Sandra, D. (2003). Compound fracture: The role of semantic transparency and morphological headedness. *Brain and Language, 84,* 26-43.

Lima, S.D., & Pollatsek, A. (1983). Lexical access via an orthographic code? The basic orthographic syllabic structure (BOSS) reconsidered. *Journal of Verbal Learning and Verbal Behaviour, 22,* 310-332.

Lockridge, C.B. & Brennan, S.E. (2002). When do speakers adjust to addresses? Effects of visual co-presence on the planning of utterances. *Psychological Bulletin and Review, 9,* 550-557.

Longtin, C.M, Segui, J., & Hallé, P.A. (2003). Morphological priming without morphological relationship. *Language and Cognitive Processes, 18,* 313-334.

Lorch, R.F., & Myers, J.L. (1990). Regression analyses of repeated measures data in cognitive research. *Journal of Experimental Psychology: Learning, Memory and Cognition, 16,* 149-157.

Mangold, R. & Pobel, R. (1988). Informativeness and instrumentality in referential communication. *Journal of Language and Social Psychology, 7,* 181-191.

Marslen-Wilson, W., Tyler, L.K., Waksler, R., & Older, L. (1994). Morphology and meaning in the English mental lexicon. *Psychological Review, 101,* 3-33.

Maxwell, S. E., & Delaney, H. D. (1993). Bivariate median splits and spurious statistical significance. *Psychological Bulletin, 113,* 181–190.

McClelland, J.C., & Rumelhart, D.E. (1981). An interactive activation model of context effects in letter perception: Part 1 Account of Basic Findings. *Psychological Review,88,* 375-407.

McConkie, G.W., & Rayner, K. (1975). The span of the effective stimulus during a fixation in reading. *Perception & Psychophysics, 17,* 578-586.

Meyer. A.S. (2004). The use of eye tracking in studies of sentence generation. In J.M. Henderson & F. Ferreira (Eds.), *The Interface of Language, Vision and Action*. Hove, UK: Psychology Press, 191-211.

Monsell, S., Doyle, M., & Haggard, P.N. (1989). Frequency effects in visual word recognition: Where are they? *Journal of Experimental Psychology: General, 118,* 43-71.

Morgan, J. L. & Meyer, A. S. (2005). Processing of Extrafoveal Objects During Multiple-Object Naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 428-442.

Morton, J. (1969). Interaction of information in word recognition. *Psychological Review, 76,* 165-178.

Moscoso del Prado Martín, F., Deutsch, A., Frost, R., Schreuder, R., de Jong, N. H. & Baayen, H. (2005). Changing places: A cross-language perspective on frequency and family size in Dutch and Hebrew. *Journal of Memory and Language 53,* 496–512.

Niswander, E., Pollatsek, A., & Rayner, K. (2000). The processing of derived and inflected suffixed words during reading. *Language and Cognitive Processes, 15,* 389-420.

Oldfield, R.C. & Wingfield, A. (1965). Response latencies in naming objects. *Quarterly Journal of Expeirmental Psychology, 17,* 273-281.

Olson, D. R. (1970). Language and thought. Aspects of a cognitive theory of semantics. *Psychological Review, 77,* 257-273.

Pechmann, T. (1984). *Überspezifikation und Betonung in referentieller Kommunikation.* Unveröffentlichte Dissertation, Universität Mannheim, Deutschland.

Pechmann, T. (1989). Incremental speech production and referential overspecification. *Linguistics, 27,* 89-110.

Pollatsek, A., & Hyönä, J. (2005). The role of semantic transparency in the processing of Finnish compound words. *Language and Cognitive Processes, 20,* 261-290.

Pollatsek, A. Hyönä, J., & Bertram, R. (2000). The role of morphological constituents in reading Finnish compound words. *Journal of Experimental Psychology: HumanPerception and Performance, 26,* 820-833.

Pykkänen, L., Feintuch, S., Hopkins, E., & Marantz, A. (2004). Neural correlates of the effects of morphological family frequency and family size: An MEG study. *Cognition, 91,* B35-B45.

Radach, R., & Kennedy, A. (2004). Theoretical perspectives on eye movements in reading: Past controversies, current issues, and an agenda for future research. *European Journal of Cognitive Psychology, 16,* 3-26.

Rastle, K. & Davis, M. (2002). On the Complexities of Measuring Naming. *Journal of Experimental Psychology: Human Perception and Performance, 28,* 307–314.

Rayner, K. (1975). The perceptual span and peripheral cues in reading. *Cognitive psychology, 7,* 65-81.

Rayner, K. (1998). Eye movements in reading and information processing: 20 Years of research. *Psychological Bulletin, 124,* 372-422.

Rayner, K., & Duffy, S.A. (1986). Lexical complexity and fixation times in reading: effects of word frequency, verb complexity and lexical ambiguity. *Memory and Cognition*, *14,* 191-201.

Rayner, K., & Juhasz, B.J. (2004). Eye movements in reading: Old questions and new directions. *European Journal of Cognitive Psychology, 16,* 340-352.

Rayner, K., & McConkie, G.W. (1976). What guides a reader's eye movements? *Vision Research, 16,* 829-837.

Rayner, K. & Pollatsek, A. (1987). Eye Movements in Reading: A tutorial review. In M.Coltheart (Ed.), *The Psychology of Reading, (pp. 327-362).* East Sussex: Lawrence Erlbaum Associates Ltd., Publishers.

Reichle, E. D., Pollatsek, A., Fisher, D. L., & Rayner, K. (1998). Toward a model of eye movement control in reading. *Psychological Review, 105*, 125-157.

Roelofs, A. (1996). Serial order in planning the production of successive morphemes of a

Word. *Journal of Memory and Language, 35,* 854-876.

Roelofs, A. (1998). Rightward incrementality in encoding simple phrasal forms in speech production: verb-particle combinations. *Journal of Experimental Psychology: Learning, Memory and Cognition, 24,* 904-921.

Rosch, E., Mervis, C.B., Gray, W.D. Johnson, D.M. & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8,* 382-439.

Rumelhart, D.E. (1985). Toward an interactive model of reading. In H. Singer and R.B.Ruddell (Eds.), *Theoretical models and processes of reading (3rd edition), (pp. 722-750).* Newark, DE: International Reading Association.

Rumelhart, D.E., & McClelland, J.L. (1982). An interactive activation model of context effects in letter perception: Part 2 The contextual enhancement effect and some tests and extensions of the model. *Psychological Review, 89,* 60-94.

Schreuder, R., & Baayen R.H. (1995). Modelling morphological processing. In L.B. Feldman (Ed.) *Morphological aspects of language processing* (pp. 131-156). Hillsdale: Erlbaum.

Schreuder, R., & Baayen, R.H. (1997). How complex simplex words can be. *Journal of Memory and Language, 37,* 118-139.

Schriefers, H.J. (1998). Morphology and word recognition. In A.D. Friederici (Ed.) *Language comprehension: A biological perspective (2nd ed.) (pp. 101-132).* Berlin: Springer.

Schriefers, H., Meyer, A., & Levelt, W.J.M. (1990). Exploring the time course of lexical access in production: Picture-word interference studies. *Journal of Memory and Language, 29,* 86-102.

Singer, H., & Ruddell, R.B. (1976). Theoretical models and processes of reading (2nd edition). Newark, DE: International Reading Association.

Smith, F. (1988). Understanding reading: A psycholinguistic analysis of reading and learning to read (4th edition). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Sonnenschein, S. (1982). The effects of redundant communications on listeners: When more is less. *Child Development, 53*, 717-729.

Spieler, D.H. & Balota, D.A. (1997). Bringing computational models of word naming down to the item level. *Psychological Science, 8,* 411-416.

Stede, M. (1993). *Lexical choice criteria in language generation.* Paper presented at the 6th conference of the European Chapter of the ACL, Utrecht, The Netherlands.

Stede, M. (2000). *The hyperonym problem revisited: conceptual and lexical hierarchies in language generation.* Paper presented at the First International Natural Language Generation Conference, Mizpe Ramon, Israel.

Stevens, J. (2002). Applied Multivariate Statistics for the Social Sciences (4th ed.)

Taft, M. (1979a). Recognition of affixed words and the word frequency effect. *Memory and Cognition, 7,* 263-272.

Taft, M. (1986). Lexical access codes in visual and auditory word recognition. *Language & Cognitive Processes, 1,* 297-308.

Taft, M. (1994). Interactive-activation as a framework for understanding morphological processing. *Language and Cognitive Processes, 9,* 271-294.

Taft, M. (2004). Morphological Decomposition and the reverse base frequency effect. *The Quarterly Journal of Experimental Psychology, 57,* 745-765.

Taft, M. & Ardasinski, S. (2006). Obligatory decomposition in reading prefixed words. *The Mental Lexicon 1:2,* 183-199.

Taft, M., & Forster, K. I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning & Verbal Behavior, 14,* 638-647.

Taft, M., & Forster, K. I. (1976). Lexical storage and retrieval of polymorphemic and polysyllabic words. *Journal of Verbal Learning & Verbal Behavior, 15,* 607-620.

Underwood, G. & Batt, V.(1996). *Reading and Understanding – An Introduction to the Psychology of Reading*. Oxford, Cambridge: Blackwell Publishers.

Underwood, G., Clews, S., & Everatt, J. (1990). How do readers know where to look next? Local information distributions influence eye fixations. *Quarterly Journal of Experimental Psychology, 42A,* 39-65.

Underwood, G., Foulsham, T., van Loon, E., Humphreys, L., & Bloyce, J. (2006). Eye movements during scene inspection: A test of the saliency map hypothesis. *European Journal of Cognitive Psychology, 18,* 321-342.

Zhu, M. (1995). Children's mastering of the quantitative principle in referential communication. *Psychological Science China, 18,* 193-196.

Zwitserlood, P. (1989). The locus of the effects of sentential-semantic context in spoken-word processing. *Cognition, 32,* 25-64.

Zwitserlood, P. (1994). The role of semantic transparency in the processing and representation of Dutch compounds. *Language and Cognitive Processes, 81,* 358-367.

Zwitserlood, P. (1994). Access to phonological-form representations in language comprehension and production. In Jr. Clifton, C. Frazier, & K. Rayner (Eds.) *Perspectives on sentence processing (pp. 83-106).* Hillsdale: Erlbaum.

Zwitserlood, P., Bölte, J., & Dohmes, P. (2002). Where and how morphologically complex words interplay with naming pictures. *Brain and Language, 81,* 358-367.

APPENDICES

Appendix A: Excerpt from Stimuli used in Experiment 1-3 (Chapter 2)

Compound	1	2	3	4	5	6	7	8	9	10	11	12
Aasgeier	6.86	8.93	9.82	9	4	5	2.23	0	6	4.74	9	4.87
Brautpaar	6.29	8.62	9.3	9	5	4	2.88	2	2	2.77	8	4.14
Busenfreund	5	8.03	10.63	11	5	6	4.73	1	3	1.39	19	7.31
Donnerkeil	4.29	7.59	7.28	10	6	4	4.54	1	4	7.07	9	3.18
Fußmarsch	6.1	9.6	8.46	10	4	6	1.65	1	21	6.23	19	5.68
Futtertrog	4.14	8.13	5.67	10	6	4	1.54	1	13	4.78	1	1.39
Gartenlaube	5.45	9.89	7.26	11	6	5	2.46	1	21	5.86	2	2.71
Goldfisch	5.57	10.02	8.93	9	4	5	4.04	1	14	5.95	27	5.7
Hufschmied	4.62	5.26	7.19	10	3	7	2.23	1	4	2.56	4	2.89
Idealbild	5.8	8.36	11.22	9	5	4	2.27	0	5	3.81	113	8.31
Käsekuchen	4.85	8.29	8.28	11	5	6	2.92	1	6	2.56	7	2.64
Laubbaum	3.85	7.59	9.55	8	4	4	1.65	1	4	1.79	35	5.81
Luftblase	5.18	10.32	6.93	9	4	5	1.88	1	44	6.05	5	3.33
Maiskolben	4.99	7.76	6.5	10	4	6	2.69	1	2	0.69	3	1.1
Ohrwurm	5.68	9.11	7.5	7	3	4	4.73	0	1	2.2	7	2.83
Poststempel	5.91	10.08	7.88	11	4	7	1.38	1	23	6.84	6	4.03
Regenschirm	6.81	9.75	7.73	11	5	6	1.62	1	17	4.98	14	5.04
Reiskorn	3.43	8.28	7.67	8	4	4	1.62	1	4	5.67	10	3.64
Sauwetter	4.74	7.25	9.8	9	3	6	4.92	1	6	2.83	25	5.67
Trostpreis	5.36	8.93	10.97	10	5	5	2	2	15	5.3	49	6.86
Weinkarte	5.85	9.64	9.37	9	4	5	2.15	1	28	4.95	35	5.72

Note. 1 = logarithmized frequency of whole compound; 2 = logarithmized frequency of first constituent; 3 = logarithmized frequency of second constituent; 4 = length of whole compound (no. of letters); 5 = length of first constituent (no. of letters); 6 = length of second constituent (no. of letters); 7 = semantic transparency; 8 = onset complexity of compound; 9 = family size of modifier; 10 = logarithmized family frequency of modifier; 11 = family size of head; 12 = logarithmized family frequency of head.

Appendix B: Stimuli used in Experiments 1 to 5 (Chapter 3)

target	geometric figure	unrelated distractor	same-category distractor
Abendkleid (evening dress)	Ellipse (ellipsis)	Nudel (noodle)	Brautkleid (wedding dress)
Badeschwamm (bath sponge)	Dreieck (triangle)	Kiwi (kiwi)	Putzschwamm (cleaning sponge)
Blechdose (tin can)	Fünfeck (pentagon)	Pinsel (paint-brush)	Steckdose (socket)
Brotmesser (bread knife)	Rechteck (rectangle)	Besen (broom)	Taschenmesser (pocket knife)
Drahtbürste (wire brush)	Sechseck (hexagon)	Schraube (screw)	Haarbürste (hairbrush)
Eichenblatt (oak leaf)	Kreis (circle)	Mörser (mortar)	Ahornblatt (maple leaf)
Elektroherd (electric stove)	Sechseck (hexagon)	Flöte (flute)	Gasherd (gas stove)
Esstisch (dining table)	Ellipse (ellipsis)	Telefon (phone)	Schreibtisch (writing table)
Faschingsmaske (carneval mask)	Kreis (circle)	Diskette (disk)	Gasmaske (gas mask)
Fingerring (ring)	Fünfeck (pentagon)	Pfau (peacock)	Rettungsring (life belt)
Frühstücksei (egg)	Kreis (circle)	Kuh (cow)	Osterei (Easter egg)
Gewürzgurke (gherkin)	Rechteck (rectangle)	Kristall (crystal)	Salatgurke (cucumber)
Glasvase (glass vase)	Quadrat (square)	Pistazie (pistachio)	Keramikvase (porcelain vase)
Gummiball (rubber ball)	Ellipse (ellipsis)	Bagger (digger)	Basketball (basketball)
Haarschere (scissors)	Sechseck (hexagon)	Zucchini (zucchini)	Papierschere (scissors)
Halskette (necklace)	Trapez (trapezium)	Spiegel (mirror)	Lichterkette (fairy lights)
Handtasche (handbag)	Trapez (trapezium)	Bandage (bandage)	Sporttasche (sports bag)
Haselnuss (hazelnut)	Rechteck (rectangle)	Tafel (black board)	Erdnuss (peanut)
Hausschwein (pig)	Sechseck (hexagon)	Schädel (skull)	Wildschwein (wild pig)
Herrenschuh (man's shoe)	Quadrat (square)	Roulette (roulette)	Turnschuh (sports schoe)
Hosenanzug (trouser suit)	Dreieck (triangle)	Hummel (bumble bee)	Taucheranzug (diving suit)
Hosenknopf (trouser button)	Ellipse (ellipsis)	Mikrofon (microphone)	Jeansknopf (jeans button)
Jogginghose (track-suit trousers)	Trapez (trapezium)	Soldat (soldier)	Latzhose (dungarees)
Kaffeelöffel (teaspoon)	Fünfeck (pentagon)	Tastatur (keyboard)	Suppenlöffel (tablespoon)
Kneifzange (pincers)	Kreis (circle)	Orange (orange)	Flachzange (flat pliers)
Kochtopf (pot)	Quadrat (square)	Zirkel (compasses)	Blumentopf (flower pot)

target	geometric figure	unrelated distractor	same-category distractor
Kornblume (cornflower)	Fünfeck (pentagon)	Käfig (cage)	Ringelblume (marigold)
Kuchengabel (pastry fork)	Trapez (trapezium)	Regal (shelf)	Stimmgabel (tuning fork)
Laubsäge (fretsaw)	Quadrat (square)	Seife (soap)	Kettensäge (chain saw)
Ledermantel (leather coat)	Dreieck (triangle)	Trommel (drum)	Bademantel (bath robe)
Lederstiefel (leather boots)	Rechteck (rectangle)	Posaune (trombone)	Gummistiefel (wellingtons)
Silbermünze (silver coin)	Quadrat (square)	Esel (donkey)	Goldmünze (gold coin)
Stecknadel (pin)	Trapez (trapezium)	Glocke (bell)	Nähnadel (sewing needle)
Stehlampe (standard lamp)	Fünfeck (pentagon)	Traktor (tractor)	Taschenlampe (torch)
Vollbart (beard)	Dreieck (triangle)	Pistole (pistol)	Schnurrbart (moustache)
Vollmond (full moon)	Sechseck (hexagon)	Anker (anchor)	Halbmond (half moon)
Wassereimer (bucket)	Dreieck (triangle)	Hocker (stool)	Mülleimer (trash can)
Weinglas (wine glass)	Kreis (circle)	Zitrone (lemon)	Sektglas (champagne glass)
Windhund (greyhound)	Rechteck (rectangle)	Schloss(lock)	Schäferhund (alsatian)
Winterjacke (winter coat)	Ellipse (ellipsis)	Nagel (pin)	Lederjacke (leather jacket)

Note: The geometric figure condition was not used in Experiments 4 and 5.

ZUSAMMENFASSUNG

Der Gebrauch von Sprache ist Voraussetzung für die alltägliche Kommunikation. Das Verstehen und Produzieren von Sprache umfasst hoch automatisierte Prozesse, wie Hören, Lesen, Sprechen und Schreiben. Die im Rahmen dieser Dissertation vorgestellte Forschung konzentriert sich auf das Lesen (Sprachverstehen) und Sprechen (Sprachproduktion) morphologisch komplexer Wörter. Morphologisch komplexe Wörter sind u.a. zusammengesetzte Wörter, so genannte Komposita, wie z.B. *Weinflasche*. Ein deutsches Kompositum ist aus mehr als einem freien Morphem (Konstituente) zusammengesetzt und besteht aus einem Grundwort (*head*) und einem Bestimmungswort (*modifier*). Das Bestimmungswort definiert das Kompositum näher, z.B. ist die Weinflasche eine Flasche für Wein. Das Grundwort definiert die semantischen, kategoriellen Eigenschaften. Diese Dissertation untersucht Komposita sowohl beim Lesen als auch beim Sprechen. Lesen bedeutet die Aufnahme visueller Informationen und deren Umwandlung in Bedeutung, d.h. Forminformationen werden mit konzeptuellen Informationen verknüpft. Beim Sprechen erfolgt zunächst die Auswahl von Konzepten, welche anschließend sprachliche Informationen aktivieren. Beide Teile dieser Dissertation basieren auf experimentell durchgeführten Experimenten.

Die Experimente in Kapitel 2 umfassen eine regressionsanalytische Untersuchung des Einflusses mehrerer Faktoren, wie Wortfrequenz, Wortlänge oder semantische Transparenz auf die Verarbeitung von über 2000 Komposita während des Lesens. Modelle zur Verarbeitung morphologisch komplexer Wörter haben verschiedene Annahmen darüber wie komplexe Wörter repräsentiert sind bzw. verarbeitet werden (z.B. Baayen & Schreuder, 1999; Butterworth, 1983; Caramazza, 1997; Taft & Forster, 1975, 1976). Studien, welche Effekte der Gesamtworthäufigkeit und der einzelnen Konstituenten auf Fixationsdauern (z.B. Bertram & Hyönä, 2003) und Reaktionszeiten (z.B. Taft, 1994, 2004) zeigten, unterstützen das Zwei-Wege Modell, d.h. morphologisch komplexe Wörter werden sowohl als Gesamtwort als auch getrennt über die einzelnen Konstituenten verarbeitet. Oft wurde in diesen Untersuchungen nur ein Faktor manipuliert, wie z.B. Häufigkeit oder semantische Transparenz und faktorielle Designs eingesetzt, welche die Menge des zu untersuchenden Stimulus Material stark einschränkten.

In drei Experimenten wird der Einfluss verschiedener Prädiktorvariablen, wie Worthäufigkeit, Wortlänge, semantische Transparenz, Anfangskomplexität, Wortfamiliengröße und Wortfamilienhäufigkeit auf die Verarbeitung von 2154 Komposita beim Lesen untersucht.

Experiment 1 konzentrierte sich auf das Messen von Blickbewegungen. Die Ergebnisse zeigen einen Einfluss der Prädiktoren Häufigkeit, Länge und Wortfamilienhäufigkeit. Experiment 2 und 3 erfassten Reaktionszeiten in einer lexikalen Entscheidungsaufgabe, wobei die signifikanten Prädiktoren Häufigkeit, semantische Transparenz und Anfangskomplexität waren. Ein Unterschied in der Art des Häufigkeitseffektes zwischen Experiment 2 und 3 ist auf die Manipulation der Pseudowort-Distraktoren zurückzuführen (Taft, 2004). Zusammenfassend ist zu sagen, dass der Einfluss verschiedener Prädiktoren auf die Verarbeitung von Komposita auf die Art der abhängigen Variable zurückzuführen ist, z.B. werden Fixationsdauern auch durch visuelle Prinzipien, wie Länge geleitet. Ein stabiler Faktor, der sich sowohl in den Blickbewegungsdaten als auch in den Reaktionszeitdaten zeigt, ist der Faktor Gesamtworthäufigkeit. Des Weiteren zeigen die Daten ebenso Effekte vom gesamten Kompositum und einzelner Konstituenten, welche die Annahme einer Verarbeitung von komplexen Wörtern über ein Zwei-Wege-Modell (Baayen & Schreuder, 1999; Caramazza et al., 1988), d.h. eine Verarbeitung als Gesamtwort sowie getrennt über die einzelnen Konstituenten, unterstützen.

Die Experimente aus Kapitel 3 untersuchen unter welchen Umständen morphologisch komplexe Wörter anstelle morphologisch einfacher Wörter zur Spezifizierung von Äußerungen produziert werden. Wann wählen Sprecher ein Kompositum wie z.B. Weinflasche, um ein Objekt zu beschreiben und wann entscheiden sie sich für das morphologisch einfache Wort wie z.B. Flasche? Den theoretischen Rahmen für diese Untersuchung bildet die Maxime der Informiertheit von Grice (1975). Bezüglich dieser Maxime stellen Sprecher so viele Informationen zur Verfügung wie möglich, aber nicht mehr als nötig, um ein Objekt ausreichend zu beschreiben. Diese Maxime kann durch überspezifizierte Äußerungen der Sprecher, besonders bei nicht-linguistischen Ambiguitäten (Objekte mit visuell hervorstechenden Eigenschaften) durchbrochen werden (z.B. „*der große, weiße Vogel*“ anstatt „*der weiße Vogel*“; Deutsch & Pechmann, 1982). Linguistische Ambiguitäten, häufig im Kontext kategoriell verwandter Objekte, werden dagegen seltener vermieden (siehe auch Ferreira et al., 2005).

In fünf Experimenten wurde untersucht unter welchen Umständen, Sprecher komplexe Wörter (z.B. Wassereimer) nutzen um ein Objekt zu beschreiben, obwohl die bevorzugte Benennung für dieses Objekt morphologisch einfach ist (Eimer). Dafür wurde das Bild-Bild Paradigma eingesetzt. Die Versuchspersonen bekamen über einen Hinweisreiz signalisiert, welches von zwei präsentierten Objekten benannt werden sollte. In der kritischen Bedingung gehörten die Distraktorobjekte zur gleichen semantischen Kategorie wie die Targetobjekte

(Mülleimer). In dieser Bedingung ist die morphologisch komplexe Benennung des Targets, nämlich Wassereimer, eine nicht-ambige Äußerung. Die komplexe Benennung ist hier notwendig, um die beiden Objekte voneinander zu differenzieren. Die Experimente zeigen, dass Sprecher Schwierigkeiten haben die bevorzugt morphologisch einfache Benennung zu überwinden. Erst mit der Instruktion die Objekte so genau zu beschreiben, so dass jemand anderes das Targetobjekt genau identifizieren kann, und mit einer Verlängerung der Dauer der Objektpräsentation nach Erscheinen des Hinweisreizes, produzierten die Sprecher mehr nicht-ambige komplexe Antworten als ambige einfache Antworten. Die Ambiguität der Äußerungen ist komplett aufgehoben, wenn das Distraktor-Bild vor dem Target-Bild benannt werden sollte. Die Ergebnisse zeigen, dass ausreichend Zeit für die Konzeptualisierung und Formulierung der Äußerung notwendig ist, um das Zielobjekt so zu benennen, so dass es in einem Kontext kategoriell verwandter Objekte zu identifizieren ist.

Zusammenfassend zeigen die Resultate des Kapitel 2, dass Worthäufigkeit ein robuster Faktor ist und die Verarbeitung von Komposita während des Lesens beeinflusst. Der Faktor Häufigkeit spielt nicht nur im Sprachverstehen eine wichtige Rolle, sondern auch in der Sprachproduktion. Es gibt Belege, dass 1) Objekte mit hoher Worthäufigkeit schneller benannt werden als Objekte mit niedriger Worthäufigkeit (Oldfield & Wingfield, 1965), 2) Worthäufigkeit der Ebene der Wortformen zugeordnet ist (Jescheniak & Levelt, 1994) und 3) Effekte der Konstituentenhäufigkeit für eine getrennte Verarbeitung komplexer Wörter spricht (Bien et al., 2005). Definiert man den Faktor Worthäufigkeit als die Häufigkeit des Vorkommens von Wörtern im Sprachgebrauch, könnte Worthäufigkeit ebenso Einfluss auf die Auswahl von Äußerungen bei Objektbenennung haben. Ist die bevorzugte morphologisch einfache Benennung der Targetobjekte in Kapitel 3 nicht auch die häufigere? Obwohl die Experimente des dritten Kapitels den Faktor Häufigkeit nicht kontrollierten, kann man sich vorstellen, dass die bevorzugte einfachere Benennung die häufigere ist. Zum Beispiel hat das Wort Glas (Häufigkeitsklasse: 10) eine höhere Häufigkeit als das komplexe Wort Weinglas (Häufigkeitsklasse: 16). Der Faktor Worthäufigkeit könnte nicht nur dem Level der Wortformen zuzuschreiben sein, sondern einem wesentlich höherem Level, nämlich dem konzeptuellen semantischen Level. Häufigkeit hat nicht nur Einfluss auf die Verarbeitung komplexer Wörter beim Lesen, sondern auch auf die lexikale Auswahl und damit die Produktion komplexer Wörter.

CURRICULUM VITAE

Andrea Böhl, geb. Krupik wurde in Teterow, Deutschland, am 16 März 1979 geboren. Nach dem Abitur am Gymnasium Teterow 1997, verbrachte sie einen 1-jährigen Auslandsaufenthalt in London, England. Anschließend studierte sie Anglistik und Amerikanistik mit den Schwerpunkten Linguistik und Kultur, Psychologie und Zivilrecht an der Universität Potsdam, wo sie 2003 den Abschluss Magistra Artium erhielt. Während ihres Studiums war sie als Studentische Hilfskraft in der Bibliothek der Universität Potsdam beschäftigt. Von 2003 – 2004 arbeitete sie als Praktikantin im Referat für Schulaufsicht Primarstufe und Förderschulen, Übergreifende Themenkomplexe, des Ministeriums für Bildung, Jugend und Sport des Landes Brandenburg. Anschließend war sie als Praktikantin am Deutschen Bundestag in Berlin und im Bürgerservice der Bundestagsabgeordneten Andrea Wicklein in Potsdam tätig. Von April 2004 bis März 2007 arbeitete sie als wissenschaftliche Mitarbeiterin und Doktorandin im Bereich Psycholinguistik am Psychologischen Institut II für Allgemeine und Angewandte Psychologie der Westfälischen Wilhelms-Universität Münster.