Stefanie Regel: The Comprehension of Figurative Language : Electrophysiological Evidence on the Processing of Irony. Leipzig: Max Planck Institute for Human Cognitive and Brain Sciences, 2009 (MPI Series in Human Cognitive and Brain Sciences; 111)

The comprehension of figurative language: Electrophysiological evidence on the processing of irony

Impressum

Max Planck Institute for Human Cognitive and Brain Sciences, 2009

Published also online at the
Institutional Repository of the University of Potsdam:
URL http://opus.kobv.de/ubp/volltexte/2009/3337/
URN urn:nbn:de:kobv:517-opus-33376
[http://nbn-resolving.org/urn:nbn:de:kobv:517-opus-33376]

Druck: Sächsisches Druck- und Verlagshaus Direct World, Dresden

ISBN 978 3-936816-85-9

The comprehension of figurative language: Electrophysiological evidence on the processing of irony

Der Humanwissenschaftlichen Fakultät der Universität Potsdam

eingereichte

DISSERTATION

zur Erlangung des akademischen Grades

doctor philosophiae

Dr. phil.

vorgelegt

von Stefanie Regel

geboren am 20. Januar 1979 in Karl-Marx-Stadt

2008

Dekanin: Prof. Dr. Ria de Bleser

Gutachter: Prof. Dr. Angela D. Friederici

PD Dr. Evelyn Ferstl

Tag der Verteidigung: 13.03. 2009

Acknowledgements

This thesis could not have been accomplished without the support and contribution of many people. In particular, I would like to thank Prof. Angela Friederici who gave me the opportunity, and the support to conduct this work at the Max Planck Institute for Human Cognitive and Brain Sciences.

I am also grateful to Prof. Angela Friederici and PD Dr. Evelyn Ferstl for agreeing to review this thesis.

My special thanks go to Dr. Thomas Gunter for his excellent advisory support, his valuable comments and suggestions, and for reading and re-reading various versions of this work.

I would also like to thank Prof. Seana Coulson for motivating discussions.

For introducing me to the methodology of ERP research I am grateful to Dirk Köster. My colleagues Jens Brauer and Beate Sabisch, Jörg Bahlmann, Henning Holle and Christian Obermeier I would like to thank for their helpful suggestions and discussions along this way.

Further, I like to thank Cornelia Schmidt and Kristiane Werrmann for their help with the acquisition of the ERP data, and especially Kerstin Flake for her expert advice with the graphic design and illustration.

I am deeply grateful to Berno Wrobel and my parents Ulrich and Kristina Regel for their continuous and unconditional support.

Contents

Acknowledgments ..... **iii**

Introduction **1**

I Theoretical and empirical background **3**

1 Figurative language comprehension **5**

1.1 Characteristics of irony 5

1.1.1 Defining irony 6

1.1.2 Characteristics of verbal irony: The identification of language-accompanying cues 7

1.1.3 Pragmatic approaches on irony 8

1.2 Psycholinguistic approaches on figurative language 10

1.2.1 The standard pragmatic model 11

1.2.2 The direct access view 13

1.2.3 The graded salience hypothesis 15

1.2.4 Implications for neurophysiological investigation of irony comprehension 17

2 Event Related Brain Potentials **19**

2.1 Electroencephalography 19

2.2 Event-related brain potentials 21

2.3 Language-related ERP components 22

2.3.1 The P200 component 23

2.3.2 The LAN component 24

2.3.3 The N400 component 25

2.3.4 The P300 component 26

2.3.5 The P600 component 27

3 Neurophysiological and -psychological evidence of figurative language comprehension **33**

3.1 Evidence from ERP studies 33

3.2 Evidence from lesion studies 36

3.3 Evidence from neuroimaging studies 40

II Experiments **45**

4 Experiment 1: Auditory processing of irony **47**
4.1 Introduction 47
4.2 Participants 50
4.3 Methods 50
4.3.1 Stimulus material 50
4.3.1.1 Pretests 52
4.3.1.2 Prosodic analyses 53
4.3.2 Procedure 55
4.3.3 Data acquisition and analysis 56
4.4 Results 57
4.5 Discussion 60

5 Visual processing of irony **67**
5.1 Experiment 2: Visual processing of irony with regard to explicit cueing 67
5.1.1 Introduction 67
5.1.2 Participants 69
5.1.3 Methods 69
5.1.3.1 Stimulus material and procedure 69
5.1.3.2 Data acquisition and analysis 70
5.1.4 Results 71
5.1.5 Discussion 74
5.2 Experiment 3: The processing of cued and uncued irony 78
5.2.1 Introduction 78
5.2.2 Participants 79
5.2.3 Methods 79
5.2.3.1 Stimulus material and procedure 79
5.2.3.2 Data acquisition and analysis 79
5.2.4 Results 80
5.2.5 Discussion 83

6 Experiment 4: The influence of pragmatic knowledge on irony comprehension **87**
6.1 Introduction 87
6.2 Participants 89
6.3 Methods 90
6.3.1 Stimulus material 90
6.3.2 Procedure 92

6.3.3 Data acquisition and analysis 92
6.4 Results 92
6.4.1 Session 1: Behavioral and ERP data 92
6.4.2 Session 2: Behavioral and ERP data 96
6.4.3 Comparison of the ERP data obtained for Session 1 and 2 99
6.5 Discussion 100
6.6 Conclusion 106

7 Specification of irony-related ERP effects 107
7.1 Experiment 5: Influences of task demands and probability of occurrence 108
7.1.1 Introduction 108
7.1.2 Participants 110
7.1.3 Method 110
7.1.3.1 Stimulus material 110
7.1.3.2 Procedure 111
7.1.3.3 Data acquisition and analysis 111
7.1.4 Results 112
7.1.5 Discussion 117
7.2 Experiment 6: Comparison of irony- and syntax-related P600 effects 120
7.2.1 Introduction 120
7.2.2 Participants 122
7.2.3 Methods 122
7.2.3.1 Stimulus material and procedure 122
7.2.3.2 Data acquisition and analysis 123
7.2.4 Results 123
7.2.5 Discussion 126
7.3 Conclusion 131

8 General discussion 133
8.1 Implications for psycholinguistic models of figurative language comprehension 138
8.2 The influence of cueing on the processing of irony 142
8.3 Concluding remarks 145

References 147

List of Figures 163

List of Tables 164

Introduction

Human language faculty enables us to communicate and interact with each other by exchanging information, expressing opinions and attitudes, and realizing various aims such as planning or debating. Still, communication is often not straightforward, as many aspects of what we are saying are not explicitly stated in an utterance but need to be interpreted by means of pragmatic and common world knowledge. This is especially the case when comprehending figurative language. Figurative (or non-literal) utterances encompass additional information associated with the contextual situation in which they occur, and convey more subtle and often different meanings that go beyond literal sentence meanings. In order to comprehend non-literal utterances, contextual information plays an important role in determining a speakers' intended meaning. The issue when and how contextual information is integrated in understanding figurative sentences, and whether literal sentence meanings need to be fully processed is examined by the present dissertation.

Human language comprehension is a highly complex cognitive process which requires the processing and integration of different types of linguistic information such as phonologic, semantic, syntactic and pragmatic information. This process is assumed to rely on various subprocesses specified for these different types of information, and to involve interactions between these processes. Despite the nature of the subprocesses is generally accepted, less agreement exists on how and when these processes interact. According to Friederici (1999, 2002), visual or acoustic language input has to be perceived and analyzed by peripheral input systems. After recognizing an acoustic signal as speech, the language input will be further analyzed on the phonological processing level resulting in a phonological representation (i.e.,, the segmentation of the signal constituents). Based on this representation the system is able to access and retrieve lexical information from the mental lexicon. This process is referred to as lexical access, and allows the retrieval of semantic and morphosyntactic information of a word. By means of syntactic information about the word's category and its potential grammatical relations, the combination of words to phrases, and to sentences is enabled (i.e., the construction of an appropriate syntactic structure). However, language comprehension that goes beyond the sentence level appears to be a rather constructive and context-dependent process whereby sentence representations have to be integrated with general world knowledge. Comprehending sentences embedded in discourse contexts often requires the understanding of speakers' motives and intentions, and comprises inference processes that are necessary for establishing a coherent representation of an utterance.

While research on language comprehension has mainly focused on the processing of syntactic and semantic information, processing mechanisms underlying the comprehending of pragmatic information are yet only partly understood. In this context, research on figurative language comprehension can shed light on understanding of implied sentence meanings, which have been expressed in an indirect way. Among several types of figurative language irony is a common and frequently occurring figure of speech (Gibbs, 1994; Holtgraves, 2001) that is used to convey speakers' beliefes and attitudes to situational events, and thus serves a variety of social and communicative functions. As irony is a highly complex linguistic phenomenon, this makes it a very interesting object of investigation from a linguistic and cognitive perspective. Research on irony can provide insights into how language is used to gain social goals, how intentions and attitudes are expressed among interlocutors, and how implied ironic meanings can be understood. Main emphasis of this dissertation is placed on this latter issue about what processing mechanisms are involved in the comprehension of irony, and in particular the time-course of irony processing. Besides, influences of contextual constraints by means of diverse language-accompanying cues will be investigated.

In the first part of this dissertation theoretical, methodological and empirical background information will be presented. **Chapter 1** comprises an introduction to figurative language and especially to irony, and outlines main theoretical approaches on figurative language comprehension. In **Chapter 2** an overview on the ERP methodology and relevant ERP components will be provided. **Chapter 3** summarizes important findings from different neurophysiological and neuropsychological studies on figurative language comprehension. In the second part of this dissertation a series og six ERP experiments on the processing of irony will be presented. In **Chapter 4**, Experiment 1 is introduced that investigated auditory sentence comprehension mechanisms involved in comprehending ironic utterances. **Chapter 5** focuses on visual sentence comprehension with regard to the influence of additional cueing by means of quotation marks (Experiment 2 and 3). In **Chapter 6**, the influence of pragmatic knowledge about a speaker's use of irony is studied (Experiment 4). Further experiments (Experiment 5 and 6) were conducted to specify the findings in response to irony that have been observed in the previous experiments (**Chapter 7**). Finally, in **Chapter 8**, the findings from the different experiments are reviewed and discussed in relation to theoretical approaches on figurative language comprehension (introduced in Chapter 1).

Part I

Theoretical and empirical background

Chapter 1

Figurative language comprehension

Research on figurative language has been conducted from different linguistic perspectives including theoretical linguistics, pragmatics and psycholinguistics, and led to a variety of theoretical and methodological approaches. In this chapter, main linguistic research traditions on verbal irony are outlined that describe characteristics and functions of ironic utterances. Special emphasis is put on the psycholinguistic perspective of figurative language comprehension. Since verbal irony conveys different meanings that go beyond literal sentence meanings, irony raises some interesting research questions onto how and when such implied figurative meanings are processed. Three approaches on figurative language comprehension, i.e., the *standard pragmatic model*, the *graded salience hypothesis*, and the *direct access view*, will be discussed with regard to proposed processing mechanisms, especially the timing of processing.

1.1 Characteristics of irony

When people are engaged in an informal conversation, they almost inevitably use irony to express something more or different than stated by the literal sentence meaning. For instance, imagine two friends who have planned going to the theatre. One of them promised to buy the tickets but then forgot to do it. Only few hours before the show starts, he remembers his promise and tells his friend that he has forgotten to buy the tickets. His friend is quiet disappointed and might reply in the following way:

(1) *Oooh, wow!*
(2) *Fantastic. / Great.*
(3) *Well done.*
(4) *That's terrific news! / What a surprise!*
(5) *I wasn't looking forward to it anyway.*
(6) *Really?*

The examples given are all instances of verbal irony which is in the focus of this dissertation. These examples illustrate that verbal irony can occur on different linguistic levels comprising interjections (1), one-word (2) or two-word phrases (3), exclamations (4), ironic understatements (5), or rhetoric questions (6). Common for all forms of

verbal irony is that they refer to a preceding event in an evaluative way and express a speaker's attitude to it. For the most part this evaluation occurs in the form of ironic criticism and less commonly in the form of ironic praise. How a speaker's intended attitude is conveyed, and how irony can be distinguished from literal language is pointed out in the following section. Before describing linguistic characteristics in more detail, attempts of defining irony will be briefly introduced. Pragmatic approaches are outlined just as far as they address the understanding of irony.

1.1.1 Defining irony

The problem of defining irony has been aptly pointed by Gibbs and O'Brien (1991) in stating "*The irony of irony is that we can often recognize ironic situations and language even though we have a terrible time trying to define irony*" (Gibbs & O'Brien, 1991, p.523). Etymologically, the term irony is derived from the Greek words 'eironeia' or 'eiron' and holds various meanings like affected ignorance, dissimulation, or derision (Pfeifer, 1995). In contemporary theories on irony four major meanings are distinguished, which refer to a particular behavior or attitude of a person (irony as philosophy of life), to situations containing an unexpected and inconvenient event (situational irony), to a fictional text in which a character does not understand the implied meaning of an expression (dramatic irony), or to a form of figurative language (verbal irony). This conceptual variation and relative vagueness of the term was one reason that irony has been considered interdisciplinary within philosophy, rhetoric, the study of literature[1], and linguistics. In consequence, by now there is no unified definition of its meaning but rather more discipline-specific views on this phenomenon (for review see the works of Hartung, 1998; Japp, 1999; Kaufer, 1981; Lapp, 1992). Likewise, a clear distinction between irony and sarcasm has not been established so far. Sarcasm is usually defined as a more aggressive form of irony directed to an individual, and intended to hurt somebody. In comparison, irony is often characterized by a kind of milder criticism that can be used to refer to someone's behavior, as well as to unexpected situations. Sarcasm and irony are often closely related to each other concerning the manner of talking but not the degree of criticism (Attardo, 2000; Haiman, 1998). From a linguistic perspective, irony is typically defined as a type of figurative language (or figure of speech) that conveys an opposite meaning, or at least different meanings of

[1] Rhetoricians used the term irony to denote to a specific rhetoric method to attain knowledge by pretending, mocking, or jesting, which has been referred to as *Socratic Irony*. The study of literature, especially during romanticism, understood irony as a philosophic and existential concept for destroying illusions (see Muecke, 1986; Stojanovic, 1991). In philosophy, irony has been associated with someone's worldview and manner of existence. According to Søren Kierkegaard irony is a mode of existence by which the subject is able to be free in a negative way (Japp, 1999).

what has been stated literally. In this way, verbal irony is considered as an allusion as well as "*the attribution of a thought, a propositional or conceptual content or a meaning*" (Wilson, 2006, p.1740). The classical definition of saying the opposite of the literal sentence meaning is employed as working definition in this dissertation. The examples of irony presented in the experiments are based on such contrarity in meaning, so that the classical description is applicable. Yet, this definition is controversially debated with respect to its general validity for diverse forms of verbal irony as well as its notion of oppositeness. For instance, irony in the form of interjections or rhetoric questions (see example 1 and 6) conveys some connotations of the literal meaning but not an opposite meaning of it. As there are forms of irony that are not based on an inconsistency between what has been said and actually meant, this definition cannot cover the phenomenon on the whole. Besides, there is much controversy about what the opposite meaning refers to, and what the literal meaning in fact denotes (see Gibbs, 2001; 2002). Accordingly, further approaches have been constructed mainly within pragmatics to resolve these difficulties in defining irony. Some of the most influential ones will be concisely described in section 1.1.3.

1.1.2 Characteristics of verbal irony: The identification of language-accompanying cues

Recognizing irony largely depends on the degree of incongruity between the situational context and the utterance itself (Barbe, 1995; Williams, 1984). The greater this contrast the easier it is to perceive an utterance as ironic. This was shown by experimental manipulations of contextual strength (Colston & O'Brien, 2000; Gerrig & Goldvarg, 2000; Ivanko & Pexman, 2003; Utsumi, 2000), and the use of negation markers (e.g.,, *not*) inserted in ironic statements (Giora, Fein, Ganzi, Alkeslassy, & Sabah, 2005). Despite that, successful understanding of irony seemed to be affected by verbal and paraverbal characteristics of the utterance. Earliest linguistic research into irony began in the 1960s by determining formal characteristics of ironic utterances, specifically their linguistic and communicative characteristics. Verbal irony was shown to be accompanied by additional cues that distinguish ironic utterances from non-ironic ones, and are effective in emphasizing deviance in meaning. By enhancing the inconsistency between the ironic and literal sentence meaning, these additional cues were assumed to facilitate the recognition and comprehension of irony.

In examining samples of various corpora, a diversity of verbal and paraverbal cues was found to accompany irony. For example, prosodic cues consisting of variations in duration, pitch and intensity have been identified in comparison to prosodic characteristics of non-ironic utterances (Anolli, Ciceri, & Infantino, 2000; Rockwell, 2000;

Weinrich, 1966). In analyzing conversational utterances, sarcastic utterances were seen to be marked by longer duration, higher pitch and a wider pitch range in comparison to literal utterances (Rockwell, 2007). Similarly, in a study by Anolli, Ciceri and Infantino (2000) higher pitch values were also seen for irony relative to non-ironic utterances. Besides prosodic marking, lexical cues such as lexemes from other sociolects and dialects, or archaic words have been identified as further markers of irony (Clyne, 1974). Similar functions have been revealed for using other types of figures of speech such as repetition, hyperbole, litotes or understatement when applied to contexts where they appear inappropriately (Giessmann, 1977; Giora, et al., 2005; Weinrich, 1966). As syntactic features indicating ironic meanings, highly complex noun phrase constructions were determined (Clyne, 1974). In addition, applying visual cues in the form of punctuation characters, e.g., quotation marks, and emoticons, or using commenting phrases, like *Isn't ironic,* explicitly signal speakers' intentions (Barbe, 1995). Apart from verbal cues, gestures and facial expressions have also been described as cues for ironic interpretations (Attardo, Eisterhold, Hay, & Poggi, 2003; Groeben & Scheele, 1986; Hartung, 1998; Rockwell, 2001). Furthermore, a number of non-verbal cues such as socio-cultural information about speakers' gender or occupation were shown to influence the comprehension of irony (Colston, 2005; Katz & Pexman, 1997; Pexman & Olineck, 2002). These cues were provided by contextual information and enriched participants' pragmatic knowledge.

To conclude, linguistic research into the characteristics of irony described a great diversity of verbal, paraverbal and non-verbal cues that can accompany irony. All these cues emphasize a deviance in utterance meaning with varying degree, e.g., most obviously by visual marking or commenting phrases. Due to variation in complexity and strength between various cues accompanying irony, in the current experiments a clearly defined subset, i.e., prosodic, visual and pragmatic cues, is chosen for investigation.

1.1.3 Pragmatic approaches on irony

In dissociation of the classical view on irony, within pragmatics different approaches on verbal irony have been developed. One of them treats irony as 'echoic use of language' (Sperber & Wilson, 1981; Wilson, 2006). Therein, speakers allude to attributed thoughts from which they dissociate themselves in the form of quoting opinions of other persons. In using irony the literal sentence meaning is expressed, but an ironic comment is mentioned (echoed) as object of contempt or disapproval. For comprehending intended meanings ironic utterances need to be interpreted as an echo of either an implicit expectation or cultural norm, or an explicit event that occurred previously. By implication, the literal meaning of an ironic utterance is supposed to correspond with intended

meanings and not to convey opposite meanings. Following the echo theory, further pragmatic approaches such as the 'echoic mention theory' (Jorgensen, Miller, & Sperber, 1984) and the 'echoic reminder theory' (Kreuz & Glucksberg, 1989) were developed. Both theories adapted the echo theory in accentuating more strongly respective functions of irony such as mentioning or reminding expectations of the speaker. By contrast, 'pretense theories' are stronger aligned to rhetoric definitions of irony in which irony is treated as a type of pretense (Clark & Gerrig, 1984; Kumon-Nakamura, Glucksberg, & Brown, 1995). Accordingly, the speaker pretends to express a particular opinion (i.e., mostly to compliment) that at the same time is intended to be recognized as pretense (Clark & Gerrig, 1984). In a more hybrid model incorporating some elements of the pretense theory, irony is described as allusional pretense (Kumon-Nakamura, et al., 1995). Common for the pragmatic approaches mentioned above is that irony is considered as device for drawing attention to the discrepancy between expected and actual events but not to the untruthfulness of an utterance. Both echoic and pretense views on irony are very useful for a comprehensive description of the phenomenon but fail to distinguish irony from other expressions such as indirect speech acts that similarly allude or remind to expected events. Besides to those pragmatic approaches, irony has also been described in terms of the speech act theory[2] by defining ironic utterances as illuctionary and perlocutionary acts (see Amante, 1981; Eggs, 1979; Groeben & Scheele, 1986; Haverkate, 1990). In the next paragraph merely main pragmatic functions of irony will be pointed out.

Several communicative functions accomplished by ironic utterances have been identified, which can comprise a variety of effects. Irony can be used to express personal attitudes and beliefs in an indirect way (Williams, 1984), to highlight a disparity between expectation and reality (Colston & O'Brien, 2000; Ivanko & Pexman, 2003; Kreuz & Glucksberg, 1989), or to allude or remind to unfulfilled expectations (Jorgensen, et al., 1984; Kreuz & Glucksberg, 1989; Kumon-Nakamura, et al., 1995; Sperber & Wilson, 1981). Moreover, using irony has also several effects on social interaction between interlocutors. The use of irony allows a speaker to appear humorously, to elevate one's status, or to act less aggressively by muting criticism (Dews, Kaplan, & Winner, 1995; Kreuz, Long, & Church, 1991; Kumon-Nakamura, et al.,

[2] The 'theory of speech acts' is based on the work of John L. Austin 'How to do things with words', which aims to define the uses of language. This theory was further developed and published by John R. Searle in 1969 (Searle, 1969). Central to the speech act theory is that utterances do not have a fixed meaning but need to be described in terms of their communicative actions as particular types of speech acts. In principle, each speech act can be distinguished into four types that are simultaneously performed, i.e., the locutinary act, the propositional act, the illuctionary act, and the perlocutionary act (Searle, 1997). While the illocutionary act accomplishes the *speech act* as such, e.g. apologizing or making a request, the perlocutionary act defines effects on the speaker, e.g. convincing or inspiring someone.

1995). Achieving emotional control and provoking reactions can also be accomplished in using irony (Dews & Winner, 1995; Lee & Katz, 1998; Roberts & Kreuz, 1994). Related to its pragmatic functions, irony has been assumed to involve several cognitive processes for understanding intended meanings. Comprehending ironic meanings requires recognizing the speaker's intention by taking perspective with that speaker, as well as evaluating contextual situations in which irony occurred (Colston, 2005; Colston & Gibbs, 2002; Holtgraves, 2000; 2005). Thus, for understanding irony pragmatic as well as common world knowledge has to be retrieved in order to interpret implied figurative meanings beyond literal sentence meanings. In the subsequent sections psycholinguistic approaches on figurative language comprehension will be described in detail.

1.2 Psycholinguistic approaches on figurative language

Psycholinguistic research on figurative language comprehension focuses on processing mechanisms underlying the interpretation of metaphors, irony or idioms and proverbs. The diversity of these figures of speech makes it difficult to explain the specific nature of the processes by one processing mechanism. Despite all types of figurative language express non-literal meanings, differences exist in their conceptual and functional characteristics that entail the involvement of distinct cognitive processes in comprehension. For example, metaphors and analogies are based on association between two concepts, which requires linking of semantic features between these two concepts[3] (Bowdle & Gentner, 2005; Coulson, 2001). Other types of speech figures such as metonymies (e.g., *Shakespeare is on the top shelf*) involve replacement of relevant meanings since a semantic entity is used to refer to other parts of it (Frisson & Pickering, 1999). Still, a common question addressed in figurative language research is whether literal meanings have to be activated before appropriate figurative meanings can be derived, or whether figurative meanings can be processed rather directly. Moreover, when and how contextual information affects comprehension processes goes along with this question. Most instances of irony are based on an incongruity between the literal and figurative sentence meaning and become obvious in regard to foregoing contextual information. Except for few instances in which irony became lexicalized, e.g., *fat chance* or *a precious lot* (see Seto, 1998; Sperber & Wilson, 1998), the interpretation of an ironic

[3] Metaphors such as *life is a journey* are based on a comparison between seemingly unrelated semantic categories from different domains. For comprehending metaphoric meanings semantic features need to be linked, or conceptually blended, by means of changing attributes of the focused concept (Coulson, 2001; Gernsbacher, Keysar, Robertson, & Werner, 2001). Note that an alternative view on metaphor comprehension has been suggested by Glucksberg (2001, 2003) who argued that processing metaphorical meanings relies on categorical assertions, and not on a comparison.

statement largely depends on the foregoing context, and thus is situation specific. Besides supportive contexts, prerequisites for comprehending irony is the ability of perspective taking with the speaker (Colston, 2005; Holtgraves, 2005), and general world knowledge shared between hearer and speaker (Gerrig & Horton, 2005). In the following, three influential psycholinguistic approaches are discussed with respect to their assumptions on the timing of irony processing. A brief review on behavioral findings in support of respective models is outlined as well.

1.2.1 The standard pragmatic model

In psycholinguistics, the 'standard model of pragmatics' has been evolved from the work of Grice (1975) and (Searle, 1979) and is one of the earliest and most influential approaches on the comprehension of figurative language. Following Grice's cooperative principle (1975) this model presumes that interlocutors contribute to an efficient and successful conversational exchange by conveying truthful, relevant and clear information. Figurative utterances are assumed to violate this principle, and in consequence to require additional processing extending over multiple phases of processing. The cooperative principle is divided into four conversational subprinciples (referred to as Gricean maxims[4]) that are related to truthfulness, adequacy, relevance, and manner of someone's conversational contributions (Grice, 1975). In case one of these maxims has been violated, utterances need to be interpreted at some deeper level, which often involves conversational implicatures (i.e., implications necessitated in conversations to derive implicitly stated meanings) to conform an utterance with communicative constraints of this principle. According to this view, irony is considered as violation of the truthfulness maxim that requires construction of a new meaning consistent with the context in which it occurred (Grice, 1975, 1989). From a psycholinguistic perspective this implies that ironic utterances are comprehended by multi-phasic processing. During initial phases of processing the literal meaning of an ironic utterance is fully activated thereby causing a semantic incoherence during integration of this meaning into the foregoing discourse context. During later phases of processing incompatible literal meanings need to be rejected, and additional inferential processes become necessary for deriving appropriate ironic meanings. By implication, the *standard pragmatic model*

[4] The Gricean maxims are classified into the maxim of quality '*Do not say what you believe to be false*', quantity '*Make your contribution as informative as is required for the current purpose*', relation '*Make your contribution relevant*', and manner '*Be perspicuous and specifically*' (Grice, 1975, 1989). These maxims are related to different criteria of conversational utterances such as truthfulness or relevance, and jointly form the cooperative principle. This principle describes pragmatic principles for an effective conversation by stating: "*Make your contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which you are engaged*" (Grice, 1975, p.47).

proposes a serial processing with temporal priority of linguistic information over contextual information. Lexical-semantic processes are suggested to be initially autonomous, and not to interact with contextual information from wider discourse contexts. Corresponding with the *standard pragmatic model* figurative language comprehension is proposed to require further processing in terms of reinterpretation after failure of a consistent utterance interpretation concurrent with the context.

Behavioral evidence for the predictions of the standard pragmatic model

The predictions of the *standard pragmatic model* have been tested by a number of behavioral studies by comparing response times for judging or reading figurative and literal sentences. In the following two studies on irony processing that provided evidence in favor of the *standard pragmatic model* will be outlined in more detail. In two experiments Dews and Winner (1999) measured judgment times in response to discourses whose final sentences achieved either an ironic meaning, or a non-ironic meaning. As ironic instances two types of irony, i.e., ironic praise and criticism, were investigated. Longer reaction times have been observed when judging the evaluative tone of both ironic criticism and ironic praise compared to their equivalent non-ironic meanings. Dews and Winner (1999) interpreted these differences in reaction times in support of the assumptions of the *standard pragmatic model*, and argued that some aspects of the literal meaning always have to be processed during the comprehension of verbal irony. Accordingly, computing appropriate ironic meanings was suggested to take part after initial activation of literal sentence meanings. Moreover, in a study by Schwoebel, Dews, Winner and Srinivas (2000) further evidence in support for the *standard pragmatic model* was supplied in showing longer reading times for ironic sentences expressing criticism compared to their literal equivalents. Reading times were measured at three phrases of an utterance, whereby the second phrase contained the critical word for either ironic or non-ironic interpretations. During the critical utterance phrase ironic criticism took longer to read than the same sentence when preserving its literal meaning. These results were taken as evidence for initial activation of literal meanings when processing irony (Schwoebel, et al., 2000). In addition, it was suggested that for deriving appropriate interpretations discrepancy between literal and ironic sentence meanings need to be recognized. Despite that reading times are online measures that can detect differences in the overall timing of language processing, they cannot reveal at what exact point in time the processing of sentences or phrases diverges. Thus, whether comprehension of ironic and literal utterances differs due to additional processing costs in detecting a semantic discrepancy or in deriving intended meanings ought to be studied in more detail by using a methodology with a higher temporal resolution preferable electrophysiological measures.

1.2.2 The direct access view

A more recent approach on figurative language comprehension was offered by Gibbs (1994, 2002). He suggested similar processing mechanisms for the processing of figurative and literal language, which was put forward in the '*direct access view*'. According to this view, the comprehension of figurative language does not involve any additional cognitive processes (Gibbs, 1994; Gibbs & Moise, 1997). This assumption is based on the notion that comprehending literal as well as non-literal meanings of a sentence largely depends on pragmatic knowledge[5], and listeners' figurative modes of thought (Gibbs, 1994, 2002). Furthermore, Gibbs suggests that literal and non-literal meanings are not distinct from each other since they are both determined by contextual information. This implies that speakers' intended meanings are isomorphic to literal meanings of the same sentence. In principle, by means of contextual information listeners can define what speakers say prior or as part of their understanding of what speakers intend to communicate (Gibbs, 1999a). Therefore, comprehending sentences that achieved figurative meanings has been proposed to be not more difficult than equivalent literal meanings, since both meanings might be extracted out of the foregoing context.

In assuming an initial influence of context, the *direct access view* is in tradition of interaction-based accounts by suggesting that contextual information is immediately incorporated into processing of linguistic information (cf. MacDonald, Pearlmutter, & Seidenberg, 1994; McClelland, St. John, & Taraban, 1989; Trueswell, Tanenhaus, & Garnsey, 1994). Accordingly, intended figurative meanings are supposed to be understood directly and effortless if figurative sentences were embedded in highly constraining contexts. Contextual information is assumed to interact with lexical-semantic processes from initial phases of processing on. Literal sentence meanings do not have to be entirely analyzed and later on rejected, before intended figurative meanings can be constructed. By use of pragmatic knowledge together with contextual information, the analysis of some aspects of word meaning is sufficient for understanding intended figurative meanings (Gibbs, 1999a, 2002). Thus, intended and contextually compatible meanings can be understood directly without leading to an incompatibility during semantic information processing. Following the *direct access view*, comprehension processes are similar for the processing of both figurative and literal language, and may not diverge because of figurativity.

[5] According to Gibbs and colleagues, for comprehending sentence meanings different aspects of pragmatic knowledge are required. Whereas primary pragmatic knowledge includes information from general world knowledge about beliefs and attitudes that are shared by both speakers and listeners, secondary pragmatic knowledge is related to specific information about particular contexts. Both kinds of pragmatic knowledge are assumed to exist along a continuum whereby primary pragmatic knowledge is presumed to be more salient, and to be immediately used for the interpretation of an utterance (Gibbs, 1999a, 1999b; Gibbs & Moise, 1997).

Behavioral evidence for the predictions of the direct access view

Evidence in favor of the *direct access view* stems from behavioral studies that showed similar reading and reaction times for the comprehension of both literal and figurative sentences. Such reaction and reading time patterns were seen for metaphors (Glucksberg, 1998; Glucksberg & Keysar, 1990), proverbs (Katz & Ferretti, 2001; Turner & Katz, 1997), as well as irony (Gibbs, 1986; Gibbs, O'Brien, & Doolittle, 1995). Results of three experiments, in which reading times for sarcastic and non-sarcastic remarks such as *You're a fine friend* were compared, showed that people did not take longer to read sarcastic than non-sarcastic sentences when embedded in adequate supportive contexts (Gibbs, 1986). Even more, for sarcastic interpretations slightly faster reading times were observed relative to equivalent literal interpretations. The processing of sarcasm occurred to be dependent on contextual information, since faster reading times were seen for sarcastic utterances following contexts that explicit echoed violated beliefs and social norms than when these utterances followed discourse contexts that did not contain such an echo. Though this study was very influential with respect to investigations of figurative language processing, there are some issues that challenged some criticism. On the one hand, reading-times were measured for complete sentences whereby processes involved in the comprehension of critical words were not detectable. So, it might be possible that sarcasm comprehension still involved distinct processing mechanisms, which did not result in overall reading time differences. On the other hand, this study included a judgment task on intended sentence meanings that could have induced strategic processing of respective interpretations.

Further evidence in favor of the *direct access view* comes from a study by Gibbs, O'Brien and Doolittle (1995) in which self-paced reading times for unintentionally and intentionally ironic statements were compared against each other. Unintentional irony occurred accidentally due to certain situational events, and took less time to read than intentional irony. These findings were taken as evidence for the assumptions of the direct access account as ironic utterances even when unintended could be understood easily if situational contexts were supportive. Since for unintended irony no longer reading times were found, Gibbs, O'Brien and Doolittle (1995) argued against multi-phasic processing whereby a speaker's intention need to be determined before appropriate sentence meanings could be understood.

The behavioral data obtained in both studies (Gibbs, 1986; Gibbs, et al., 1995) challenged the predictions of the *standard pragmatic model*, which cannot account for faster processing times during figurative language comprehension. Likewise, in more recent studies facilitating effects of contextual information on the recognition and comprehension of sentences conveying figurative or implied meanings have also been

reported (Colston, 2002; Colston & O'Brien, 2000; Ivanko & Pexman, 2003). Reading times for ironic compared to literal sentences varied dependent on the degree of situational negativity of the context in which the target sentences were embedded (Ivanko & Pexman, 2003). Whereas participants took more time to read ironic statements that followed strongly negative contexts (e.g., breaking an appointment), they were faster in reading ironic statements in response to weakly negative contexts, (e.g., being delayed). Ivanko and Pexman (2003) explained these differences in reading times by the degree of contextual support for particular interpretations as predicted by the *direct access view*.

1.2.3 The graded salience hypothesis

An alternative approach of figurative language comprehension is offered by the *graded salience hypothesis* (Giora, 1997, 1999) that forms a hybrid account between the two models discussed above. Giora (1995) regards irony as a form of indirect negation that relies on dissimilarity between the literal and implied meaning. According to the *graded salience hypothesis*, initial processing of lexical information is an encapsulated and graded process in which salient meanings of words or expressions are retrieved from the mental lexicon (Giora, 2003). During initial processing, contextual information is processed in parallel but does neither interact with lexical processes, nor inhibit salient meanings when contextually incompatible (Giora, 2002; Peleg, Giora, & Fein, 2001). Salient meanings are defined as prominent[6] and context-independent meanings coded in the mental lexicon. In case that words or expressions have multiple meanings varying in their salience, Giora (2003) suggests that this process is graded. While most salient meanings are accessed earlier than less salient meanings, similarly salient meanings are activated at the same time. Thus, most salient meanings are always accessed initially irrespective of their literality, or contextual support. Initial processing of both the literal and figurative meaning is supposed to be identical in making the most salient meanings available. This implies that the processing of figurative sentences only diverges from that of literal sentences during later phases of processing if accessed salient meanings cannot be integrated with contextual information. In that case non-salient meanings are assumed to require further activation of less salient meanings, or to entail additional inferential processes for deriving contextually appropriate meanings. As opposed to the *direct access view*, contextual information is proposed to have a very limited impact unable to restrict initial access of salient meanings that might be contextually incompatible. Contextual information may only interfere with semantic processes

[6] Prominent meanings of words or expressions are considered as the most conventional, frequent, familiar, and prototypical meanings of a word (see Giora, 2003).

during later phases of processing where it gains importance in constructing appropriate meanings by inferencing. If such additional processing is required, salient meanings will either be maintained or suppressed depending on their role in constructing compatible meanings (Giora & Fein, 1999b).

Behavioral evidence for predictions of the graded salience hypothesis

Evidence for the *graded salience hypothesis* comes from behavioral studies that investigated the comprehension of irony (Giora & Fein, 1999a; Giora et al., 2007; Giora, Fein, & Schwartz, 1998), as well as metaphors, idioms and proverbs (for review see Giora 2002). Differences in reaction times for figurative and literal sentences have been suggested to result from differences in salience of meanings. Conventional forms of irony (i.e., familiar and salient instances such as *Very funny*) could be processed as easily as literal interpretations in showing similar response times to lexical decisions as seen for literal sentence meanings (Giora & Fein, 1999a). By contrast, initial processing of unconventional forms of irony occurred to be more difficult since longer response times were revealed for probe words presented after an interval of 150 ms. These differences in response times disappeared when probes were presented after an interval of 1000 ms. Giora and Fein (1999a) interpreted the results in support of the *graded salience hypothesis*. During initial processing salient meanings were accessed regardless of figurativity or contextual information, which caused processing difficulty in case of unconventional instances of irony. Appropriate but less salient meanings of unconventional irony became available during later stages of processing, so that processing difficulties at this stage were not anymore present.

In a recent study by Giora and colleagues (2007) further evidence was provided for the salience approach. Behavioral results of four experiments showed that neither contextual information nor expectancy for irony facilitated the comprehension of ironic utterances. In these studies the expectancy for an ironic utterance was increased by introducing one particular speaker that uttered all ironic comments, as well as by presenting exclusively ironic discourses in one experimental block. Still, the processing of irony occurred to be more difficult than literal sentences in showing longer reading as well as response times, respectively. Giora and colleagues (2007) interpreted the results as an index of temporal priority of salience-based interpretations over expectation-based interpretations resulting from contextual information. However, an important question related to this study is whether the observed differences in reading time indeed resulted from initial activation of more salient literal meanings, or whether they could have resulted from differences in contextual strength for both literal and ironic interpretations. While the expectancy for ironic interpretations has been pretested, it has not been reported whether expectancy values were comparable to literal interpretations.

1.2.4 Implications for neurophysiological investigation of irony comprehension

Research into figurative language has shown that irony is based on the disparity between the literal and ironic sentence meaning, which is set off by contextual information to which an ironic utterance is referred to. Irony can be accompanied by various verbal and paraverbal cues that have been assumed to facilitate the recognition and comprehension of intended meanings. The comprehension of irony requires figurative interpretation that goes beyond the literal sentence meaning in which pragmatic aspects such as the speaker's intention has to be inferred. Figurative language processing has been suggested to engage either different processing mechanisms during derivation of implied figurative meanings (Grice, 1975), or to depend on salience of sentence meanings (Giora, 1999). Alternatively, similar processing mechanisms has been assumed for interpreting both literal and figurative language (Gibbs, 1994). The behavioral studies mentioned above supported the different approaches on figurative language comprehension but yet appeared to be less sensitive in investigating the exact timing of comprehension processes. While the absence of differences in response times for literal and figurative sentences were interpreted in favor of similar comprehension processes (Gibbs, 1986), different comprehension processes might have still occurred in figurative language processing without affecting the overall comprehension.

This dissertation aims to contribute to the specification of neurocognitive processes involved in figurative language comprehension in the case of irony. Whether or not the processing of an ironic sentence interpretation is identical to that of a literal interpretation is examined by means of electrophysiological measures that are more sensitive to potential processing differences than behavioral measures. In case electrophysiological correlates do not reveal differences between the processing of literal and ironic sentences, this would further support the predictions of the *direct access view* (Gibbs, 1994). In addition, the influence of irony accompanying cues on the recognition and comprehension of implied ironic meanings will also be investigated.

Chapter 2

Event Related Brain Potentials

Human language comprehension occurs in a minimum of time whereby various types of complex linguistic information such as phonetic, semantic and syntactic information are analyzed and integrated into a complete mental representation. Within psycholinguistics one of the main research questions is the investigation of the time-course of language comprehension, as well as psychophysiological correlates of the neural activity underlying the processing of linguistic information. In order to examine the nature and timing of language processing, event-related brain potentials (ERPs) are an ideal investigative tool that is able to image brain activity online (i.e., immediately at the time point of stimulus processing). Because of their high-temporal resolution in millisecond range, ERPs are capable to reflect rapidly occurring underlying cognitive processes as they unfold over time. Moreover, ERP methodology is not dependent on active task requirements for electrophysiological measures. The investigation of language comprehension can be accomplished in a more natural setting compared to other methodologies used to examine the timing of neurocognitive processes. With regard to the comprehension of irony, ERPs can help to detect subtle differences between the processing of figurative and literal language. This chapter gives a brief introduction on the electroencephalography, in particular its generation and recording, as well as on the extraction of ERPs. A review of relevant ERP components will conclude this chapter.

2.1 Electroencephalography

Electroencephalography (EEG) is an electrophysiological measurement of the brain activity at the human scalp surface whereby voltage variations of cortical field potentials are imaged. This neural activity of the brain can be measured due to the cytoarchitectural organization of the human cortex. The cortex consists of 10^9-10^{10} neurons, mainly pyramidal cells, that enable the generation of larger extracellular and even extracerebral field potentials. Pyramidal cells are vertically oriented in direction to the scalp surface, and can spread out over multiple cortical layers (see Birbaumer & Schmidt, 2003). A great number of cell somata are found in the lower cortical layers

(i.e., layer III, IV and V). While the axons of pyramidal cells can extend to lower layers (i.e., up to layer VI) as well as to subcortical structures, dendrites reach in the upper cortical layers I and II. Spines of the dendrites build synapses with synaptic endings of different afferent axons. This structural organization allows a current flow and the generation of dipolar fields[7] measurable at the scalp surface. The synchronous activation of large populations of neurons (i.e., approximately between 10^3 and 10^4 neurons that fire simultaneously) can lead to the summation of the electrochemical activity of single neurons to larger electrical fields (Barlow, 1993). The neuronal activity relies on inhibitory as well as excitatory post-synaptic potential variations (or depolarization) caused by a momentary excitation of neurons due to stimulation. By attaching scalp electrodes to the human scalp surface this brain activity can be recorded as voltage variations. Amplitudes of the EEG can fluctuate between -100 and 100 μV, and the EEG frequency can range up to more than 100 Hz[8].

However, there is much brain activity which is not recordable at a distance on the scalp surface. Reason for this can be that the neuronal activity is not sufficiently synchronous to generate larger field potentials (Coles & Rugg, 1997). Even more, the structural organization of many neuronal assemblies within subcortical layers prevent the generation of detectable electrical field potentials. As these neurons are symmetrically structured and often not aligned in the same spatial orientation, closed fields are generated. Consequently, EEG recordings merely reflect a coarse measure of all the neural activity originated in the brain whereby only some portions of apparent neurocognitive processes can be detected.

EEG recording of the electrical brain activity is an indirect neurophysiological measure and consists of differences in voltage fluctuations between two electrodes. These electrodes are either placed over two 'active' brain regions (bipolar derivation), or an 'active' and relatively 'inactive' region as, for instance, the nasal bone or mastoid (monopolar derivation). Typically the ongoing brain activity is continuously recorded at several electrode sites that are situated according to a standard configuration[9] (see

[7] Dipolar fields are electrical field potentials that are generated by different distribution of negative and positive polarizations leading to an equalizing current. Single electrical fields can summate to an open field that configure dipoles when neurons are aligned in parallel orientation and are synchronously activated.

[8] According to their frequency, EEG can be distinguished in several frequency bands such as alpha waves (8-13 Hz) or beta waves (more than 13 Hz), which are related to different states of mental activation (Birbaumer & Schmidt, 2003).

[9] This electrode configuration is based on the 10-20 system of Jasper (1958), which defines the position of 19 electrodes. This system has been expanded to a greater number of electrodes by the guidelines of the *American Electroencephalographic Society* (Sharbrough, et al., 1991), and allows a standardization of the electrode configuration on the scalp surface. The establishment of such guidelines were necessary in order to ensure the comparability of EEG recordings across the variety of electrophysiological studies.

Figure 2.1). The recorded voltage variations are small signals in relation to other bio-electrical activity, so that they need to be amplified and after that digitized.

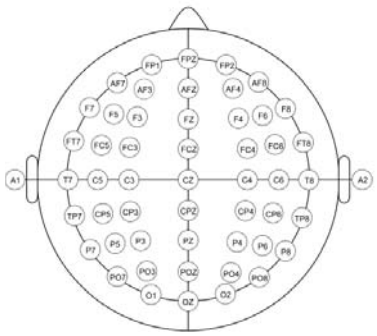

Figure 2.1. The map displays the standard electrode configuration of a multi-channel EEG recording. Electrode labels are based on respective electrode positions on the scalp including their lateralization on the left (odd numbers) and right hemisphere (even numbers).

2.2 Event-related brain potentials

ERPs are signal-averaged EEG epochs that are time-locked to the presentation of an external event. These evoked potentials contain negative and positive voltage deflections, and consist of small signals whose amplitudes vary approximately between 5-10 µV (Kutas & Dale, 1997). The procedure of EEG recording and ERP quantification is schematically illustrated in Figure 2.2. As the recorded EEG activity is not specific to the occurrence of an external stimulus but comprises to large parts background activity (i.e., non-linear fluctuations referred to as noise), the ERP signal needs to be extracted

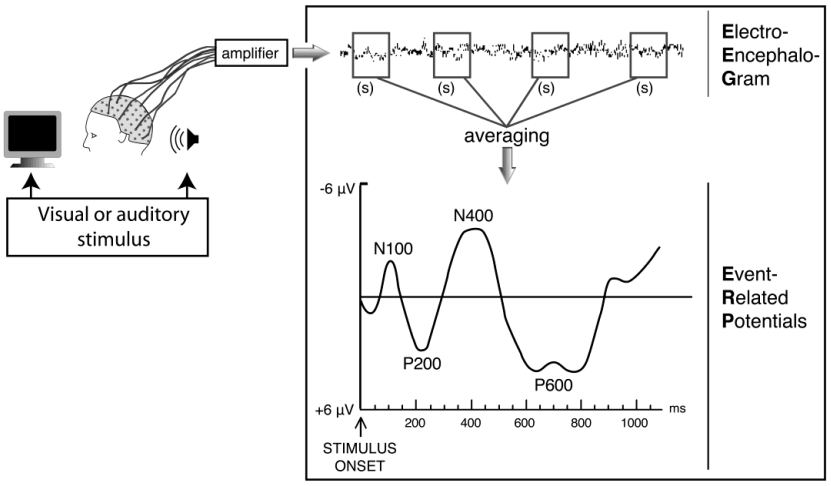

Figure 2.2. Schematic illustration of the EEG recording as well as ERP quantification, and subsequent ERP component extraction (in adaption to Coles & Rugg, 1997).

by reducing the signal-to-noise ratio. An appropriate method for quantifying the ERPs is to average EEG recordings of repetitive stimulus presentations time-locked to the stimulus onset. This method is based on the assumption that the varying background activity will tend to zero when EEG epochs timed to the stimulus presentation are averaged. The event-related portions of the signal are increased, and unspecific background portions are decreased. The remaining voltage variations are supposed to represent the neural activity related to the processing of the stimuli. To analyze ERPs they are normally aligned to a pre-stimulus baseline, e.g., 200 ms before stimulus onset[10], that determines the mean amplitude of an interval preceding the stimulus. The resulting amplitudes of the ERPs appear as peaks and valleys when displayed in a diagram (see lower part of Figure 2.2). Some features of the ERP amplitudes (i.e., their positive and negative deflections) can be determined as ERP components. One method for defining ERP components is to classify the peaks and valleys with respect to their electrophysiological features (i.e., polarity, topography, and latency), as well as to their functional features like their sensitivity to certain experimental manipulations (Coles & Rugg, 1997). This method relies on a combination of the physiological and functional approaches to component definition and sets up a common technique. However, as a particular ERP response can result from different neuronal activity generated from distinct brain regions, the problem of component overlap might occur. Although there is no approach that avoids all potential problems in defining ERP components, particular components could still be identified with regard to their electrophysiological and functional characteristics (see below). Qualitative differences in the characteristics of the ERP components, particularly in their topographic distribution, are supposed to result from the engagement of different neural generators and might reflect distinct functional processes. In contrast, quantitative differences as in amplitude size of an ERP component most likely reveal differences in the proportion of involvement of specific cognitive processes.

2.3 Language-related ERP components

According to the complex and multidimensional nature of ERP responses, qualitative as well as quantitative comparisons of perceptual and cognitive processes involved in the processing of particular stimuli are possible. In language comprehension research stimuli contain certain types of linguistic information including specific manipulations of it. The question whether ERPs in response to these stimuli are specific for language processes could not be confirmed. Still, a number of ERP components have been identi-

[10] The baseline can also be applied after the critical event was presented, i.e., post-stimulus onset, by reason of experimental manipulation.

fied that appeared to be strongly related to language processing. A common classification of ERP components is that into exogenous and endogenous components. With respect to their sensitivity, exogenous components are mostly associated with the perception of physical stimulus features such as modality or intensity, and emerge within the first 100 ms after stimulus onset. Endogenous components are mainly modulated by psychological factors as, for instance, attention processes or task-relevance of stimuli, and usually occur after 100 ms of stimulus presentation (Coles & Rugg, 1997). As there are ERP components in the latency range of 100-200 ms, which vary by means of both physical and psychological characteristics of the stimuli, this distinction into exogenous and endogenous components can only roughly be based on latency. In the next section some language-related ERP components are described with regard to their functional characteristics.

2.3.1 The P200 component

The perception of auditory and visual stimuli has been found to elicit a phasic positivity with a frontocentral maximum and a peak latency of approximately 150-250 ms post-stimulus. According to its amplitude and latency, this positivity has been referred to as P200 component. The amplitude of this early positivity has been described as a reflection of exogenous, as well as endogenous processes. While the P200 was shown to be sensitive to the detection of physical stimulus features (see Crowley & Colrain, 2004 for review; Hillyard & Münte, 1984; Luck & Hillyard, 1994), it also appeared to be sensitive to higher cognitive processes such as selective attention or task-relevance of stimuli (Dunn, Dunn, Languis, & Andrews, 1998; Picton & Hillyard, 1974). Furthermore, the P200 was shown to be related to the processing of at least some semantic aspects of verbal and non-verbal stimuli (Azizian, Watson, Parvaz, & Squires, 2006; Blanchet, Gagnon, & Bastien, 2007; Boddy & Weinberg, 1981; Herbert, Kissler, Junghöfer, Peyk, & Rockstroh, 2006; Kanske & Kotz, 2007; Schapkin, Gusev, & Kuhl, 2000). For example, when retrieval of semantic information was facilitated during second reading of words modulations of the P200 were observed (Raney, 1993; van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991). In addition, in a study by Dambacher, Kliegl, Hofman and Jakobs (2006) word frequency and predictability (correlated with word position) have been found to influence the amplitude of the P200. Recent studies using semantic priming paradigms (i.e., prime-target pairs) reported an increase of the P200 amplitude for semantically associated words (Coulson, Federmeier, Van Petten, & Kutas, 2005; Landi & Perfetti, 2007). On basis of this findings the P200 component is thought to reflect early detection of semantic processing differences. Though there is some evidence that higher cognitive and even language-

related processes modulate the P200 component, its sensitivity is not yet fully understood.

2.3.2 The LAN component

In a variety of studies on the processing of syntactic information differential ERP responses have been identified. One of them is an anterior negativity with an amplitude maximum either unilaterally over left lateral electrode sites or bilaterally (Friederici, Hahne, & Mecklinger, 1996; Münte, Heinze, & Mangun, 1993; Neville, Nicol, Barss, Forster, & Garrettdew, 1991; Rösler, Putz, Friederici, & Hahne, 1993). This component referred to as LAN has frequently been observed between 300-500 ms after stimulus onset, though its latency onset can vary to some degree. The LAN exhibits some sensitivity to the processing of morphosyntactic information, and occurred in response to subject-verb disagreements concerning syntactic gender, case or number (Deutsch & Bentin, 2001; Friederici, Pfeifer, & Hahne, 1993; Gunter, Friederici, & Schriefers, 2000; Gunter, Stowe, & Mulder, 1997; Hoen, Deprez, & Dominey, 2007; Silva-Pereyra & Carreiras, 2007). The amplitude of the LAN was also more pronounced in response to violations of word-category constraints (Friederici, Gunter, Hahne, & Mauth, 2004; Friederici, et al., 1996; Münte, et al., 1993), or verb-argument agreement (Rösler, et al., 1993). By contrast, left anterior negativities have also been observed in response to non-syntactic anomalies that required increased demands of verbal working memory (King & Kutas, 1995; Kluender & Kutas, 1993; Münte, Schiltz, & Kutas, 1998). For example, when noun phrases were referentially ambiguous during discourse comprehension, this memory-demanding processing situation evoked an enhanced LAN amplitude (Van Berkum, Brown, Hagoort, & Zwitserlood, 2003). Additionally, for the

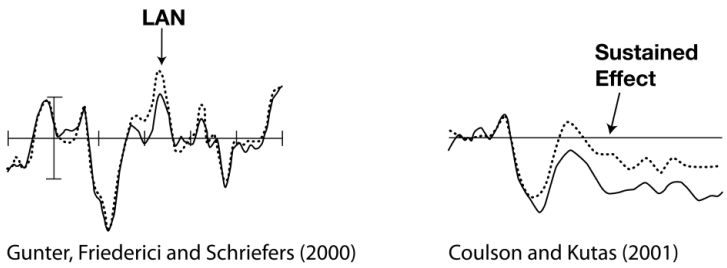

Figure 2.3. Left anterior negativities seen for morphosyntactic violations in a study by Gunter et al. (2000) (left illustration), and for the comprehension of jokes reported by Coulson and Kutas (2001) (right illustration).

comprehension of jokes which required frame-shifting (i.e., a kind of semantic-conceptual reanalysis) and thereby involved an upload of working memory a left lateralized negativity was seen as well (Coulson & Kutas, 2001). Whereas these negativities related to working memory processes were long-lasting, syntax-related LAN effects can be normally localized by their clear peak latency (see Figure 2.3). As shown by these studies, the LAN component seemed to be associated with functionally distinct cognitive processes that are involved in the processing of aspects of syntactic information, as well as in more general operations as the load of working memory resources.

2.3.3 The N400 component

Another ERP component that is sensitive to the processing of linguistic information is the N400 component. This negativity occurs in the latency range of approximately 250-500 ms with a peak at about 400 ms after stimulus onset. The N400 has a centroparietal scalp distribution that is larger over the right than the left hemisphere. An N400 was first observed by Kutas and Hillyard (1980a, 1980b) for visually presented sentences that contained a semantic anomaly. This effect could be replicated for the auditory modality, which provided evidence for modality independence of the N400 component (Friederici, et al., 1993; Holcomb & Neville, 1991). The emergence of an N400 was typically effected by semantic expectancy and the degree of contextual constraints as well (Federmeier & Kutas, 1999; Kutas & Hillyard, 1984; Swaab, Brown, & Hagoort, 2003; van Petten, Coulson, Rubin, Plante, & Parks, 1999). Words that were semantically high expected (determined by cloze probability[11]) evoked a smaller N400 component than semantically less expected words (Kutas & Hillyard, 1984). A reduction of the N400 amplitude was also reported for words that were contextually constrained either on the word level (Chwilla, Brown, & Hagoort, 1995), or sentence level (for review see Kutas & Federmeier, 2000; Kutas, Van Petten, & Kluender, 2006). The sensitivity of the N400 appeared to be linked to semantic integration of individual words into sentence contexts. Moreover, the amplitude of the N400 varied with word frequency (Van Petten & Kutas, 1990), and repetition of stimuli (Besson, Kutas, & Van Petten, 1992; van Petten, et al., 1991). In response to high frequent compared to low frequent words the N400 was reduced, as well as for words that have been repeated. These findings indicate that the N400 reflects processes of lexical access (i.e., the ease with which word entries can be accessed in the mental lexicon). By implication, the N400 appears

[11] Cloze probability is a measure of semantic expectany of words in a certain context that is obtained by a cloze procedure (Taylor, 1953) in which participants are asked to complete a sentence with the word that first comes to their mind.

to be an index of lexical-semantic information processing such as lexical access and selection, or semantic integration.

In addition, modulations of the N400 component were also seen for manipulations of contextual constraints on the discourse level (St. George, Mannes, & Hoffman, 1994, 1997; Swaab, Camblin, & Gordon, 2004; Van Berkum, Hagoort, & Brown, 1999; Van Berkum, Zwitserlood, Hagoort, & Brown, 2003). In a study by St. George and colleagues (1994) a greater N400 was observed for words presented in untitled text paragraphs relative to those presented in titled paragraphs. Comparable effects of global discourse contexts on the N400 were also reported by Van Berkum, Hagoort and Brown (1999). Words that were acceptable in a local sentence context but semantically unacceptable on the discourse level elicited a larger N400 component than respective acceptable words. As shown by those studies the amplitude of the N400 was inversely related to words that semantically fit within global discourse contexts. In addition, an N400 effect has also been evoked by pragmatic anomalies (Kuperberg, Holcomb, et al., 2003; Laurent, Denhieres, Passerieux, Iakimova, & Hardy-Bayle, 2006; Otten & Van Berkum, 2007), and violations of world knowledge (Hagoort, Hald, Bastiaansen, & Petersson, 2004; Hald, Steenbeek-Planting, & Hagoort, 2007). Thus, the N400 appears to be a function of lexical-semantic and pragmatic information processing on the word, sentence and discourse level.

2.3.4 The P300 component

The P300 is one of the most intensively investigated ERP components that is generally agreed to comprise several subcomponents such as P3a, 'novelty P3' or P3b, and thus to represent a complex of components[12]. Accordingly, this component has also been termed LPC (*late positive complex*) (Sutton & Ruchkin, 1984). The P300 has first been identified as ERP component in the 1960s. In a study by Sutton, Braren, Zubin & John (1965) a late positivity with a latency onset of about 300 ms post-stimulus presentation and a centroparietal amplitude maximum was observed for rare and task relevant stimuli. This brain potential became known as P3b (or classic P300), which will be referred to as P300 in the current thesis. A P300 effect is usually evoked by means of 'oddball paradigms' whereby two different stimuli have to be discriminated either by overtly or covertly responding. Findings of P300 in response to 'oddball' events led to the sugges-

[12] These subcomponents have been distinguished as they were shown to be partially different in sensitivity and scalp distribution. For instance, the so-called 'novelty P3' occurred for novel, non-target stimuli when presented within a series of similar stimuli and revealed a frontocentral scalp distribution (Courchesne, Hillyard, & Galambos, 1975). In this regard the 'novelty P3' appears to be functionally related to the P3a, as both components were seen for infrequent non-target stimuli, and might reflect orienting processes resulting from involuntary attention shifts.

tion that this component reflects revision of mental representations, a process also known as context-updating (Donchin, 1981; Donchin & Coles, 1988). If a new stimulus is encountered, previous stimulus representations held in working memory need to be changed or 'updated'. Alternatively, the P300 has been interpreted as a function of monitoring on evaluation and reaction to a stimulus (Verleger, Jaskowski, & Wascher, 2005). In general, this component has been associated with memory processes involved in evaluation of task relevant stimuli, and subsequent storage operations (for reviews see (Picton, 1992; Polich, 2007). Moreover, a P300 component has been obtained for auditory and visual stimuli, and appeared to be sensitive to stimulus probability, salience, and task relevance as well as difficulty (for review see Kok, 2001; Pritchard, 1981). The less probable the occurrence of a certain stimulus, the more pronounced was the P300 amplitude (Picton, 1992). Similarly, the P300 increased with increasing complexity and capacity demands induced by task requirements (Ullsperger, Metz, & Gille, 1988). As P300 effects were seen in response to diverse non-linguistic and linguistic stimuli, this component is agreed to reflect more general cognitive processes related to perception and evaluation of stimuli, rather than specific processes involved in the processing of one particular type of information.

2.3.5 The P600 component

In prior ERP research a late positivity that emerged after 500 ms stimulus presentation was demonstrated to be specifically sensitive to syntactic aspects of language processing, and thus has been referred to as P600 component or SPS (*syntactic positive shift*) (Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992; Osterhout, McKinnon, Bersick, & Corey, 1996). This brain potential displayed a centroparietal scalp distribution and its occurrence appeared to be independent of input modality. A P600 emerged in response to a variety of syntactic anomalies in the auditory presentation modality (Friederici, et al., 1993; Osterhout & Holcomb, 1993) as well as the visual modality (Neville, et al., 1991). For example, these anomalies comprised violations of phrase structure (Friederici & Meyer, 2004; Gunter & Friederici, 1999; Hagoort, et al., 1993), verb-argument agreement (Friederici & Frisch, 2000) (Osterhout & Hagoort, 1999), or morphosyntactic constraints (Hagoort, 2003; Palolahti, Leino, Jokela, Kopra, & Paavilainen, 2005; Rossi, Gugler, Hahne, & Friederici, 2005). An enhanced P600 seen for syntactic anomalies has been associated with reanalysis processes of the violated sentence structure (Friederici, et al., 1993; Neville, et al., 1991). Moreover, an increase of the P600 amplitude has also been observed for non-preferred syntactic structures (Osterhout, Holcomb, & Swinney, 1994) as well as syntactically complex or ambiguous sentence structures (Friederici, Hahne, & Saddy,

2002; Friederici, Steinhauer, Mecklinger, & Meyer, 1998; Kaan & Swaab, 2002) in which syntactic constraints were not violated. In this context, larger P600 components were interpreted as function of syntactic integration and structural reanalysis processes. In case sentences are syntactically ambiguous sentences (i.e., garden-path sentences) the initial sentence structure need to be revised to build-up an alternative syntactic construction (Friederici, Mecklinger, Spencer, Steinhauer, & Donchin, 2001). P600 effects related to complexity and syntactic ambiguity displayed a more frontocentral amplitude maximum than P600 effects seen for violations of syntactic constraints.

Since earliest reports of a syntax-related P600 component, this ERP component has been controversially debated with regard to its sensitivity. As the amplitude of the P600 was shown to be modulated by semantic information, these findings called into question whether this brain potential is specifically sensitive to syntactic information (Ericsson, Olofsson, Nordin, Rudolfsson, & Sandstrom, 2008; Gunter, et al., 2000; Vissers, Chwilla, & Kolk, 2006). In line with these observations are numerous ERP studies that revealed P600-like effects in response to a variety of semantic and pragmatic anomalies (see Table 2.1). For example, a late positivity was elicited by syntactically correct and unambiguous sentences like *The cat that fled from the mice* but that contained a semantic reversal anomaly (Kolk, Chwilla, van Herten, & Oor, 2003; van Herten, Kolk, & Chwilla, 2005). P600 effects have also been reported for thematic role and animacy violations (Hoeks, Stowe, & Doedens, 2004; Kuperberg, Sitnikova, Caplan, & Holcomb, 2003; Nieuwland & Van Berkum, 2005), as well as pragmatically incongruous sentences (Kuperberg, Holcomb, et al., 2003). Such 'semantic P600' effects have been observed across languages as well as independent of task requirements (Kolk, et al., 2003; Nieuwland & Van Berkum, 2005). Common for all these studies (presented in Table 2.1) is that the emergence of such late positivities was independent of a specific type of linguistic information. Thereby 'semantic P600' effects appeared to result from a variety of semantic and pragmatic manipulations. Interestingly, this late positivity often emerged when some degree of semantic relatedness was given. For instance, semantically expected or related target words most likely evoked larger P600 amplitudes compared to unrelated targets (Bouaffre & Faita-Ainseba, 2007; Vissers, et al., 2006). Findings of P600 effects for non-syntactic manipulations led to distinct functional interpretations of this ERP component. It has been suggested to reflect late integration processes involving these various types of information (Friederici, et al., 2004; Friederici & Weissenborn, 2007), or more general cognitive processes as monitoring (Kolk & Chwilla, 2007; Kolk, et al., 2003). Most recently, the P600 has been interpreted as reflection reanalysis and interpretation processes based on semantic information (Ericsson, et al., 2008; Nieuwland & Van Berkum, 2005).

Reference	Manipulation	Modality	Language	Task	ERPs		Implications
Coulson & Kutas (2001)	Semantically high and low constrained sentences ending in jokes (*) or non-jokes *She read so much about the bad effects of smoking she decided she'd have to give up* *reading/habit. *Statistics indicate that Americans spend 80 million a year on games of chance, mostly* *weddings/dice.	Visual	English	Comprehension question	N400 LAN	LPC (frontal) LPC	The N400 is sensitive to expectations based on frames, schemas and scripts retrieved from long-term memory. The late positivity for jokes resembles the P3b, and might reflect a violation of frame-level expectations.
Ericsson, Olofsson, Nordin, Rudolfsson & Sandstroem (2008)	Syntactically correct or incorrect (*) sentences with three types of semantic completeness: semantically coherent (a) or incoherent (b), pseudo sentences (c) *(a)The hiker saw the faint light from the fire.* *(a)*The hiker saw **the** faint light from the fire.* *(b)The brush moved the white prize from the vein.* *(b)*The brush moved **the** white prize from the vein.* *(c)The bolp prinched the crochy proul from the goll.* *(c)*The bolp prinched **the** crochy proul from the goll*	Visual	Swedish	Acceptability judgment		P600 P600 ↓ no P600	Semantic information modulated the amplitude of the P600: reduced with decreasing semantic coherence and void of lexical content. The P600 is possibly a reflection of reanalysis processes based on semantic information.
Gunter, Friederici & Schriefers (2000)	Morphosyntactically manipulated sentences with a high or low cloze probability *Sie befährt das Land mit einem alten Wartburg.* **Sie befährt den Land mit einem alten Wartburg.* *Sie bereist das Land auf einem kräftigen Kamel.* **Sie bereist den Land auf einem kräftigen Kamel.*	Visual	German	Probe-detection task	LAN LAN	P600 ↓ P600	The P600 was modulated by semantic expectancy: less pronounced for high cloze sentences. Semantic information processing affects syntactic processes during a later processing phase.
van Herten, Kolk & Chwilla (2005)	Semantic reversal anomalies in syntactically correct and unambiguous sentences with varying numbers of agent and theme (sg/pl vs. sg/sg) *The poachers that at the fox hunted ...* ** The fox that at the poachers hunted ...* *The poacher that at the fox hunted ...* ** The fox that at the poacher hunted ...*	Visual	Dutch	Plausibility judgment		P600 P600	A P600 was observed for syntactically non-anomalous sentences that required semantic reversal. The P600 might be a function of monitoring processes to check upon the veridicality of ones sentence perception.

Continues on next page...

Reference	Manipulation	Modality	Language	Task	ERPs		Implications
Hoeks, Stowe & Doedens (2004)	High and low constrained sentences (on the message-level) including lexical-semantic fit anomalies *The javelin was by the athletes thrown…* **The javelin was by the athletes summarized…* **The javelin has the athletes thrown…* **The javelin has the athletes summarized…*	Visual	Dutch	Plausibility judgment	N400 N400	P600 P600 P600	P600 effects were seen for semantic and thematic processing difficulties in absence of syntactic anomalies. P600 may index effortful syntactic processing to obtain a semantically coherent and plausible sentence representation.
Juottonen, Revonsuo & Lang (1996)	Semantically congruous and incongruous sentences *Last night I had a strange dream.* **The family moved into a new radio.*	Auditory	Finnish	Recognition memory test (between blocks)	N400	LPC	The late positivity may be a reflection of semantic-conceptual integration.
Kemmerer, Weber-Fox, Price, Zdanczyk & Way (2007)	Sentences containing two types of reversed adjective sequences that contradicted linear order (d) or lexical-semantic constraints (e) *Jennifer rode a huge gray elephant…* (d)**Jennifer rode a gray huge elephant…* (e)**Jennifer rode a small huge elephant…*	Visual	English	Acceptability judgment	N400 ↓ N400 ↓	P600 P600	Relative to control sentences, a reduced N400 and enhanced P600 were seen for reversal conditions. The P600 may reflect a momentary shift between alternative adjective order constructions.
Kolk, Chwilla, van Herten & Oor (2003)	Subject-relative and object-relative sentences including semantic anomalies that were related to implausible events *The mice that from the cat fled…* **The cat that from the mouse fled…*	Visual	Dutch	Acceptability judgment (Exp.1) No task demands (Exp.2)		P600	Semantic anomalies in subject-relative sentences evoked P600 effects independent of task demands. P600 is related to a conflict between two semantic interpretations reflecting general processes such as monitoring.
Kuperberg, Holcomb, Sitnikova, Greve, Dale & Caplan (2003)	Pragmatically (f) and morphosyntactically (g) manipulated sentences *My parents... because the baby would cry.* *(f)*My parents... because the baby would phone.* *(g)*My parents... because the baby would cries.*	Visual	English	Plausibility judgment	N400	(frontal) P600 P600	The N400 appeared to be sensitive to semantic association and expectancy. The P600 might be a late appearing P300 related to the decision of the plausibility judgment task.

Continues on next page...

Reference	Manipulation	Modality	Language	Task	ERPs		Implications
Kuperberg, Sitnikova, Caplan & Holcomb (2003)	Sentences including pragmatic anomalies (h) or thematic role animacy violations (i) *For breakfast the boys would only eat…* *(h)*For breakfast the boys would only bury...* *(i)*For breakfast the eggs would only eat…*	Visual	English	Plausibility judgment	N400 N400	P600	The P600 in response to pragmatically unlikely verbs seemed to be sensitive to violations of thematic structure, and may reflect processes of integration or repair of this violation.
Münte, Heinze, Matzke, Wieringa & Johannes (1998)	Sentences (within discourses) that had a morphosyntactic (j), semantic (k) or orthographic (l) anomaly *Die Hexe benutzte ihren Besen, um...* *(j)*Die Hexe benutzte ihren Besens, um...* *(k)*Die Hexe benutzte ihren Traum, um...* *(l)*Die Hexe benutzte ihren Behsen, um...*	Visual	German	Comprehension question (at the end of each block)	LAN N400	P600 P600 P600	The P600 showed a sensitivity to non-syntactic anomalies, and which challenges a syntax-specific view of this ERP component.
Nieuwland & van Berkum (2005)	Discourses with semantically coherent or incoherent continuations of a story character (animacy violated) Discourse: *A tourist checked-in at the airport ...* *Next, the woman told the tourist that...* **Next, the woman told the suitcase that...*	Auditory	Dutch	No task demands		P600	The P600 indicates a late detection of a semantic anomaly, and might reflect a delayed, more careful interpretation process. Alternatively, the P600 may index monitoring processes.
Salmon & Pratt (2002)	Discourses having a semantically acceptable or unacceptable endings Discourse: *Computer system broke down...* *Fortunately, I didn't lose any files.* ** Fortunately, I didn't lose any friends.*	Auditory	Hebrew	Semantic decision task	N400 + P560	LPC	The P560 seemed to be associated with processes of global integration and conclusion drawing. The LPC was modulated by semantic congruency and context level, and reflects global coherence processes.
Vissers, Chwilla & Kolk (2006)	ERPs to misspelled words in high and low cloze sentences (pseudo homophones) *In that library the pupils borrow books...* **In that library the pupils borrow bouks...* *The pillows were stuffed with books...* **The pillows were stuffed with bouks...*	Visual	Dutch	No task demands	N400 N400	P600	A P600 to pseudo homophones was only seen for high-cloze sentences. The P600 seems to be a function of monitoring processes, and may have resulted from a conflict situation either to accept or reject a word.

Table 2.1. Selected ERP studies in which P600-like effects were observed for non-syntactic manipulations. Examples of experimental items are denoted in italics whereby the critical word is underlined. Sentences having a low cloze probability are highlighted in grey.

Furthermore, the P600 appeared to be sensitive to non-language specific processes engaged in the processing of harmonic principles in music (Patel, Gibson, Ratner, Besson, & Holcomb, 1998), or arithmetic rules (Nunez-Pena & Honrubia-Serrano, 2004). In addition, findings of an influence of probability of stimulus occurrence on the P600 amplitude brought up the question whether the P600 could be a subcomponent of the domain-general P300 component (Coulson, King, & Kutas, 1998b; Gunter, et al., 1997). In a study by Coulson and colleagues (1998b), for both ungrammatical and improbable stimuli comparable late positivities were obtained that were indistinguishable in their topographic distribution. Similarly, the amplitude of the P600 was affected by sentence complexity and probability of occurrence suggesting a resemblance of the P600 to the P300 component (Gunter, et al., 1997). Both positivities typically emerged in the latency range of 300-600 ms and showed a centroparietal scalp distribution. The observed similarities were interpreted in favor of an electrophysiological and hence functional relatedness of both late positive shifts (Coulson, King, & Kutas, 1998a; Coulson, et al., 1998b; Gunter, et al., 1997). However, there is also some evidence for a dissociation between the P600 and P300 component. Osterhout, McKinnon, Bersick and Corey (1996) observed differences in the sensitivity of both ERP components to manipulations of task demands and probability. Moreover, differences in scalp distribution of both positivities were also seen in this study. Besides, in a study by Frisch, Kotz, von Cramon & Friederici (2003) basal ganglia were shown to contribute to the generation of the P300 but not the P600 component. This indicates an engagement of different neural sources in generation of both effects. This view was revised in a recent study by Kotz, Schubotz, Sakreida, Friederici & van Cramon (2006), as patients with lesions in basal ganglia indeed showed a P600 when provided with additional timing information. Still, in this patient group the P600 differed from the P300, which provides further evidence for a distinctiveness of both brain potentials.

Taken together, there is some evidence that suggests a dissociation of P600 and P300 as being rather differential ERP components. The P600 appeared to be sensitive to various kinds of linguistic (i.e., syntactic and semantic) information but also non-linguistic information. This ERP component was shown to be predominantly associated with aspects of syntactic information processing besides to some semantic and pragmatic aspects of language. As P600 effects varied to some extent in scalp distribution this implies that at least partially different neural sources underlie this component. Hence, the P600 seems to be no unitary ERP component but to comprise a complex of components, which have been identified as language relevant brain potentials reflecting controlled processes of syntactic and semantic-pragmatic information processing.

Chapter 3

Neurophysiological and -psychological evidence of figurative language comprehension

To gain insights into neurocognitive processes as well as cortical mechanisms and structures underlying figurative language comprehension different methodologies have been employed. Findings from lesion and neuroimaging studies add information on the involvement of brain areas and their contributions to the processing of implied figurative meanings. Neurophysiological and neuropsychological data from studies on irony comprehension as well as other types of figurative language including metaphors and proverbs will be pointed out. Findings of this wider field of research can provide evidence to theory of figurative language comprehension.

In the beginning of this chapter, some ERP studies on metaphor and proverb comprehension are outlined that enable comparison of the timing of different forms of figurative language processing. Furthermore, findings of patients with deficits in figurative language comprehension and particularly in irony comprehension will be summarized. In the final section, results of some neuroimaging studies using functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography (PET) will be outlined. Emphasis of these studies was put on the investigation of cortical mechanisms as revealed by activation patterns in the human brain when comprehending figurative sentences.

3.1 Evidence from ERP studies

As evoked potentials are measures of brain activity with a high temporal resolution, they are very useful for investigating the time course of language processing and neurocognitive mechanisms underlying this processing (cf. chapter 2). A number of studies used ERPs for exploring figurative language comprehension including various types of speech figures such as irony (Cornejo, et al., 2007; Katz, Blasko, & Kazmerski, 2004), metaphors (Arzouan, Goldstein, & Faust, 2007; Blasko & Connine, 1993; Coulson &

Van Petten, 2002, 2007; Kazmerski, Blasko, & Dessalegn, 2003; Pynte, Besson, Robichon, & Poli, 1996; Sotillo, et al., 2004; Tartter, Gomes, Dubrovsky, Molholm, & Stewart, 2002), or proverbs and idioms (Ferretti, Schwint, & Katz, 2007; Laurent, et al., 2006). Most of these studies reported greater amplitudes of the N400 component during comprehending figurative sentences in relation to literal sentences. Findings suggest that processing semantic information appears to be more difficult during figurative language comprehension. In the following section evidence from these ERP studies is reviewed in more detail, and implications for theory on figurative language comprehension will be pointed out.

Examinations on the comprehension of irony by means of ERPs focused on the impact of social and cultural factors (Katz, et al., 2004) as well as on effects of different interpretative strategies (Cornejo, et al., 2007). Greater N400 amplitude followed by a P900 effect has been observed for sarcastic statements relative to literal ones (Katz, et al., 2004). As little was reported about the experimental methods used in this study (e.g., experimental material and task demands), it is not clear whether other factors may have contributed to the observed differences in the ERPs. Regarding the presence of an N400 effect, it might be possible that this ERP response resulted from differences in semantic expectancy rather than semantic integration difficulties (cf. section 2.3.3). An increased N400-like ERP component has also been reported for irony when participants were required to apply a holistic interpretative strategy (i.e., to focus on sentence plausibility). Such an effect was absent when participants used an analytic strategy by focusing on sentence congruency (Cornejo, et al., 2007). These findings have been taken as evidence for different processing strategies during irony comprehension dependent on either holistic or analytic evaluations. The N400 effect has been related to differences in semantic expectancy caused by induction of the holistic strategy in which literal expressions were semantically less expected than ironic expressions.

ERP studies on metaphor comprehension revealed processing differences between figurative and literal sentences in showing mainly N400 effects. Findings of an increase in the N400 amplitude have been associated with semantic incongruency due to an initial activation of the literal meaning of metaphors (Pynte, et al., 1996). Recent studies have shown that other factors such as frequency and familiarity of metaphors, or semantic and contextual constraints can influence the comprehension of metaphoric sentences (Arzouan, et al., 2007; Coulson & Van Petten, 2002; Pynte, et al., 1996; Tartter, et al., 2002). For example, when relevant contextual information was provided the processing of metaphors was facilitated resulting in decreased amplitudes of the N400 (Pynte, et al., 1996). Alike, comparable effects on the N400 amplitude have been

observed for the processing of familiar (conventional) metaphors compared to less-familiar (novel) metaphors (Arzouan, et al., 2007). In consequence, alternative explanations of the processing difficulties reflected in the N400 have been proposed. Coulson and Van Petten (2002) suggested that literal and figurative language comprehension involves similar processing mechanisms differing only in the degree of conceptual blending. This notion is based on findings of graded N400 amplitudes in response to target words embedded in three different types of sentential contexts. Sentences span a continuum from literal to metaphoric meanings by including literal mappings as intermediate metaphoric meanings (Coulson & Van Petten, 2002). While literal sentence completions elicited smallest N400 amplitude, this effect increased with increasing figurativity and was largest for metaphoric completions. The comprehension of metaphoric sentences has been suggested to involve mapping operations between two concepts of different domains whereas a larger N400 component possibly arose from an early phase of semantic comparison. Accordingly, the processing of sentence meanings might vary due to the complexity of conceptual integration.

In comparison to irony and metaphors, idioms and proverbs are invariable constructions that have been established in language use, and whose figurative meanings usually become apparent due to contextual embedding. In a recent ERP study on the processing of proverbs an increased N400 amplitude has been reported at mid-sentence position of proverbs (Ferretti, et al., 2007). This ERP response was related to processing difficulties in integrating figurative meanings in discourse contexts caused by initial activation of the literal meanings of proverbs. In a further study by Laurent and colleagues (2006) a larger N400 in response to idioms has also been observed. As the amplitude of the N400 decreased for familiar idioms compared to unfamiliar idioms, this result has been explained by salience of figurative meanings. High salient meanings of familiar idioms were assumed to be automatically accessed leading to smaller N400 amplitudes (Laurent, et al., 2006). For unfamiliar idioms a larger P600 component following the N400 was seen, and which has been interpreted as reflection of post-lexical integration processes. According to Laurent and colleagues (2006), the processing of idioms differs as a consequence of the involvement of either compositional or non-compositional operations in dependence of salience of figurative meanings.

Common for all forms of figurative language is that they convey different aspects of meaning than literally stated. From this perspective jokes are somehow conceptionally related to figurative language as they often imply different meanings than expected on basis of the foregoing context. The various forms of verbal jokes are usually based

on surprise by referring to other situations than initially introduced, and which typically constitute the payoffs of jokes (for review of theories on jokes see Norrick, 2003; Ritchie, 2004). In this way, humorous remarks form a complex type of language use that requires contextual information as well as common world knowledge for their interpretation. Accordingly, the comprehension of jokes is assumed to involve conceptual revision, or so-called frame-shifting (Coulson & Kutas, 2001; Coulson & Lovett, 2004). When encountering verbal jokes, listeners are required to perform some kind of semantic reanalysis whereby existing information has to be reorganized into a new frame retrieved from long-term memory. Evidence for such processing mechanisms was provided by an ERP study of Coulson and Kutas (2001). Therein, jokes evoked a sustained left anterior negativity in the latency range of 500-900 ms that was assumed to reflect frame-shifting. An additional N400 indicating violation of semantic expectancy and late positivity were also seen in response to jokes. Findings reveal that mapping information from one frame into another seems to be a highly complex process that occurs relatively late during comprehension.

Taken together, ERP investigations of the timing of figurative language processing revealed that comprehending figurative meanings appeared to require extra processing costs especially for processing of semantic information. Relative to literal language comprehension, such processing difficulties were shown for various types of speech figures including metaphors, proverbs or idioms. These figures of speech most frequently resulted in an increased N400 component suggesting that lexical access and semantic integration was more difficult when comprehending non-literal language. Thereby the underlying comprehension processes varied dependent on salience of figurative sentences (Laurent, et al., 2006; Pynte, et al., 1996). Regarding the processing of figurative and humorous sentences, there is evidence that distinct cognitive processes seemed to be involved, and that successful comprehension of implied meanings could not merely be based on linguistic information but seemed to require additional contextual information as well as pragmatic knowledge.

3.2 Evidence from lesion studies

Neuropsychological research on the ability of language processing is based on the lesion deficit approach, which is one of the earliest developed methodologies to gain insights into the organization of the language function in the brain. This approach is grounded on the observation of specific kinds of language deficits following temporary or permanent brain lesions. While selective deficits allow deduction of the functional

significance of the affected brain area, this method is controversially debated in terms of its accuracy in localizing particular brain functions. Examining groups of patients with approximately identical brain lesions often comprises some heterogeneity in severity of lesions, as well as affected brain regions. Such differences are likely to entail some variation in patients' performance on certain tasks, and thus make clear functional interpretations difficult. Still, this approach is able to supply broad categories of language functions underlying widespread regions of the brain. In this section, findings of some lesion studies on figurative language processing are reviewed since they provide further insights into neurocognitive processes and the neuroanatomical basis of this capacity. Studies focusing on neuropsychiatric diseases like schizophrenia[13] with relation to figurative language comprehension are not further addressed within this thesis.

While brain lesions of the left hemisphere (LH) caused severe language disorders comprising different types of aphasia, lesions of the right hemisphere (RH) led only to some linguistic impairment especially deficits in communicative skills (Bookheimer, 2002; McDonald, 2000a). Classical aphasic symptoms (i.e., disturbance of basic language functions such as syntactic or semantic information processing) were largely absent in patients with RH or frontal lobe lesions. However, successful interpersonal communication regarding the understanding of speakers' intentions, beliefs or emotions occurred to be selectively impaired. Likewise, after damage to RH regions the ability to comprehend figurative language was often disturbed as well. For example, deficits in comprehending implied meanings have been observed for indirect requests, sarcasm and metaphors (Brownell, 1998; Brownell, Simpson, Bihrle, Potter, & Gardener, 1990; Giora, Zaidel, Soroker, Batori, & Kasher, 2000; Kaplan, Brownell, Jacobs, & Gardener, 1990; for review see Thoma & Daum, 2006). In a study by Giora and colleagues (2000) damage to the RH was specifically associated with deficits in comprehending sarcasm suggesting that the RH is involved in reinterpreting literal meanings in order to derive appropriate sarcastic meanings. As the same patients were less impaired in processing metaphors relative to irony, distinct neurocognitive processes seem to underlie the comprehension of metaphors and irony (Giora, et al., 2000). Moreover, patients with RH lesions revealed deficits in using contextual information as well as making elabora-

[13] In a number of patient studies it was shown that patients with schizophrenia are disturbed in their ability to comprehend different forms of figurative language such as metaphor and irony (Iakimova, Passerieux, Laurent, & Hardy-Bayle, 2005; Kircher, Leube, Erb, Grodd, & Rapp, 2007; Langdon & Coltheart, 2004; Mo, Su, Chan, & Liu, 2008). These selective impairments have been explained by diverse cognitive deficits as, for instance, difficulties in mental inferencing. As investigations of figurative language comprehension in patients with schizophrenia are mainly aimed to study thought patterns of these patients, they are not further reviewed here.

tive inferences that were necessary for understanding non-literal meanings of conversational remarks (Kaplan, et al., 1990). These deficits were assumed to result from tients' impaired understanding of speakers' mutual knowledge as well as their mental states concerning intentions and attitudes. Similarly, relative to normal participants RH patients showed poor performance in interpreting counterfactual remarks, which was largely attributed to patients' deficits in mentalizing (Winner, Brownell, Happe, Blum, & Pincus, 1998). McDonald (McDonald, 2000b) concluded that besides drawing such mental inferences, conversational inferences concerning both the counterfactual character of sarcasm as well as its communicative intent are required for understanding non-literal forms of speech such as sarcasm. However, RH lesions have also been associated with general pragmatic disorders including deficits in integrating and synthesizing information within discourse contexts (for review see McDonald, 1999), interpreting non-literal sentences (Winner, et al., 1998), or ignoring plausibility (McDonald, 2000a). Even if there is agreement upon contributions of the RH to language processing in context, its exact function is heterogeneously described.

Comprehending figurative language has also been impaired in patients with closed head injury (CHI) or traumatic brain injury (TBI). These brain injuries are mainly caused by accidents, and primarily lead to damages of the frontal lobe although connected brain regions are often also affected. While the frontal lobe is involved in higher level language functions as well as executive functions[14], damage to this region caused numerous communicative deficits including non-literal language processing. Patients with damage to the frontal lobe are often non-aphasic but still suffer from impairments in social and pragmatic communication as they are often stimulus bound and unable to process implied non-literal meanings (McDonald, 1992, 2000b). Specifically, patients with CHI are limited in their capacity to draw conversational implicatures required for comprehending pragmatic meanings (Bara, Tirassa, & Zettin, 1997; McDonald & Pearce, 1996). Along with communicative disorders, patients with frontal lobe lesions often exhibit difficulties in conceptual and problem-solving skills and abnormalities in social behavior (McDonald, 1999, 2000b). As disturbances in interpreting contradictory sarcastic remarks are correlated with their conceptual skills, this suggests that inferential reasoning plays at least some role for understanding sarcasm (McDonald & Pearce, 1996). Moreover, damage to the frontal lobe particularly the prefrontal cortex was associated with profound deficits in comprehending empathy in concert with irony (Shamay-Tsoory, Tomer, & Aharon-Peretz, 2005; Shamay, Tomer, & Aharon-Peretz,

[14] Executive functions include inferencing, planning, monitoring that have been located predominantly in the frontal lobe (Shallice & Burgess, 1996).

2002). This observation led to the suggestion that deficits in irony processing resulted to some extent from an impaired ability of mentalizing[15] (i.e., to infer people's state of mind, thoughts and feelings). Some role of mentalizing in figurative language comprehension was further supported by recent lesion studies (Bibby & McDonald, 2005; Channon, Pellijeff, & Rule, 2005; for review see Martin & McDonald, 2003). For example, Channon, Pellijeff and Rule (2005) reported correlations between mentalizing scores and deficits in sarcasm comprehension for patients with CHI. In a study by Martin and McDonald (2005) TBI patients were shown to be incapable to infer intended communicative meanings, and thus to interpret implied ironic meanings of a statement. However, patients' deficits in irony comprehension were associated with difficulty in inferential reasoning rather than specifically in mentalizing (Martin & McDonald, 2005). Examination of communicative abilities of TBI patients revealed that patients had difficulty in a variety of pragmatic phenomena such as deceits or irony but still were able to comprehend standard communicative acts like requests (Angeleri, et al., 2008). Accordingly, deficits in irony comprehension could not merely consist of mentalizing but appeared to involve other higher-level neurocognitive abilities required for grasping more subtle conversational remarks (Angeleri, et al., 2008). It needs to be noted that different findings reported by these studies might have resulted from applied task requirements. To assess patients' capacity in comprehending figurative language their performance on sentence-to-sentence or sentence-to-picture matching was measured. As test questions were presented verbally or non-verbally, this might have affected patients' performance.

To conclude, findings suggest that beside the ability to make inferences, mentalizing as well as intact conceptual knowledge seems to be engaged in comprehending implied meanings of irony. With regard to neuropsychological evidence about neural structures underlying these processes, results of patient studies indicated the involvement of large neural networks in the RH and frontal lobe. For identifying functions of particular brain areas other neurophysiological methodologies preferable fMRI and PET are rather adequate measurements since they allow a more detailed description of the organization of language function.

[15] Theory of Mind (or mentalizing) is defined as the ability to attribute speakers' intentions, emotions or thoughts to their mental states and beliefs about the world (C. D. Frith & Frith, 1999; Gallagher & Frith, 2003; Premack & Woodruff, 1978). This ability plays an important role for social cognition, and is assumed to be mediated by a set of brain regions including the medial prefrontal cortex, the temporal poles and the posterior superior temporal sulcus (U. Frith & Frith, 2003).

3.3 Evidence from neuroimaging studies

Functional neuroimaging techniques such as fMRI and PET are hemodynamic measures of neural activity which can detect changes in regional cerebral blood flow, and may reflect enhanced activation in different areas in the brain. Since these methods have a high spatial resolution of brain activity, they can provide neuroanatomical information about brain structures contributing to the processing of pragmatic and figurative aspects of language. In this section findings from neuroimaging research are reported predominantly on processing irony and additionally on metaphors and idioms.

Understanding language in context often requires several comprehension processes such as making bridging or elaborative inferences, using common world knowledge, or pragmatic interpretation. For instance, inferencing the emotional status of a protagonist during text comprehension evoked activation in the ventromedial prefrontal cortex and the extended amygdaloid complex (Ferstl, Rinck, & von Cramon, 2005). Establishing coherence between subsequent sentences resulted in activation of the left frontomedian wall, the posterior cingulate and precuneal regions (Ferstl & von Cramon, 2001). Moreover, language processing in context has been identified to be mediated by an extended language network comprising the anterior temporal lobe and the dorsomedial prefrontal cortex among other brain regions (Ferstl, Neumann, Bogler, & von Cramon, 2008). Likewise, interpreting figurative language appeared to engage widespread neural networks that are not restricted to the language dominating left hemisphere (LH) but reach out to various brain regions of the RH. For example, in a PET study on metaphor comprehension activations of several LH regions including the prefrontal and basal frontal cortex, middle and inferior temporal gyri, the precuneus and parietal cortex have been observed (Bottini, et al., 1994). In addition, the processing of metaphoric meanings revealed activations of a subset of equivalent regions of the RH, i.e., the prefrontal cortex, the middle temporal gyrus, the precuneus and posterior cingulate. Findings suggest that the RH is engaged in figurative language comprehension and might contribute to mental imagery and retrieval of episodic memory. Similarly, evidence for a sensitivity of the RH to processing figurative language, in particular metaphors has also been shown in recent studies using fMRI (Ahrens, et al., 2007; Mashal, Faust, & Hendler, 2005; Mashal, Faust, Hendler, & Jung-Beeman, 2007; Shibata, Abe, Terao, & Miyamoto, 2007). Nevertheless evidence from fMRI studies is mixed in showing RH contributions to metaphor comprehension. Specific involvement of the RH in processing implied meanings of metaphoric sentences was not supported in other studies (Lee & Dapretto, 2006; Rapp, Leube, Erb, Grodd, & Kircher, 2007; Stringaris,

Medford, Giampietro, Brammer, & David, 2007). For instance, processing of metaphoric relative to literal language resulted in more left-hemispheric activation in prefrontal and temporo-parietal regions but not in the RH (Lee & Dapretto, 2006). Thus, involvement of the RH has been suggested to depend on other factors such as novelty of figurative interpretations, or semantic distance between literal and metaphoric meanings. In accordance with this, RH engagement has been seen for interpreting jokes (Coulson & Williams, 2005; Coulson & Wu, 2005), drawing inferences (Mason & Just, 2004; St. George, Kutas, Martinez, & Sereno, 1999), resolving lexical ambiguity (Faust & Chiarello, 1998; Mason & Just, 2007), or processing ambiguous idioms (Zempleni, Haverkort, Renken, & Stowe, 2007). By implication, processing figurative meanings as well as semantic and pragmatic information of utterances occurring in contexts seems to involve brain activation patterns that extend beyond single literal sentences. In comparing neural networks contributing to the processing of metaphors and other forms of figurative language, differential patterns of brain activity were observed indicating that distinct processing mechanisms were present. During the processing of discourses completed by metaphoric statements greater activation of the left inferior frontal gyrus and inferior extrastriate, and the bilateral inferior temporal cortex was observed in comparison to literal and ironic statements (Eviatar & Just, 2006, see Figure 3.1). In contrast, discourses ending in ironic statements evoked increased activation of the right superior and middle temporal gyri relative to literal and metaphoric statements. FMRI data confirm that functionally distinct neurocognitive processes seemed to be involved in comprehending different aspects of figurative meanings mediated by different brain regions. Higher activation in the RH seen for irony has been associated with the construction of a coherent discourse representation, whereas extra activity in the left inferior gyrus and inferior temporal regions seen for the processing of metaphors has been related to more effortful semantic selection of a more abstract meaning (Eviatar & Just, 2006). As engagement of differential neural networks seemed to be influenced by complexity of irony and metaphor, other experimental factors such as task requirements were shown to affect processing mechanisms involved in figurative language comprehension as well. In a recent study on the comprehension of implicit meanings in social situations including ironic and literal expressions, the right temporal pole revealed greater activation for ironic expression compared to literal ones independent of task (Wakusawa, et al., 2007). In contrast, larger activation in the medial orbitofrontal cortex seen for the processing of irony occurred to be dependent on task requirements (i.e., judgment of situational appropriateness). While the right temporal pole has been assumed to contribute to automatic recognition of irony, the medial orbitofrontal cortex

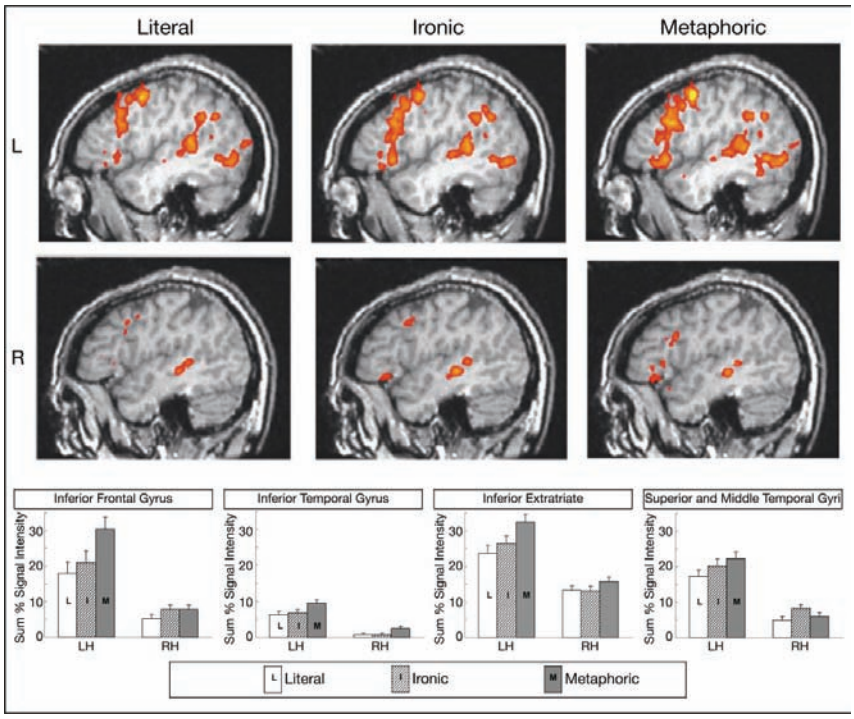

Figure 3.1. Activation patterns (averaged over 16 participants) for literal, ironic and metaphoric sentences seen in a fMRI study by Eviatar and Just (2006). Greater activation was shown in the left hemisphere (L) for metaphors than for ironic and literal sentences. More activation in response to irony was observed in the temporal area of the right hemisphere (R) relative to metaphoric and literal sentences.

has been related to conscious assessment of irony (Wakusawa, et al., 2007). In addition, successful understanding of sarcasm has been found to involve mentalizing as shown by neuropsychological studies (see section 3.2). In a study by Uchiyama and colleagues (2006) comprehending sarcastic utterances elicited larger activation of the medial prefrontal cortex that has been identified as part of the mentalizing system. This finding suggests that some kind of mentalizing (specifically recognizing a speaker's attitude) appears to be required for comprehending implied ironic meanings. Among other cortical regions higher level of activation has been reported for the left inferior prefrontal gyrus. Increased activation in this region has been associated with extra activity in integrating semantic and mentalizing processes (Uchiyama, et al., 2006).

To conclude, the observation of different patterns of brain activation that extended beyond activity for literal language comprehension implies that comprehending irony and metaphors requires additional processing. Involvement of partially distinct neurocognitive processes during comprehension of these two types of figurative language

was shown by differences in sensitivity of particular brain regions of the LH and RH. The processing of irony recruited the medial prefrontal cortex that could be attributed to mentalizing (Uchiyama, et al., 2006), as well as the right superior and middle temporal gyri involved in processing coherence of the ironic utterance with regard to contextual information (Eviatar & Just, 2006).

Part II

Experiments

Chapter 4

Experiment 1: Auditory processing of irony

This experiment is the first study of a series of ERP experiments that aimed to investigate language processing mechanisms underlying the comprehension of verbal irony. Irony is a form of figurative language that serves a variety of communicative and social functions, and appears to be pragmatically more complex than literal language. Ironic utterances occur predominantly in informal everyday communication where they are often realized acoustically. Therefore, the current experiment begins with the examination of the processing of ironic sentences in the auditory domain. Besides investigating the comprehension of ironic language, focus is on the perception of prosodic cues, which frequently accompany the use of verbal irony.

4.1 Introduction

The comprehension of irony has mainly been investigated by behavioral studies that measured reaction times for reading or judging ironic sentences in comparison to non-ironic sentences (see chapter 1). Findings of these studies provided support for three psycholinguistic approaches on figurative language comprehension. Behavioral data that indicated longer reading and response times for ironic meanings compared to literal meanings of the same sentence have been interpreted as evidence for the claims of the *standard pragmatic model* (Dews & Winner, 1999; Schwoebel, et al., 2000). By contrast, the observation of similar reaction times in response to ironic and literal sentences has been taken as support for the *direct access view* (Gibbs, 1986; Ivanko & Pexman, 2003). So far, there are only two studies (Cornejo, et al., 2007; Katz, et al., 2004) that examined the comprehension of irony as well as sarcasm by means of ERPs (see chapter 3). Both studies revealed an increase in the N400 amplitude for ironic and sarcastic sentences relative to their literal equivalents, respectively. However, it remains still unsolved whether the emergence of an irony-related N400 effect resulted from differences in contextual constraints than in pragmatic meaning. As semantic expectancy was not controlled for in the study by Cornejo et al. (2007), it may be that ironic sentences were semantically less expected which could have led to the emergence of an N400

effect. Moreover, inducing task-related processing strategies in examining the comprehension of irony might not have revealed processing mechanisms involved in irony comprehension under more natural processing condition where biases of task are absent. The question whether the processing of irony involves different comprehension processes than literal language has not been answered yet when confounding factors such as contextual strength or task-induced interpretation strategies were controlled. Moreover, when and how contextual information is taken into account during the interpretation of irony still remains unclear.

In the current experiment the comprehension of ironic sentences compared to non-ironic sentences is examined by means of evoked potentials (ERPs). As shown in chapter 2, ERPs are very useful in studying language processes online, i.e., the time point of their occurrence. Potential processing differences are immediately indicated by means of the high temporal resolution in the millisecond range of this methodology. Ironic and non-ironic sentences were embedded into two types of discourse contexts that provided the background information for respective interpretations. In order to exclude that a potential N400 effect is related to differences in semantic-pragmatic expectancy two pretests including a cloze probability test (Taylor, 1953) were conducted on the experimental materials. In case an irony-related N400 effect is still evoked, this would confirm the occurrence of semantic integration difficulties during the interpretation of non-literal sentences.

With regard to the psycholinguistic approaches on figurative language comprehension described in chapter 1, the following hypothesis can be made. If an N400 component in absence of any earlier ERP effects (i.e., before 400 ms after stimulus presentation) will be obtained, these results would support the assumptions of the ***standard pragmatic model*** (Grice, 1975). According to this model, comprehension processes of both ironic and non-ironic sentences should be identical during initial phases of processing (i.e., lexical access) since literal meanings of both ironic and non-ironic sentences are assumed to be accessed first. Contextual information is suggested to affect comprehension processes during later processing phases after the integration of literal meanings into global contexts biasing an ironic sentence interpretation failed. Consequently, inferential processes would be required for deriving appropriate ironic meanings that could possibly result in an additional late positivity. As previous ERP studies reported P600 effects for various semantic-conceptual manipulations (see Table 2.1 in section 2.3.4), the emergence of such a 'semantic P600' effect in response to irony could be predicted because this ERP component was shown to be sensitive to global semantic and inferential processes (Hoeks, et al., 2004; Kuperberg, Sitnikova, et al., 2003; van Herten, et al., 2005). Following the *standard pragmatic model*, it is

therefore hypothesized that no early ERP effects but an N400 component possibly followed by a late positivity are elicited by ironic relative to non-ironic sentences.

According to the ***direct access view*** (Gibbs, 1994, 2002), neither early nor late ERP effects (an N400 component and late positivity) are predicted. If contextual information constrains literal and figurative interpretations to the same degree, comprehension processes should not diverge neither during initial phases of processing nor during later phases. Contextual information has been assumed to interact with lexical processes so that appropriate meanings irrespective of figurativity should be accessed directly. By implication, figurative sentences are supposed to involve similar processing mechanisms alike literal sentences if both sentence types are embedded in rich supportive contexts (Gibbs, 1999a). Thereby, intended ironic meanings can be accessed immediately, which renders further inferential processes unnecessary. If this model holds true, then ERPs in response to ironic and literal sentences should be identical by revealing no differences in the ERPs for both sentence types.

Regarding the ***graded salience hypothesis*** (Giora, 1997, 1999), similar patterns of brain activity reflected by the ERPs to literal and ironic sentences are expected whenever both meanings are comparable in their salience (see section 1.2.3). While this prediction merely holds for conventional (or even idiomatic) forms of irony, in case of less conventional irony as used in the current experiment processing differences are hypothesized for later phases of processing. According to Giora (2003) higher salient literal meanings will be accessed initially when encountering irony, which is expected to result in similar ERP responses for literal and ironic sentences within earlier time ranges (i.e., before the onset of the N400 component). During semantic integration, processing difficulties are predicted if initially activated meanings cannot be integrated into foregoing discourse contexts. While additional inferential processes were proposed to be engaged in computing appropriate ironic meanings, for later phases of processing an N400 component possibly followed by a late positivity might be observed in response to irony. Thus, for both the *standard pragmatic model* and the *graded salience hypothesis* similar ERP patterns can be predicted in case of unconventional irony, which comprises an irony-related N400 component and a potential late positivity.

A second aim pursued in this experiment was to investigate potential influences of prosodic cues on the comprehension of irony. Besides linguistic information, prosody often contains emotional information that can convey additional aspects of meaning or express certain connotations. For example, speaker's attitudes are often expressed in the way he raises or lowers his voice, which might provide additional clues of how to interpret his or her utterances. As has been shown in behavioral studies ironic utterances are often accompanied by prosodic cues that differ from those of literal utterances

(Anolli, et al., 2000; Rockwell, 2000, 2007). Ironic utterances were characterized by variations in fundamental frequency, duration and intensity compared to literal utterances. Such prosodic marking may imply deviance in utterance meaning against literal sentence interpretations. Regarding the processing of irony, it is still unclear whether prosodic information contributes to the sentence interpretation, and whether it has a facilitating effect on the perception or comprehension of irony. In particular, it is of special interest in how far this additional information can affect the processing of utterances that are marked differently by an ironic or normal prosody. If prosodic information has an impact on the comprehension of irony, this should result in different ERP patterns for ironic sentences characterized by an ironic prosody relative to those characterized by a normal prosody.

4.2 Participants

Forty right handed and native German-speaking students were invited to participate in the experiment and were paid for their participation. All subjects (22 female) had a mean age of 24.7 years (SD 3.12), normal or corrected-to-normal vision and no hearing impairment.

4.3 Methods

4.3.1 Stimulus material

The stimulus material contained 120 experimental sentences that were manipulated pragmatically and prosodically (see Table 4.1). Stimuli consisted of three discourse sentences that constituted the discourse contexts for the target sentence. Two types of discourse contexts were created that ended in the same (i.e., semantically and syntactically identical) target sentence that only differed in pragmatic meaning. A target sentence achieved an ironic meaning when it contradicted the foregoing discourse context. Specifically, ironic sentences contained an opposite meaning of what could be expected literally as an adequate reply within this context. By contrast, the same target sentence retained a non-ironic meaning when it corresponded to a discourse context biasing a literal sentence interpretation. Thereby, the target sentence final word was critical for respective sentence interpretations since at this position it became obvious whether the sentence was conflicting with the context or not.

Table 4.1. Example of an experimental item used in the current experiment. Ironic and non-ironic target sentences achieved respective interpretations in regard to prior discourse contexts.

Discourse context	Target sentence
Am Wochenende wollte Michael noch schnell ein paar Sachen einkaufen. Als er im Supermarkt zur Kasse geht, ist dort eine lange Schlange wartender Leute. Verdrießlich stellt sich Michael an und meint:	(ironic) *Das ist ja großartig.*
Michaels Freundin hat sich neben vielen anderen Bewerbern an der Schauspielschule beworben. Nach mehrmaligem Vorsprechen erhält sie tatsächlich eine Zusage. Michael freut sich sehr für sie und sagt begeistert:	(non-ironic) *Das ist ja großartig.*

For the prosodic manipulation, a female professional speaker spoke all target sentences with a natural ironic and a natural normal intonation. Target sentences and discourse contexts were spoken continuously as complete discourses. Recordings included the discourses, which were taped with a DAT recorder and digitized at a sampling rate of 48.6 kHz. In order to create prosodic-pragmatic violation conditions discourse contexts and target sentences were cross-spliced. Target sentences with a normal prosody were spliced to discourse contexts biasing an ironic interpretation, and sentences with an ironic prosody were spliced to non-ironic discourse contexts. Thus, contexts and prosody were fully crossed leading to four experimental conditions (see Table 4.2) and a total set of 480 items.

Table 4.2. The four experimental conditions employed in the present experiment.

	Prosody	
Context	***ironic***	***normal***
ironic	ironic congruent	ironic incongruent
non-ironic	non-ironic incongruent	non-ironic congruent

For experimental presentation, the stimulus material was pseudorandomized and divided into four item versions of 120 items each. In this way, each experimental item was only presented once within each version. Experimental conditions were equally divided within all versions (i.e., 30 items of each condition). To ensure that participants were paying attention to the discourses, the acoustic presentation of the discourses was followed by a comprehension question that was presented visually.

In order to make sure that target sentences did not differ in their semantic expectancy, and were indeed perceived as ironic and non-ironic, two pretests (i.e., a cloze procedure and a rating study) were conducted in advance to the main study. Furthermore, to detect prosodic parameters of ironic and normal prosody prosodic analyses were performed on the stimulus material. Both pretests, as well as prosodic analyses are described below in the following sections.

4.3.1.1 Pretests

At first, a cloze probability test (Taylor, 1953) was carried out to control the semantic-pragmatic expectancy of target sentence meanings. Since ironic instances were neither conventional nor idiomatic, a cloze procedure was necessary to preclude processing difficulties due to differences in semantic-pragmatic expectancy between ironic and non-ironic sentences. In this test, potential experimental items were presented except for the sentence final word, and participants were asked to complete the missing ending with the most appropriate word. In total, 175 potential target sentences were created and embedded in both types of discourse contexts. As described above all discourses were spoken by a professional female speaker, and digitized. The target sentence final word was removed using a *speech wave editor* (CoolEdit2000). Thereby, it was ensured that no coarticulation effects were present. All items were pseudorandomized across two lists, so that each version of the sentence appeared only once in a list. Twenty-eight students (12 female, mean age 24.0 years (SD 2.74)) participated in the cloze procedure. Whenever ironic and non-ironic sentences gave rise to the same semantic ending, discourses were included as experimental items. In total, 120 items with a cloze probability of at least 90% were obtained. Ironic sentences were expected to 91% (SD 11.29), non-ironic sentences to 96.7% (SD 6.88). Semantic expectancy of ironic target sentences was still about 5% lower than of their non-ironic equivalents (paired t-test on items $t(119)=28.25$, $p<0.0001$).

In order to verify that experimental items were perceived as ironic or non-ironic a further pretest, i.e., a rating study, was conducted on the items obtained from the cloze procedure. Twenty participants (ten female, mean age 23.9 years (SD 3.28) who did not participate in the cloze probability test) took part. Again all items were pseudorandomized and balanced across two lists. Participants were asked to listen to the discourses and to rate the target sentences on a 5-point scale from non-ironic (1) to very ironic (5). A clear difference between ratings of ironic and non-ironic target sentences was observed. On average, ironic sentences were rated with 4.3 as relatively high ironic, and non-ironic sentences with 1.5 as rather non-ironic (paired t-test on items $t(119)=2187.9$, $p<0.0001$).

4.3.1.2 Prosodic analyses

To detect prosodic parameters of ironic and normal prosody acoustic analyses were performed by using *Praat* (version 4.3.07, http://www.praat.org). Duration, fundamental frequency (F0) and intensity were extracted for complete target sentences, as well as separately for the sentence beginning and the sentence ending. Time points of onset and offset of each of these segments were set by detailed listening and visual inspection of the speech signal. Differences between ironic and normal prosodic realizations were tested using paired t-tests.

The duration of each speech segment was analyzed by subtracting the onset from the offset. Differences in duration were found for the complete sentence, as well as for both the sentence beginning and ending (see Table 4.3). For all speech segments, ironic prosody was characterized by longer duration. In addition, the duration of entire discourses was analyzed to control for potential length effects. The discourses had an average duration of 13282 ms that did not differ significantly across both context types ($t(238)=1.43$, n.s.).

Fundamental frequency (F0) values were extracted at the onset, minimum, maximum and offset of each segment as these values reveal the most important characteristics of the F0 contour. A frequency range between 75 and 500 Hz was chosen for the analysis. Differences in F0 were found at the minimum of the complete sentence and particularly the sentence ending, as well as at the offset of the sentence beginning (see Table 4.4). Hence, ironic prosody was characterized by a higher pitch at the target sentence beginning and a lower pitch minimum at the target sentence offset.

The intensity contour was analyzed starting with an intensity minimum of 60 dB. Differences in intensity were observed for all speech segments suggesting a slightly lower intensity of ironic prosody that was constantly present (see Table 4.5).

In sum, prosodic analyses of the target sentences showed that ironic prosody differed in its perceptual features from normal prosody. Ironic prosody was characterized by sentence initial and final lengthening, both higher pitch maximum at the sentence beginning but lower pitch minimum at its offset, and permanently lower intensity.

Table 4.3. Results from acoustic analyses of the experimental material for differences in duration (in ms).

Mean values of duration (in ms)				
Segment	Mip	Mnp	t	p
Sentence	1608	1555	7.18	*0.00*
Beginning	225	212	3.14	*0.07*
Ending	600	570	9.67	*0.00*

Significant effects are marked in italics. Mip = Mean values for ironic prosody. Mnp = Mean values for normal prosody.

Table 4.4. Results from acoustic analyses of the experimental material for differences in fundamental frequency (in Hz).

Mean values of fundamental frequency (in Hz)																
	Onset				Maximum				Minimum				Offset			
Segment	Mip	Mnp	t	p	Mip	Mnp	t	p	Mip	Mnp	t	p	Mip	Mnp	t	p
Sentence	242	236	1.72	0.19	342	328	2.06	0.15	140	149	4.68	*0.03*	211	202	0.80	0.37
Beginning	238	237	0.01	0.93	263	254	2.88	*0.09*	210	206	1.27	0.26	231	223	4.99	*0.03*
Ending	205	208	0.48	0.49	253	243	2.39	0.12	150	163	10.9	*0.00*	189	185	0.52	0.47

Significant effects are marked in italics. Mip = Mean values for ironic prosody. Mnp = Mean values for normal prosody.

Table 4.5. Results from acoustic analyses of the experimental material for differences in intensity (in dB).

Mean values of intensity (in dB)																
	Onset				Maximum				Minimum				Offset			
Segment	Mip	Mnp	t	p	Mip	Mnp	t	p	Mip	Mnp	t	p	Mip	Mnp	t	p
Sentence	68	69	0.85	0.35	80	80	0.82	0.36	64	65	5.30	*0.02*	63	64	4.78	*0.03*
Beginning	68	69	0.85	0.36	77	77	0.20	0.65	67	68	1.38	0.24	71	72	3.66	*0.05*
Ending	68	69	5.26	*0.02*	75	76	2.85	*0.09*	64	65	3.75	*0.05*	63	64	4.62	*0.03*

Significant effects are marked in italics. Mip = Mean values for ironic prosody. Mnp = Mean values for normal prosody.

4.3.2 Procedure

Participants were seen individually in a 45 minutes session, during which they were seated in a dimly lit, soundproof cabin facing a computer screen at a distance of about 100 cm. They were asked to listen attentively to the discourses and to reply to the comprehension task as accurately as possible. For this task a test statement was presented that had to be judged with Yes or No. Participants had to decide whether or not the statement reflected the foregoing discourse contexts. Half of the statements were correct and half were incorrect. Responses were given via a button press. Before the actual experiment started, participants received an introduction and a short training of ten trials.

A trial sequence started with the auditory presentation of a discourse (approximately 13300 ms) during which a fixation cross was visually presented in the middle of the computer screen (see Figure 4.1). This fixation cross was presented in white for the first 8000 ms and turned into red for the rest of the auditory presentation including an additional interval of 1500 ms. Subjects were instructed to avoid eye movements during the occurrence of the red fixation cross. At that time when the fixation cross disappeared subjects had to perform the comprehension task. Soon after the response was given (within a period of 6000 ms) and an intertrial-interval of 1000 ms, the next trial started. Yes and No answers were completely balanced across all four experimental conditions ensuring that neither task nor decision related expectancy was induced.

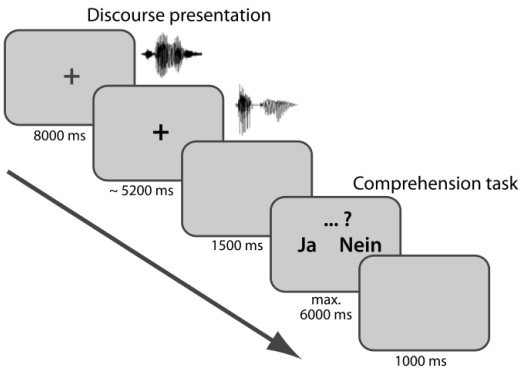

Figure 4.1. A schematic illustration of the trial. The arrow at the left indicates the temporal sequence. The descriptions at the right depict the presentation on the screen. The time intervals at the left show the duration of each phase (in ms).

4.3.3 Data acquisition and analysis

During the experiment both response times and accuracy rates were measured. Response times were not reported since a temporal delay of 1500 ms between stimulus presentation and the comprehension task was present. Accuracy rates are reported for the behavioral performance, and were used for ERP evaluation. For the statistical analysis of accuracy rates a repeated-measures ANOVA with the factors *Context* (ironic/non-ironic) and *Prosody* (ironic/normal) was calculated.

The electroencephalogram (EEG) was recorded using 52 Ag-AgCl electrodes mounted in an elastic cap (Electro Cap international). Bipolar horizontal and vertical electro-oculogram (EOG) was recorded to control for eye movements. Electrode resistance was kept under 5 K-ohm. The EEG was referred to the left mastoid, while the EEG from the right mastoid was also recorded for later re-referencing purposes. The EEG and EOG data were recorded continuously with a band pass between DC and 70 Hz, and were digitized at 250 Hz.

Average ERPs were computed for the critical word (i.e., at sentence final position) for each electrode position for each of the four experimental conditions (see Table 4.2). Averages included only correctly answered trials that were aligned to a 200 ms prestimulus baseline. ERPs were averaged from -200 ms before up to 1000 ms after presentation of the critical word. All trials that contained ocular, muscular or technical artifacts were excluded from the analysis (approximately 5% of the current experiment).

For statistical analysis of potential ERP effects the 300-500 ms latency window comprising the N400 component, and the 500-900 ms latency range for a potential late positivity effect were chosen. Based on visual inspection, an additional post-stimulus latency window between 100-400 ms for a left anterior negativity was computed. All dependent variables were quantified using multivariate analyses of variance (MANOVAs). The multivariate approach to repeated measurements was used to avoid problems concerning sphericity (Vasey & Thayer, 1987). For distributional ERP analyses two topographical factors *Anterior/Posterior* and *Region of Interest* (*ROI*) were defined and completely crossed, yielding 14 different *ROIs* each containing three electrodes (see Figure 4.2). Within-subject factors were *Anterior/Posterior* (2), *ROI* (7), *Context* (ironic/non-ironic) and *Prosody* (ironic/normal). Whenever interactions were found, further analyses were carried out.

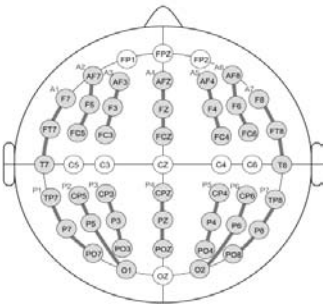

Figure 4.2. The map shows the regions of interest chosen for the experiments. The ROIs contained three electrodes each and were allocated in anterior ROIs (A1-A7) and posterior ROIs (P1-P7).

4.4 Results

Behavioral data. Participants showed an excellent performance on the comprehension task. Accuracy rates were equally divided across all four conditions. The mean accuracy rate was 95.3% (SD 3.40). Statistical analysis did not show any significant effects (F(1,39)=0.00-1.73, n.s.).

Electrophysiological data. As ironic prosody was shown to differ already at the target sentence beginning (see section 4.3.1.2), the ERPs were analyzed for both the onset as well as the offset of the target sentences. The results are described separately for the target sentence onset and offset in the subsequent sections.

ERPs at the target sentence onset

Figure 4.3 displays ERPs in response to ironic and normal prosody at the target sentence beginning. Two negative waveforms peaking around 100 ms and 400 ms with a posterior scalp distribution were observed. According to the visual inspection, two latency windows of 100-200 ms and 300-500 ms were chosen for statistical analysis.

The main analysis of the **100-200 ms** latency window showed an interaction of Anterior/Posterior with Prosody (F(1,39)=6.16, p<0.02). On the basis of this interaction, separate analyses were performed for anterior and posterior sites. A marginally significant effect of Prosody was found for posterior sites (F(1,39)=3.79, p<0.06) but not for anterior sites (F(1,39)=0.25, n.s.). This implies that ironic prosody evoked a slightly increased N100 component at the target sentence onset.

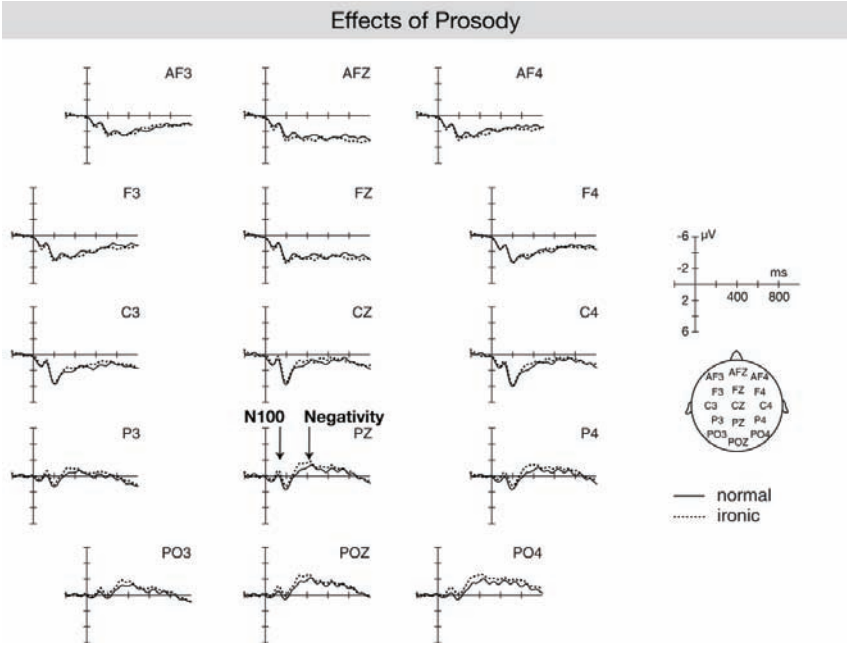

Figure 4.3. Grand average ERPs elicited by sentence initial words spoken with a normal prosody (solid line) or an ironic prosody (dotted line). In this and all subsequent figures negativity is plotted upwards. The acoustic onset of the critical word is at 0 ms on the x-axis.

For the **300-500 ms** time window, the statistical analysis revealed a further interaction between the factors Anterior/Posterior and Prosody ($F(1,39)=4.21$, $p<0.05$). In separate analyses for anterior and posterior sites a marginally significant effect of Prosody was only present on posterior electrode positions ($F(1,39)=3.69$, $p<0.06$). Hence, ironic prosody evoked not only a marginal N100 effect but also a further negativity peaking around 400 ms over parietal electrode sites.

ERPs at the target sentence offset

As shown in Figure 4.4, ERPs at target sentence offset revealed a sustained left anterior negativity and a later parietally distributed positivity, which were both larger for ironic sentences compared to non-ironic sentences. An irony-related N400 component was not observed.

Statistical analyses for the **100-400 ms** latency window showed a three-way interaction between Anterior/Posterior, ROI and Context ($F(6,34)=2.87$, $p<0.02$). On the basis of this interaction, further analyses were carried out for anterior and posterior sites separately. A significant interaction of ROI with Context ($F(6,34)=2.90$, $p<0.02$) was found for anterior electrode sites only. Resolving this interaction by ROI revealed a main effect of Context in the most left anterior ROI, i.e., A1 ($F(1,39)=5.31$, $p<0.03$).

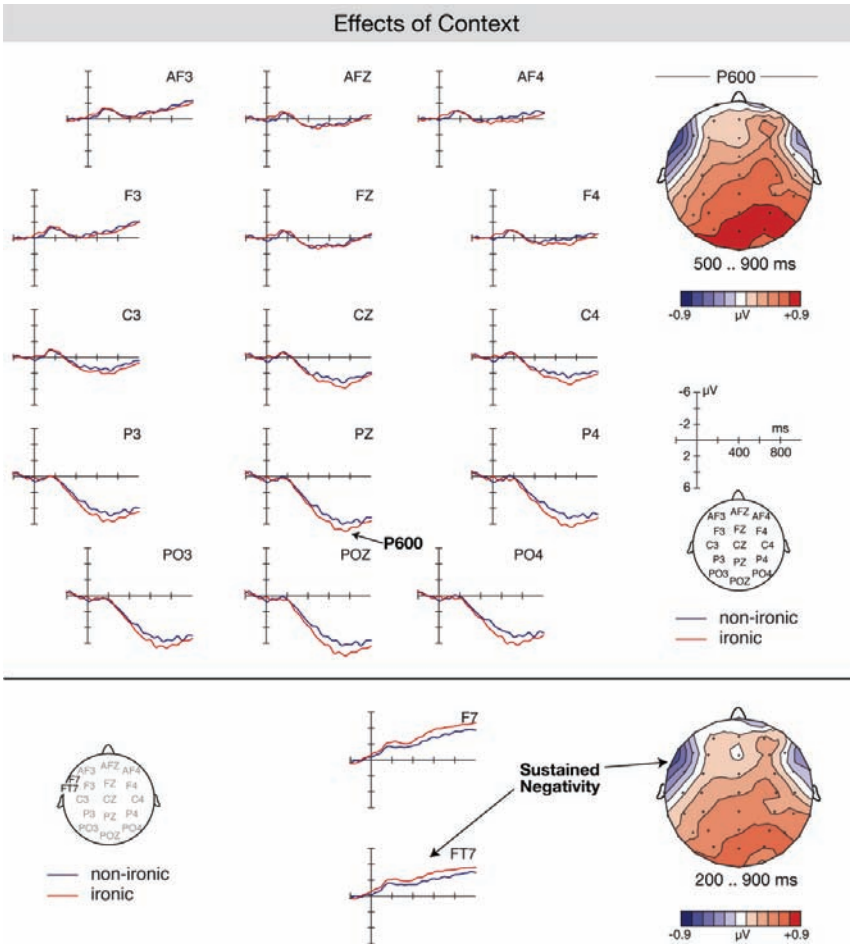

Figure 4.4. Grand average ERPs elicited by sentence final words that indicated a non-ironic sentence meaning (blue line), or pointed to an ironic meaning (red line) with respect to the foregoing discourse context. The acoustic onset of the critical word is at 0 ms on the x-axis. The lower part of the figure displays the grand average ERPs at two electrodes (F7 and FT7) of the most left anterior ROI (i.e., A1). The topographic maps on the right side show the scalp distribution of the ERP effects in response to irony.

For all other ROIs an effect of Context was not significant (F(1,39)=0.02-1.30, n.s.). This analysis confirms that a sustained negativity has been evoked in response to ironic sentences, which was restricted in its scalp distribution to left anterior electrode positions, i.e., F7, FT7 and T7. To define the latency onset of this effect four time windows of 50 ms each beginning at 100 ms were analyzed. Significant three-way interactions of Context with Anterior/Posterior and ROI were found in the 150-200 ms, 200-250 ms and 250-300 ms latency windows (F(6,34)=2.31-3.25, $p<0.05$). Follow-up analyses for anterior sites showed further interactions between Context and ROI only in the 250-300ms time window (F(6,34)=4.32, $p<0.002$). Resolving this interaction revealed a

main effect of Context in the most left anterior ROI, i.e., A1 ($F(1,39)=4.28$, $p<0.04$). This analysis shows that the left anterior negativity had its onset around 250 ms post-stimulus presentation.

Within the N400 latency window of **300-500 ms** statistical analysis revealed a three-way interaction of Anterior/Posterior, ROI and Context ($F(6,34)=2.90$, $p<0.02$). Separate analyses for anterior and posterior sites showed an interaction of ROI with Context anteriorly ($F(6,34)=3.03$, $p<0.02$), but not posteriorly ($F(6,34)=1.33$, n.s.). Further subanalyses for each anterior ROI revealed a marginally significant effect of Context in the most left anterior ROI, i.e., A1 ($F(1,39)=3.69$, $p<0.06$) but not in any other ROIs ($F(1,39)=3.69$, n.s.). This confirms the observation that in response to ironic sentences an N400 component was not elicited. However, the early starting left anterior negativity seen for irony was still present in this later latency range of 300-500 ms.

The main statistical analysis for the **500-900 ms** latency window again showed a three-way interaction of Anterior/Posterior with ROI and Context ($F(6,34)=5.22$, $p<0.001$). Based on this interaction, anterior and posterior electrode sites were analyzed separately. The follow-up analysis for posterior sites revealed a main effect of Context ($F(1,39)=6.53$, $p<0.01$). This indicates that ironic sentences evoked a late positivity that was distributed over posterior electrode positions. For the analysis of anterior sites an interaction of ROI with Context was present ($F(6,34)=5.55$, $p<0.0004$). Further analyses were carried out for each anterior ROI separately, whereby only the most left anterior ROI (i.e., A1) showed a main effect of Context ($F(1,39)=4.60$, $p<0.04$). This result substantiates the long-lasting left anterior negativity elicited by ironic sentences.

4.5 Discussion

In the present experiment the comprehension of verbal irony in relation to prosodic information was investigated by means of ERPs. The findings show that processing ironic sentences compared to equivalent literal sentences elicited a differential pattern of brain activity at the target sentence offset. At this position, critical words were presented that pointed to an ironic or literal sentence interpretation. In response to irony early and late ERP effects were seen. Sentences that achieved an ironic meaning elicited a sustained left anterior negativity starting around 200 ms (referred to as sustained LAN) followed by an additional late posterior positivity in the latency range of 500-900 ms. As this positivity resembled a P600 component in its electrophysiological characteristics (i.e., consisting of a latency onset of about 500 ms post-stimulus with an amplitude maximum over parietal sites), it is classified as P600 effect. Most importantly, the comprehension of irony did not result in an increase in the amplitude of the N400 component. Moreover, the processing of irony appeared to be uninfluenced by different

prosodic patterns when critical words were presented. Yet, an effect of Prosody was observed at the target sentence onset. Relative to normal prosody, ironic prosody evoked two negative shifts at posterior electrode positions, i.e., an N100 component and a later negativity peaking around 400 ms. In the following section, the ERP effects at different sentence positions are discussed separately.

ERP effects at the target sentence onset

At sentence initial position, marginal effects of Prosody (i.e., an early and a later negativity) were found. However, interactions with Context were not revealed. Both negativities were larger in amplitude for ironic than for normal prosody suggesting that specific prosodic realizations have been perceived already at about 100 ms after stimulus presentation. At this position of the sentence, ironic prosody was characterized by initial lengthening, higher pitch and lower intensity values. The perception of the combination of these different prosodic features may have caused an effect on the amplitude of the early sensory N100 component. Variations in physical stimulus features were shown to reliably modulate such early ERP components that may be associated with processes of selective attention to differential stimulus characteristics (Hansen, Dickstein, Berka, & Hillyard, 1983; Sanders & Neville, 2003; Thornton, Harmer, & Lavoie, 2007). Moreover, ironic prosody had an impact on later processing indicating that different prosodic characteristics have clearly been detected. Since at the target sentence onset relatively few information is provided about potential sentence interpretations, the absence of an interaction of Prosody with Context is not too surprising. The findings imply that differences between ironic and normal prosody have been perceived but did not influence further processing of lexical-semantic information at this position of the sentence.

ERP effects at the target sentence offset

ERPs measured at the target sentence final word clearly indicate different brain responses for ironic and non-ironic sentences during initial and late phases of processing. In response to irony an early starting sustained LAN and a P600 component were elicited. An increased N400 component for ironic sentences was not seen. With regard to the *standard pragmatic model* (Grice, 1975) and the *graded salience hypothesis* (Giora, 1997, 1999), these findings do not support the assumptions of both models concerning initial processing of figurative language in the case of irony. For initial phases of processing both models suggested an involvement of similar cognitive processes in comprehending ironic and non-ironic sentences. Accordingly, literal or most salient meanings respectively should have been activated initially leading to a semantic incompatibility phase when integrating this meaning into an irony-biasing discourse

context. However, the emergence of such an early starting ERP effect is an index of initial processing differences in comprehending irony. This negativity was distributed over left anterior electrode sites and resembled a sustained LAN effect related to processes of working memory. Enhanced LAN amplitudes have been typically observed in response to violations of morphosyntactic constraints (Gunter, et al., 2000; Hagoort, Brown, & Osterhout, 1999) but also to an increase of working memory processes (Anderson & Holcomb, 2005; King & Kutas, 1995; Rösler, Pechmann, Streb, Röder, & Hennighausen, 1998). These latter negative ERP deflections often displayed a continuous shift as this was seen for the sustained left anterior negativity in response to irony. In the current study morphosyntactic anomalies have not been induced so that it is rather unlikely that the observed sustained LAN reflects operations associated with syntactic information processing. With regard to the literature, it is even more likely that this negativity is a reflection of working memory processes related to the comprehension of irony. Discourses ending in an ironic statement may have been more complex in their conceptual structure concerning the interpretation of figurative meanings. In order to derive appropriate ironic meanings including speakers' communicative intents, additional information from pragmatic and common world knowledge could have been necessary. Retrieval of such information from long-term memory, and active manipulation of literal sentence meanings possibly led to an increased load on working memory resources, which is probably indicated in an increased amplitude of the sustained LAN. Likewise, larger LAN amplitudes were found for the comprehension of humorous sentences (Coulson & Kutas, 2001; Coulson & Lovett, 2004). A sustained LAN related to the comprehension of jokes has been interpreted as extra processing costs associated with conceptual-semantic reanalysis that enable shifting from one frame into another (cf. section 3.1). Therein, retrieving new information from long-term memory and reorganizing existing information into a new frame has been proposed to cause increased working memory processes reflected in a larger LAN amplitude (Coulson & Kutas, 2001). Even if the comprehension of irony does not require frame shifting it still has been reported to involve mentalizing, and the use of pragmatic and common world knowledge (cf. chapter 3). By means of prior supportive contextual and prosodic information, it may be possible that foregoing information is hold into working memory and is immediately completed by pragmatic and common world knowledge retrieved from long-term memory. Nonetheless, whether the left anterior negativity in response to irony is in fact related to working processes and reflects a general process needs to be examined in more detail. While the enhanced sustained LAN for jokes had a later latency onset (i.e., around 500 ms after stimulus presentation) and was shown for the visual presentation modality, further research is necessary to see whether the cur-

rently observed left anterior negativity is a reliable effect for the processing of irony independent of modality. If so, then a comparable sustained LAN is expected to be elicited for the comprehension of irony when presented visually.

Despite these early processing differences, a semantic incompatibility phase indexed by a larger amplitude of the N400 for irony did not occur. The absence of such an irony-related N400 component implies that difficulty in semantic integration of the sentence final word into foregoing contexts were not apparent. The amplitude of the N400 was shown to be modulated by the ease of semantic integration, and would have been increased the more difficult such integration (Chwilla, et al., 1995; Friederici, Steinhauer, & Frisch, 1999; van Petten, et al., 1999). However, ironic and non-ironic sentences did not differ within the N400 time window suggesting that processing of semantic information was not more difficult when encountering irony. With respect to the assumptions derived from the ***standard pragmatic model*** (Grice, 1975), the recognition of a semantic incongruency was assumed during integration of initially activated literal meanings with foregoing contextual information. Regarding the ***graded salience hypothesis*** (Giora, 1997, 1999) similar processing difficulties have been predicted since ironic sentences presented in the current experiment were less salient (unconventional) instances of irony. Thus, both models cannot explain the findings of the current ERP study for processing lexical-semantic information. The processing of semantic information seemed to be equivalent for both ironic and literal sentences since no N400 effect was seen. Nevertheless, in two ERP studies N400 effects have been observed for the processing of irony and sarcasm, respectively (Cornejo, et al., 2007; Katz, et al., 2004). As mentioned, these different findings might have been observed due to differences in semantic expectancy between ironic and non-ironic sentence completions rather than reflecting difficulties in semantic integration. When sentence final words are semantically expected particular sentence endings are restricted to a relatively small set of potential meanings, which was seen to result in a reduction of the N400 amplitude (see Kutas & Hillyard, 1984). Therefore, the N400 has been related to semantic expectancy as well as semantic integration difficulties as variations of this component were seen due to contextual constraints (see for example Brown & Hagoort, 1993; Federmeier & Kutas, 1999; Kutas & Hillyard, 1984). Accordingly, differences in semantic expectancy between ironic and non-ironic sentences might have caused an enhancement of N400 reflecting more effortful processing of semantic information. Such explanation was also suggested by Cornejo et al. (2007) as possible description of their data, and might hold true for the findings by Katz, Blasko and Kazmerski (2004) as well. In case differences in semantic expectancy are present, this hinders a clear interpretation of N400 effects as

an index of processing difficulties associated with semantic integration of word meanings with prior contextual information (see section 2.3.3).

With regard to the ***direct access view*** (Gibbs, 1994, 2002), the current findings are not in accordance with the claims of this model. Accordingly, a direct comprehension of ironic meanings has been assumed when sentences would be embedded in rich and supportive contexts. Experimental materials showed a high cloze probability for both ironic as well as non-ironic sentence endings which implies that discourse contexts provided rich contextual support for respective sentence interpretations. Hence, brain responses for ironic and non-ironic sentences should not have differed corresponding to the *direct access view*. Still the ERPs revealed early as well as late effects when encountering critical information for ironic interpretations, which makes the proposed processing mechanism rather improbable. Even if the critical word of ironic sentences could be activated and integrated as easily as their non-ironic equivalents, the observation of a sustained LAN and P600 component clearly reveals processing differences. The emergence of a late positivity in absence of an N400 component for irony is quite surprising, since it was most frequently associated with aspects of syntactic information processes. The observed P600 is rather comparable to 'semantic P600' effects that were elicited by violations of semantic and thematic constraints (see Table 2.1 in section 2.3.5). In these studies late positive ERP effects have been interpreted as reflections of global coherence or semantic-conceptual integration processes (Juottonen, et al., 1996; Salmon & Pratt, 2002), or monitoring of current sentence perception (Kolk, et al., 2003; van Herten, et al., 2005). Yet, the occurrence of a P600 component in response to pragmatic manipulations has rarely been reported. In a study by Kuperberg et al. (2003), pragmatically anomalous sentences elicited an enhanced P600 in addition to an N400 component. While this positive shift was related to task requirements of plausibility judgments, the functional interpretation of the current P600 remains speculative. One possible interpretation is that the P600 in response to irony may reflect comprehension processes at a pragmatic, conceptual level. While at this stage of processing different types of information need to be integrated, the P600 might be a function of late integration processes of semantic and prior contextual information into a coherent mental model. Alternatively, the P600 effect might be a reflection of pragmatic interpretation processes. As assumed by Grice (1975), and for less salient irony by Giora (1994, 2002) additional inferential processes are required in order to compute appropriate pragmatic interpretations of ironic statements. The disparity between literal meanings of target sentences and their foregoing discourse contexts might involve inferential processes whereby ironic meanings including their communicative intents might be derived. Still, whether such processes are indeed reflected in the amplitude of the P600

requires further evidence. With regard to previous findings of P600 effects in response to various syntactic but also semantic anomalies, this positive shift seems to be sensitive to the processing of different kinds of linguistic information. Up to now, the current findings partially seem to support the assumptions of both the *standard pragmatic model* and the *graded salience hypothesis* regarding the proposed later processing of irony. However, the current ERP data did not provide evidence for the assumptions of the *direct access view*. Furthermore, whereas ERPs revealed differences between both sentence types, manipulating pragmatic complexity did not affect the behavioral performance of the participants. Behavioral data obtained by the comprehension task showed an excellent performance across all conditions indicating that figurativity of sentences had no influence on the overall comprehension of discourses.

The influence of cueing by prosody

The question whether prosodic information facilitated the comprehension of irony cannot be verified by the current findings. As mentioned above ironic prosody showed an impact at the target sentence onset but not at its offset. When encountering the target sentence final word neither main effects of Prosody, nor interactions of Prosody with Context were found. There may be three major reasons for the absence of an effect of prosody at this sentence position. On the one hand, it might be that semantic information at the target sentence offset overruled prosodic information since at this position it became clear whether sentences achieved an ironic or a non-ironic meaning. Participants might have primarily relied on semantic information for interpreting sentence meanings than taking prosodic cues into account. On the other hand, prosodic information has already been perceived at the target sentence onset, which could have led to some kind of redundancy of prosodic cueing at the sentence offset. As prosodic information unfolds continuously over time, it possibly rendered variations in pitch and duration at this sentence position less informative. Moreover, a further reason might be apparent from the prosodic characteristics of irony itself. In behavioral studies on the realization and perception of ironic prosody, different prosodic cues have been identified to accompany irony (Anolli, et al., 2000; Rockwell, 2000, 2007). Besides higher and lower pitch values, longer as well as shorter duration have been reported for ironic prosody compared to normal prosody (see section 1.1.2). Differences in prosodic characteristics are possibly language-specific (i.e., English versus Italian) but may also suggest that ironic prosody contains some variance, and therefore provides a less reliable cue in signaling ironic interpretations. Moreover, a potential uncertainty about the function of prosodic cues was probably enhanced by the experimental design applied in the current study. Ironic target sentences were accompanied by both ironic and non-ironic prosody, so that prosodic cues were possibly less apparent in cueing particular

meanings. Though ERPs at target sentence onset revealed that ironic prosody has been perceived, in how far prosody affected the processing of ironic sentences (before presenting critical words) remains speculative. Further research is necessary to see, how and when additional (prosodic or even more explicit) cues may facilitate the comprehension of irony.

Chapter 5

Visual processing of irony

5.1 Experiment 2: Visual processing of irony with regard to explicit cueing

5.1.1 Introduction

In Experiment 1 the processing of verbal irony in the auditory presentation modality was explored by means of evoked potentials. To some extent ERPs provided evidence for the processing mechanisms proposed by the *standard pragmatic model* (Grice, 1975) and the *graded salience hypothesis* (Giora, 1997, 1999). The ERPs revealed differences during initial and late phases of processing in comprehending ironic sentences compared to literal ones when sentences were presented as connected speech. In response to irony a sustained LAN and an additional P600 component were elicited. Most importantly, an irony-related N400 component was not obtained. As findings were observed for the auditory modality, it is unclear whether the observed brain potentials were modality specific, or whether they can be generalized across modalities by replication for the visual presentation modality. If a similar ERP pattern will be found for the visual domain, this would provide further evidence for the reliability of previously obtained ERP effects, and thus suggests similar processing mechanisms underlying irony comprehension independent of modality. Moreover, studying the processing of irony under similar conditions as employed in behavioral studies (see chapter 1) allows a better comparability of the experimental findings.

Another aim pursued in the current study was to investigate influences of cueing by the use of punctuation characters on irony comprehension. While in Experiment 1 influences of prosodic cues have been explored, the present study addresses the function of graphic cues (i.e., punctuation marks) in the form of quotation marks in comprehending irony. Such graphic cues are more explicit than prosodic information, and thus are more likely to affect the comprehension of irony. An impact of punctuation on language comprehension has been examined in the context of syntactic information processing, in particular sentence parsing (see Steinhauer 2003). In this study by Stein-

hauer (2003) the presence of commas appeared to affect syntactic parsing and prevented from initial misinterpretations. The processing of prosodic boundaries as well as commas that mimicked prosodic boundaries in the visual domain resulted in a *Closure Positive Shift*. Findings suggest that commas serve as visual triggers for phonological phrasing, and are functionally equivalent to linguistic prosody. With respect to quotation marks additional visual information conveyed by this type of punctuation might affect sentence interpretation as well, even if on another level than syntactic parsing. Besides to certain verbal cues (see section 1.1.2), irony was shown to be accentuated by a variety of paraverbal cues such as quotation marks or emoticons in written language. Such cues frequently occur in everyday communication using email or text message, since they provide a possibility to convey intended non-literal sentence meanings outside of oral communication situations. Adding quotations to particular words or phrases of written sentences lays explicit emphasis on deviance in sentence interpretation, and point to ironic sentence meanings (Dudenredaktion, 2006). Compared to prosodic information, punctuation cues are more prominent in nature, because they are less variable and more obvious in appearance. These characteristics suggest that this kind of cueing may have an effect on the perception as well as interpretation of intended ironic meanings. Research on irony comprehension has mainly concentrated on the processing of ironic utterances per se, while effects of paraverbal cues in signaling respective utterance meanings have rarely been investigated. In Experiment 1 effects of prosody were shown at the target sentence onset but not at its offset (i.e., the position of the sentence at which implied sentence meanings can be recognized). As prosodic information unfolds continuously over time it might be possible that it exerted an influence on sentence processing earlier than at the sentence final position. To specify when and how language-accompanying cues contribute to the processing of irony, in the current experiment quotation marks have been employed that allowed to control for the temporal impact of cueing. The target sentence final word was put in quotations which ensured that cueing occurred at the same point in time at which potential sentence meanings become clear. If quotation marks indeed affect the comprehension of irony, it is hypothesized that such an effect results in different ERP patterns for the processing of irony presented with or without such graphic cues. As there are no comparable ERP studies that examined the impact of visual cueing in this context, no further specification of potential ERP effects can be made.

5.1.2 Participants

Forty native German-speaking students (20 female) performed the experiment and were paid for their participation. All subjects were right-handed and had normal or corrected-to-normal vision. The mean age was 24.9 years (SD 3.20).

5.1.3 Methods

5.1.3.1 Stimulus material and procedure

The stimulus material was identical to Experiment 1 except for the prosodic manipulation. Instead of prosodic information punctuation cues in the form of quotation marks were induced. Both discourse contexts and target sentences were presented visually. The target sentence final word was critical for potential sentence interpretations (see Table 4.1). In order to bias particular interpretations, critical words were put in quotation marks in half of all experimental items. In this way, quotation marks were valid for 50% of the items (i.e., for ironic sentences), and invalid for another 50% of the items (i.e., for non-ironic sentences). Experimental manipulations contained the two-leveled factors *Context* (ironic/non-ironic) and *Quotations* (with/without quotations), which were fully crossed leading to four experimental conditions. Equivalent to the 2-by-2 experimental design of Experiment 1, two congruent and two incongruent conditions were created (see Table 5.1). For experimental presentation, the 120 items were again pseudorandomized and equally divided into four item versions. Within each version the four experimental conditions were equally divided (i.e., 30 items of each condition). After visual presentation of the discourses the comprehension task followed. Again, half of the test statements were correct, half were incorrect.

Table 5.1: The four experimental conditions employed in the present experiment.

	Quotation marks	
Context	***with quotations***	***without quotations***
ironic	"ironic" congruent	ironic incongruent
non-ironic	"non-ironic" incongruent	non-ironic congruent

The experimental procedure was identical to that of Experiment 1 except for the presentation modality of the experimental items. A trial sequence for the visual item presentation is illustrated in Figure 5.1. Discourse contexts were presented in one block of three lines on a computer screen in front of the participants. After reading the discourse contexts participants were instructed to press a button to continue with the presentation (otherwise automatic continuation after 20000 ms). Target sentences were presented word-by-word whose presentation onset was introduced by the occurrence of

a fixation cross for 200 ms at the center of the screen. Each word appeared in a rapid serial visual presentation mode for 300 ms and was succeeded by a blank screen for 200 ms. After sentence offset there was a blank screen for another 1500 ms before the presentation of the comprehension task started. A trial was completed when the response was given (maximal response time of 6000 ms). The inter-trial interval was 1000 ms. Word length was always kept within 2° and word height within 4° of the visual field. All words were presented in light grey on a dark background.

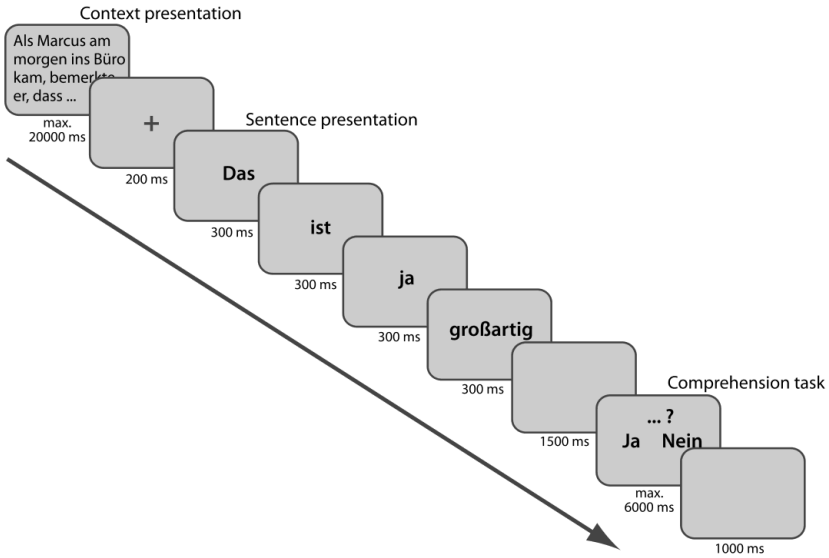

Figure 5.1: A schematic illustration of a trial when presented visually. The arrow at the left shows the temporal sequence of one trial. The time intervals beneath the screen shots indicate the duration of each presentation phase.

5.1.3.2 Data acquisition and analysis

Data acquisition and analysis were identical to Experiment 1. In the statistical analysis the two-leveled factor Prosody was replaced by the factor Quotations (with/without quotations). ERPs were analyzed at target sentence offset, i.e., at the presentation of critical words. Approximately 11% of the correctly answered trials were excluded from the averages due to ocular artifacts (EOG rejection +/-40 µV).

5.1.4 Results

Behavioral data. The mean accuracy rate was 95.3% (SD 3.80) indicating that participants' performance was comparable to Experiment 1. The statistical analysis showed an interaction of Context with Quotations ($F(1,39)=7.59$, $p<0.01$). Follow-up analyses for each context type separately showed a main effect of Quotations solely for non-ironic contexts ($F(1,39)=4.27$, $p<0.05$). Participants performed slightly better when non-ironic sentences were presented without quotation marks (mean accuracy rate 96.4% (SD 4.02)) than with quotations (mean accuracy rate 94.9% (SD 5.06)).

Electrophysiological data. Grand average ERPs are illustrated in the Figures 5.2 and 5.3. For all conditions target sentence final words elicited a P1-N1 complex at occipital sites that is characteristic for the processing of visual stimuli. Visual inspection of the waveforms (see Figure 5.2) suggests that a P600 component emerged in response to irony, which had a centroparietal scalp distribution. An irony-related N400 component

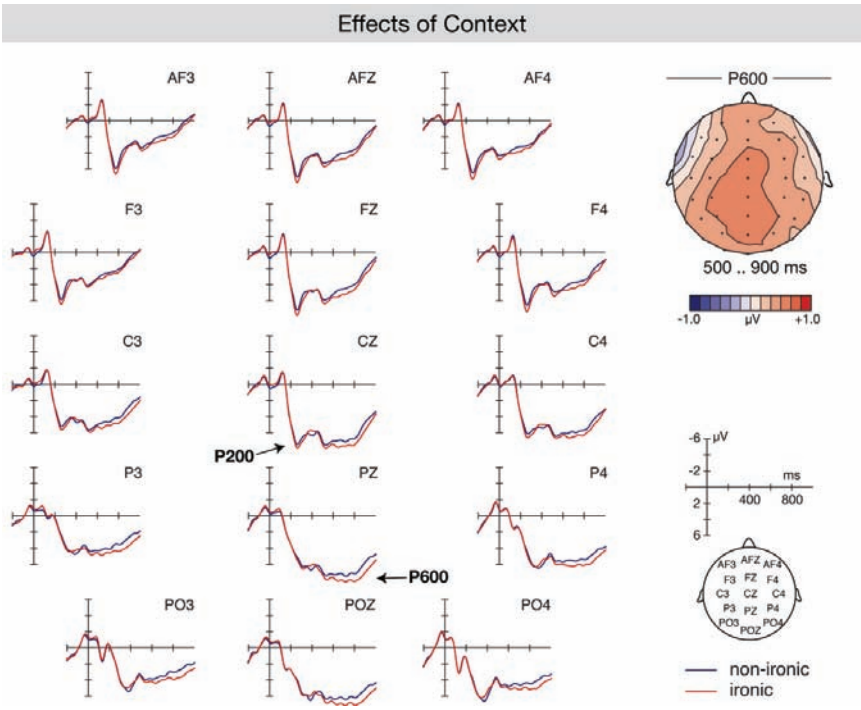

Figure 5.2. Grand average ERPs elicited by sentence final words, which indicated a non-ironic sentence meaning (blue line), or implied an ironic meaning (red line) with respect to the foregoing discourse context. The visual onset of the critical word is at 0 ms on the x-axis. In this and all following figures negativity is plotted upwards. The topographic map on the right shows the scalp distribution of the P600 component.

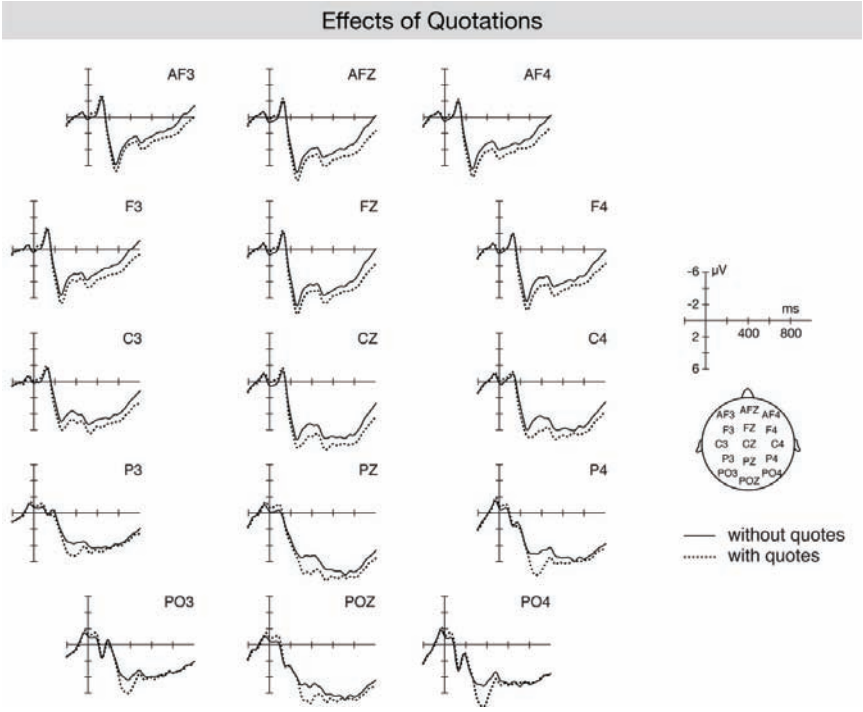

Figure 5.3. Grand average ERPs elicited by sentence final words that were presented without quotation marks (solid line) or with quotation marks (dotted line).

seemed to be absent also in the visual presentation modality. An early starting left anterior negativity as observed for ironic sentences in Experiment 1 was not seen. However, an early positivity peaking around 250 ms seemed to be present instead. To cover this effect an additional time window of 200-300 ms was analyzed. In response to quotation marks (see Figure 5.3) a sustained positivity was evoked which had its latency onset at about 200 ms.

The main statistical analysis of the **100-400 ms** time window showed neither effects nor interactions of Context ($F(6,34)=0.02-1.77$, n.s.). The analysis confirms that the early starting left anterior negativity elicited by ironic sentences for the auditory domain (see Figure 5.4) could not be replicated for the visual domain.

The statistical analyses for the additional latency window of **200-300 ms** revealed a main effect of Quotations ($F(1,39)=11.94$, $p<0.001$) as well as an interaction between Quotations and Anterior/Posterior ($F(1,39)=9.58$, $p<0.001$). A further interaction between Context and ROI ($F(6,34)=3.24$, $p<0.01$) was also significant. Subanalyses were carried out for anterior and posterior sites separately, which showed a main effect of Quotations for the anterior site only ($F(1,39)=18,78$, $p<0.0001$). This analysis indicates

sentence final words put in quotations evoked an early positivity that had its amplitude maximum over anterior scalp sites. Resolving the interaction of Context with ROI revealed a significant effect of Context for the most central ROI, i.e., R4, ($F(1,39)=3.99$, $p<0.05$) as well as marginally significant effects for the adjacent ROIs, i.e., R3 and R5 ($F(1,39)=2.71$-3.10, $p<0.10$). In contrast to Experiment 1, ironic sentences presented visually elicited a P200 effect but no early starting left anterior negativity.

In the **300-500 ms** time window, neither effects of Context ($F(1,39)=0.03$, n.s.), nor interactions of Context with any other factor ($F(6,34)=0.03$-1.47, n.s.) were significant. This implies that an irony-related N400 effect did not occur for the visual modality as well. However, the statistical analyses of this latency window revealed a main effect of Quotations ($F(1,39)=20.69$, $p<0.001$) and an interaction of Quotations with Anterior/Posterior and ROI ($F(6,34)=2.65$, $p<0.03$). Further analyses for anterior and posterior sites separately showed main effects of Quotations anteriorly ($F(1,39)=11.41$, $p<0.002$) and posteriorly ($F(1,39)=26.07$, $p<0.0001$). The early positivity seen for sentence final words put in quotations lasted until this later time window.

In the **500-900 ms** latency window significant effects of Context ($F(1,39)=5.00$, $p<0.03$) as well as of Quotations ($F(1,39)=6.22$, $p<0.02$) were present. In addition, interactions between Context, Anterior/Posterior and ROI ($F(6,34)=2.22$, $p<0.06$) and between Quotations and Anterior/Posterior ($F(1,39)=8.54$, $p<0.01$) were found. The three-way interaction was resolved by separate analyses for anterior and posterior sites, and revealed a main effect of Context posteriorly ($F(1,39)=7.78$, $p<0.01$). An additional two-way interaction between Context and ROI ($F(6,34)=3.69$, $p<0.01$) anteriorly was also present. Resolving this interaction showed a significant effect of Context in the most central anterior ROI, i.e., A4, ($F(1,39)=3.97$, $p<0.05$) and a marginally significant effect in the right-central anterior ROI, i.e., A5, ($F(1,39)=3.51$, $p<0.07$). The analyses confirm that the P600 component elicited by ironic sentences could be replicated for the visual modality but showed a more widespread distribution over frontocentral and parietal sites. Subanalyses of the interaction of Quotations with Anterior/Posterior mentioned above revealed a significant effect of Quotations on anterior electrode sites ($F(1,39)=15.30$, $p<0.0004$). This indicates that sentence final words put in quotations evoked a sustained positivity which already started around 200 ms and was still present in the latency window of 500-900 ms. An interaction between Context and Quotations was not seen in any of the time windows analyzed, which suggests that cueing by quotation marks did not affect the processing of irony.

5.1.5 Discussion

The aim of the present experiment was two-fold. On the one hand, this study was set out to replicate the ERP pattern observed for the comprehension of irony for the auditory domain. On the other hand, this study was conducted to explore an effect of cueing by quotation marks on the perception and interpretation of irony. The results showed that late ERP effects were reliably evoked in response to irony, whereas earlier effects appeared to be less robust for the visual presentation modality. Regardless of presentation modality, ironic sentences elicited a larger P600 component in comparison to literal sentences. Both P600 effects emerged 500 ms after stimulus presentation and showed centroparietal amplitude maxima. Thereby the P600 seen for the visual modality showed a somewhat more widespread scalp distribution including frontocentral electrode positions. Importantly, as seen for the auditory domain an irony-related N400 component was absent also for the visual domain. A sustained left anterior negativity could not be replicated in response to irony. Instead a P200 component was evoked by ironic sentences relative to non-ironic sentences. Regarding an influence of cueing by quotation marks on irony comprehension, ERPs did not reveal such an effect. An interaction between Quotations and Context was not found indicating that the processing of irony did not diverge in presence or absence of quotation marks. In the following, ERP effects obtained for irony are discussed with respect to implications on proposed processing mechanisms, as well as effects of cueing by quotation marks.

Late ERP effects in response to irony

The obtained ERP data imply that processing irony involved similar comprehension processes during late phases of processing for both the auditory and visual presentation modality. The results suggest that the ERP pattern consisting of a P600 component in absence of an N400 component can be generalized across modalities for the processing of verbal irony. Regarding psycholinguistic approaches on figurative language comprehension, the current findings only partially support the assumptions of the *standard pragmatic model* (Grice, 1975) and the *graded salience hypothesis* (Giora, 1997, 1999). ERPs did not provide evidence for a semantic incompatibility during the processing of irony since an increase on the amplitude of the N400 component was not found. As discussed above in more detail (see section 4.5), an N400 effect evoked by ironic sentences compared to equivalent literal sentences would have implied semantic integration difficulties as predicted by the *standard pragmatic model* (Grice 1975). Instead a late positive component consistently emerged, that resembled the P600 component obtained for the auditory processing of irony (cf. Experiment 1). As mentioned previously, P600 effects have been usually observed in response to syntactically complex

or anomalous sentences (Friederici, et al., 2002; Kaan, Harris, Gibson, & Holcomb, 2000; Osterhout & Mobley, 1995), but also to semantic and pragmatic anomalies (Kolk, et al., 2003; Kuperberg, Holcomb, et al., 2003; van Herten, et al., 2005). The P600 component seen in the current study was more pronounced for sentence final words pointing to ironic sentence interpretations compared to literal ones. Ironic sentences were pragmatically more complex by conveying a different meaning than literally stated. This suggests that an increase in pragmatic complexity resulted in extra processing costs during late stages of processing indicated by a larger P600. The observation of an irony-related P600 might reflect pragmatic interpretation comprising the derivation of appropriate sentence meanings. Such processing may include inferences on the message level that may comprise deriving speakers' communicative intents (Giora, 2002; Grice, 1975). According to the psycholinguistic models, the findings of Experiment 1 and 2 suggest that the comprehension of irony does not involve a semantic incompatibility phase but still requires additional inferential processes. Hence, the current ERP data provide support for the claims of the *standard pragmatic model* as well as the *graded salience hypothesis* concerning late phases of processing. Proposed initial processing phases by these two models, as well as assumptions of the *direct access view* cannot be confirmed by the ERP data obtained in Experiment 1 and 2.

Early ERP effects in response to irony

Just as for the auditory domain an early ERP effect in response to irony was elicited for the visual modality. Nevertheless this effect was a modulation of the P200 component and had no resemblance to the left anterior negativity seen in Experiment 1. This early positivity had its peak latency between 200-300 ms and showed a topographic distribution over frontocentral and centroparietal sites. Both the LAN and P200 effects emerged in the same latency range of 200-300 ms which suggests that at this point in time the processing of ironic and literal sentences diverged. With respect to the *standard pragmatic model* (Grice, 1975) as well as the *graded salience hypothesis* (Giora, 1997, 1999) lexical and semantic information processing should have been identical during initial processing of both sentence types, as the literal and most salient meanings respectively were assumed to be activated first. Although both ERP effects had a similar latency onset, differences in morphology, distribution and latency (i.e., only the negativity was long-lasting) were observed. These temporal and topographic differences imply that functionally distinct cognitive processes were associated with both effects. In Experiment 1 it was suggested that the observed sustained LAN might be related to an increased load of working memory resources by retrieval of additional information from long-term memory and manipulation of literal sentence meanings. Though these assumed comprehension processes cannot be confirmed as general

processing mechanism by the current findings. The results suggest that the occurrence of a sustained LAN apparently depended on presentation modality. Note that there seemed to be a comparable left anterior negative shift in the time window of 500-900 ms in response irony, but this ERP response did not reach significance. The absence of a sustained LAN effect is surprising for two reasons. On the one hand, experimental stimuli and task requirements were the same despite the experimental manipulation of cueing by quotation marks. On the other hand, a sustained LAN has been reported for the visual domain in a series of ERP studies (King & Kutas, 1995; Kluender & Kutas, 1993; Münte, Schiltz, et al., 1998). What are the exact causes that a comparable effect could not be replicated in the current experiment cannot conclusively be answered. One explanation might be that additional cueing by quotations somehow affected general comprehension processes of both ironic and literal sentences leading to a modulation of the sustained LAN amplitude.

Still, instead of a sustained LAN a larger P200 was elicited by ironic sentences when they were presented visually. A P200 component has mostly been reported for exogenous but also for endogenous processes. For instance, this early positivity was shown to be sensitive to processes of semantic organization (Azizian, et al., 2006; Blanchet, et al., 2007; Boddy & Weinberg, 1981), and to visual implicit categorization of non-verbal stimuli (Pernet, et al., 2003). These studies revealed that besides attentional processes the P200 can be linked to stimulus evaluation of both verbal and non-verbal stimuli. A P200 has also been associated with initial detection of semantic incongruity between word pairs in a semantic categorization task (Landi & Perfetti, 2007). Larger amplitude of P200 was observed for semantically related pairs than unrelated pairs, and for associatively related pairs compared to categorically related pairs. With regard to the present finding of an enhanced P200 in response to irony, this effect resulted from foregoing contextual information that biased an ironic interpretation. It might be possibly that this P200 is a reflection of early stages of semantic analysis processes. Although early semantic effects on the P200 were often induced by task demands (e.g., semantic categorization tasks), the observation of a P200 effect suggests that semantic processing differences could be detected as early as 200 ms after stimulus presentation independent of task relevance. It might be possible that participants built up strong semantic expectations based on foregoing discourse contexts which possibly affected comprehension processes at this initial stage of processing in causing extended semantic analysis of word meanings. At this position of the sentence, respective sentence interpretations became apparent, which probably seemed to involve additional processing of lexical-semantic information of ironic sentences. Until now, electrophysiological evidence of early semantic context effects stems from studies indicating that

retrieval of lexical-semantic information occurs already 200 ms after stimulus presentation (Hagoort & Brown, 2000; Martin-Loeches, Hinojosa, Casado, Munoz, & Fernandez-Frias, 2004; Penolazzi, Hauk, & Pulvermüller, 2007; Pulvermüller, 2001). As these studies reported modulations of different ERP components, further evidence is necessary to substantiate a sensitivity of the P200 to aspects of lexical-semantic information processing. While comparable effects have not been reported for pragmatic manipulations so far, further research is required to determine whether the P200 can in fact be related to early semantic analysis processes.

The influence of cueing by quotation marks

Regarding the question whether additional cueing by applying quotation marks affected the comprehension of irony, cannot be proved by the present ERP data. An interaction of Quotations with Context was not found in any of the latency windows that have been analyzed (i.e., 200-300 ms, 300-500 ms and 500-900 ms). This finding implies that the way of cueing by means of quotation marks was neither effective in facilitating the perception nor the interpretation of irony. A possible explanation for the lack of detectable interactions is grounded on the experimental 2-by-2 design used in the current experiment. As quotations were added to ironic and non-ironic sentences, these punctuation marks were only valid in half of the items (i.e., solely for ironic sentences), and remained invalid when used for literal sentences. Presenting both ironic and non-ironic sentences with such cues possibly caused an ambiguity in the function of quotations, so that their role in cueing irony was probably equivocal. Behavioral data provide some support for this explanation in showing better performance for non-ironic items that were presented without quotations than for those presented with quotation marks. Accordingly, the way of cueing certain interpretations seemed to affect the overall comprehension of discourses. The current experimental design corresponded to that of Experiment 1, and was applied to replicate the ERP pattern observed for auditory processing of irony. However, it was limited in exploring potential influences of quotation marks on the processing of irony. Whether or not language-accompanying cues like quotation marks exert an influence on the comprehension of ironic meanings need to be further investigated by using an experimental paradigm in which the meaning of quotations is unambiguous, and which allows a direct comparison of the processing of cued irony versus uncued irony.

5.2 Experiment 3: The processing of cued and uncued irony

5.2.1 Introduction

The current experiment was constructed to further examine the function of language-accompanying cues for the comprehension of figurative language. Findings of Experiment 2 suggest that cueing verbal irony in an ambiguous manner did not have an impact on the comprehension of ironic sentence meanings. Applying cues to both ironic and non-ironic interpretations might have rendered their functional meaning rather uninformative, and thus ineffective in cueing a particular sentence interpretation. In order to study potential influences of cueing by quotation marks on irony comprehension, in the current study an alternative experimental paradigm has been employed in which the function of quotations became definite in cueing only ironic sentence interpretations. By applying an experimental block cueing information was unambiguous for implied ironic sentence interpretations allowing an examination of processing mechanisms underlying the comprehension of irony under different contextual constraints (i.e., by presence or absence of additional cues). In the first block of the experiment critical words of both ironic and literal sentences were presented without quotation marks. In this case, ironic interpretations of the target sentences solely became apparent on the basis of foregoing contextual information. Thus, the processing of uncued irony can be scrutinized. In the second block of the experiment quotation marks were added only to critical words of ironic sentences, and not to literal sentences. In this way, quotations were functionally unambiguous in cueing ironic meanings, and thus further constrained potential sentence interpretations on whether an utterance was meant ironically or not. Consequently, comparison of the ERPs for comprehending cued and uncued irony between both blocks can give insights in the effectiveness of language-accompanying cues in constraining sentence interpretations. If the occurrence of additional punctuation cues has an impact on irony comprehension, then different ERP patterns should be evoked in response to cued and uncued irony. In case cueing has an influence on the perception and interpretation of irony, then interactions of Cues with Context are expected during early (i.e., 200-300 ms) as well as late (i.e., 500-900 ms) time windows. With respect to the ERP effects obtained in Experiment 1 and 2 a similar pattern (i.e., emergence of an irony-related P600 effect in absence of an N400 component), is predicted for irony presented without quotations. Regarding early ERP effects found previously (cf. Experiment 2), a comparable P200 effect should be evoked in case this ERP component is a reliable effect for irony presented in the visual modality.

5.2.2 Participants

Forty native German-speaking students (20 female, mean age 23.5 (SD 2.30)) took part in the experiment and were paid for their participation. All of them were right handed and had normal or corrected-to-normal vision.

5.2.3 Methods

5.2.3.1 Stimulus material and procedure

The stimuli as well as the experimental procedure were the same as used in Experiment 2. Instead of using quotations marks for both ironic and non-ironic sentences, in the current experiment quotations were only applied to irony (during the second block). The experimental items were newly pseudorandomized and divided into two versions of 120 items each. In this way, none of the target sentences was repeated within one version. Every version was split into two blocks, so that each block contained a total of 60 items (i.e., 30 ironic and 30 non-ironic sentences). While in the first block both ironic and non-ironic sentences were presented without quotation marks, in the second block all ironic sentences were cued by quotation marks added to the target sentence final word. The experimental manipulation consisted of the factors *Context* (ironic/non-ironic) and *Cues* (uncued/cued irony).

Table 5.2 The four experimental conditions as induced in Experiment 3.

	Cues	
Context	***uncued irony*** (BLOCK 1)	***cued irony*** (BLOCK 2)
ironic	ironic	"ironic"
non-ironic	non-ironic	non-ironic

5.2.3.2 Data acquisition and analysis

The data acquisition and analysis were identical to those of Experiment 2 (see section 5.1.3.2). For the statistical analyses the factor Quotations was replaced by the two-leveled factor Cues (uncued/cued irony). Since the LAN effect could not be replicated for the visual modality, the 100-400 ms time window is not analyzed any longer. Instead ERPs are calculated for the P200 latency window of 200-300 ms. About 13% of all correctly answered trials were rejected from the data analysis because of ocular artifacts (EOG rejection +/-40 µV).

5.2.4 Results

Behavioral data. Comparable to Experiment 1 and 2, accuracy rates revealed an excellent performance across all conditions indicated by a mean accuracy rate of 96.2% (SD 3.01). The statistical analysis showed a significant effect of Cues ($F(1,39)=4.56$, $p<0.04$) but no effect of Context ($F(1,39)=1.81$, n.s.). Subjects performed slightly better during the first block (mean accuracy rate of 96.7% (SD 1.12)) than during the second block (on average 95.5% (SD 1.22)).

Electrophysiological data. The upper part of Figure 5.4 displays ERPs obtained for uncued irony, whereas the lower part of this figure shows ERPs for cued irony. A clear P1-N1 complex was shown for all sentence types, irrespective of cueing. In comparison to non-ironic sentences, cued and uncued irony evoked differential ERP patterns. For uncued irony presented without quotations (see upper part of Figure 5.4) a P600 seemed to be present, which showed a centroparietal amplitude maximum. In addition, a late sustained negativity was seen on left anterior electrode sites. Visual inspection of the ERPs for cued irony suggests the occurrence of a sustained positivity starting around 200 ms (see lower part of Figure 5.4). The positivity seemed to have an earlier latency onset and a more widespread topographic distribution than the P600-like effect for uncued irony. An increased N400 component was not present neither for both uncued irony, nor for cued irony.

The statistical analyses of the **200-300 ms** epoch revealed main effects of Context ($F(1,39)=11.04$, $p<0.002$) and Cues ($F(1,39)=7.54$, $p<0.01$). A three-way interaction was found between Cues, Context and ROI ($F(6,34)=2.86$, $p<0.02$). On the basis of this interaction, follow-up analyses were carried out for each block separately. A significant two-way interaction between Context and ROI was only present for the second block when irony was cued by quotation marks ($F(6,34)=3.22$, $p<0.01$). Subsequent analyses for each ROI separately revealed main effects of Context for all ROIs ($F(1,39)=9.62$-17.77, $p<0.004$). Thus when cueing irony by quotation marks evoked a positivity with a widespread scalp distribution, and a latency onset around 200 ms post-stimulus.

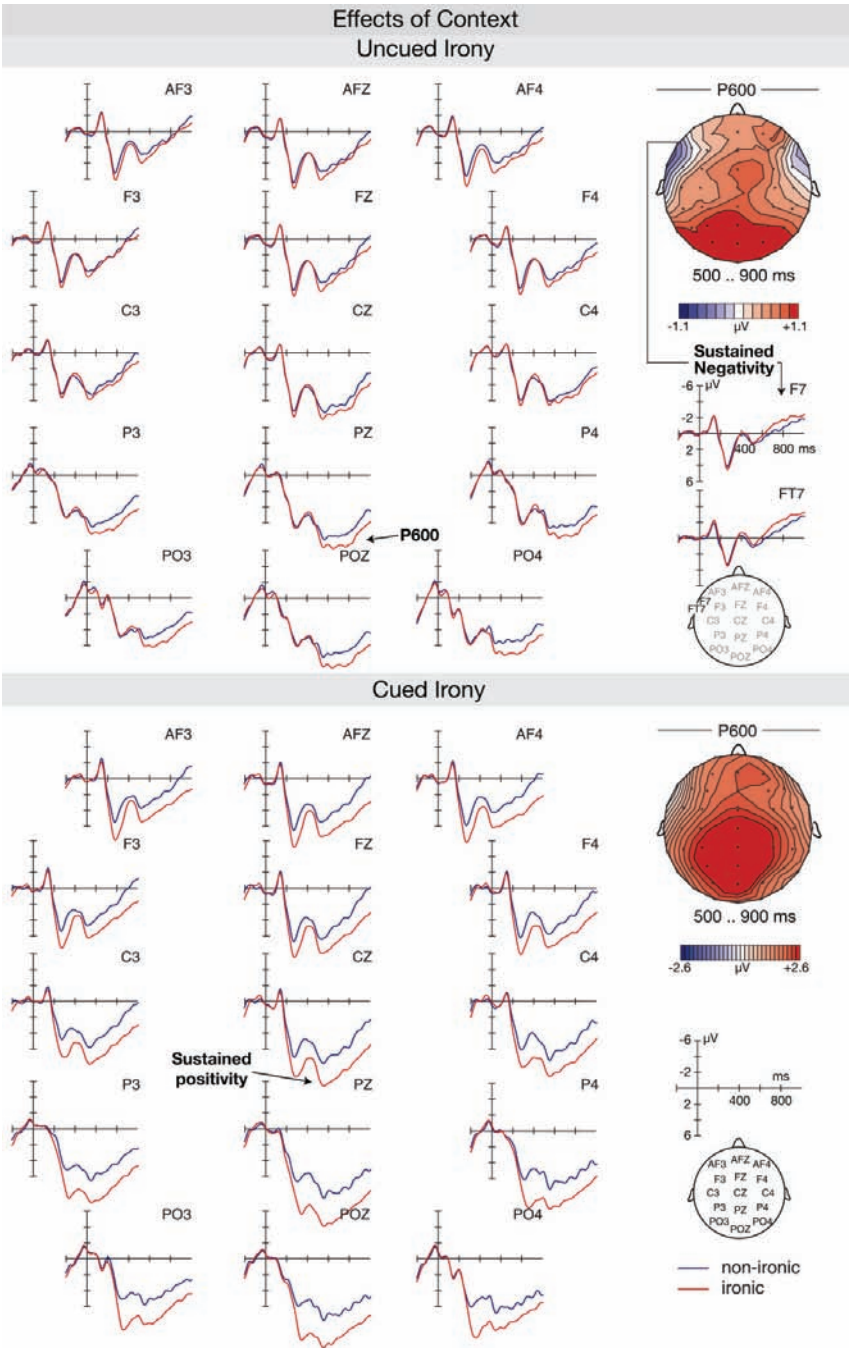

Figure 5.4. Grand average ERPs to sentence final words of ironic (red line) and non-ironic sentences (blue line). The figure displays ERPs and topographic maps for uncued irony presented without quotation marks (see upper part), as well as for cued irony by adding quotation marks (see lower part).

In the **300-500 ms** latency window, main effects of Context ($F(1,39)=15.86$, $p<0.001$) and Cues ($F(1,39)=43.44$, $p<0.001$) were found. In addition, a three-way interaction between Context, Cues and Anterior/Posterior ($F(1,39)=17.11$, $p<0.001$) was significant. Resolving this interaction by Cues revealed an effect of Context ($F(1,39)=29.63$, $p<0.0001$) and a further interaction between Context and Anterior/Posterior ($F(1,39)=4.36$, $p<0.04$) for the second block only. Separate analyses for anterior and posterior sites showed main effects of Context for the second block, i.e., the presence of quotations, ($F(1,39)=10.90$-39.52, $p<0.001$). The analyses confirm that the positivity in response to cued irony is a long-lasting effect that showed a widespread topographic distribution.

In the time window of **500-900 ms**, main effects of Context ($F(1,39)=28.61$, $p<0.001$) and Cues ($F(1,39)=6.41$, $p<0.01$) were found. A four-way interaction of all factors was also significant ($F(6,34)=2.66$, $p<0.03$). Follow-up analyses were carried out for each block separately. Independent of the occurrence of cues, for both blocks three-way interactions between Context, Anterior/Posterior and ROI were present ($F(6,34)=2.77$-2.83, $p<0.03$). Resolving these three-way interactions by Anterior/Posterior revealed main effects of Context on posterior sites for the first block ($F(1,39)=7.71$, $p<0.01$) as well as for the second one ($F(1,39)=26.94$, $p<0.0001$). Moreover, on anterior sites significant interactions of ROI and Context ($F(1,39)=3.55$-4.58, $p<0.01$) were also obtained for both blocks. Separate analyses for each of the anterior ROIs revealed a main effect of Context in the most left anterior ROI, i.e., A1, for the first block in which irony was uncued ($F(1,39)=4.60$, $p<0.04$). Effects of Context for cued irony were found in nearly all anterior ROIs (i.e., A2-A7) for the second block ($F(1,39)=12.37$-28.71, $p<0.001$). The analyses indicate that independent of the presence of cues, late positivities were evoked in response to irony which differed in their latency onset and topographic distribution. Relative to non-ironic sentences uncued irony elicited a P600 component that was distributed over parietal electrode positions, and had a latency onset of around 500 ms after stimulus presentation. In response to cued irony, a sustained positivity was obtained, which had its onset already around 200 ms post-stimulus and displayed a widespread distribution comprising anterior and posterior electrode sites.

5.2.5 Discussion

In this experiment the comprehension of irony has been further investigated with respect to an impact of cueing by quotation marks. In applying relevant punctuation cues to ironic sentences, these cues provided additional constraints for ironic sentence interpretations in addition to contextual information (i.e., within the second block). By contrast, the interpretation of ironic sentences was solely constrained by contextual information of prior discourse contexts (i.e., within the first block). Whereas in Experiment 2 the application of such additional cues did not reveal an impact on the processing of irony, the experimental paradigm used in the current study was effective in showing that extra cueing by quotation marks does in fact influence irony comprehension. Differential ERP patterns were obtained for cued and uncued irony, which suggests that comprehension processes underlying figurative language comprehension diverged dependent on further contextual constraints by paraverbal cues. In the following, the ERP effects observed in response to cued and uncued irony are discussed separately with respect to implications for the effectiveness of cueing.

Processing of irony in presence of additional cueing

In comparison to the ERP effects for uncued irony, a different ERP pattern occurred when ironic interpretations have been cued by quotation marks, i.e., within the second block. Ironic sentences elicited a sustained positivity starting around 200 ms after stimulus presentation, which had a large amplitude with a scalp distribution over anterior and posterior sites. As this positive shift was still present within the latency range of 500-900 ms and displayed no topographic differences, it appeared to be one long-lasting effect.

The emergence of a sustained positivity suggests that further constraining information provided by quotation marks has been taken into account from an initial stage of processing on. Since quotations clearly pointed to ironic sentence interpretations, their occurrence seemed to facilitate the processing of irony. Apparently, distinct comprehension processes were involved relative to irony not marked by comparable cues. Figurativity of ironic sentence meanings might have been detected earlier than in absence of cueing information. The early onset of the sustained positivity may suggest that the processing system achieved enough evidence for an immediate recognition of a deviance in meaning, which seemed to affect later interpretation of appropriate ironic meanings. Accordingly, irony comprehension should have been resulted in lower processing demands for cued irony. As an enhancement in ERP amplitudes observed for cued irony in comparison to uncued irony is most likely an index of extra processing costs, the ERP data suggest an in-depth processing in case of cued irony.

Relative to uncued irony, the sustained positivity might reflect quantitative distinct processes during initial and late stages of processing. As sentence interpretations were highly constrained by the presence of quotation marks, it might be possible that ironic sentences have been processed more extensively. Implied ironic meanings could have been easily noticed, and might have caused deeper processing of conveyed meanings and speakers' communicative intents. As presented ironic instances were non-conventional, literal sentence meanings might have required further processing to derive contextually appropriate interpretations. Thus, it seems likely that computing different sentence meanings as explicitly signaled by quotations might have resulted in such large ERP response. As quotation marks have shown to be incorporated immediately into the comprehension of irony, this clearly suggests that additional cueing affected processing mechanisms underlying the comprehension of irony. Alternatively, it might be possible that processing costs indexed by the sustained positivity resulted from a higher amount of information processing, as the processing system was confronted with extra information by the occurrence of quotations. Still, such greater visual input should have only influenced early exogenous ERP components but not endogenous components if cueing information was not relevant for sentence interpretation.

Processing of irony in absence of additional cueing

A late positivity starting around 500 ms after stimulus presentation occurred in response to ironic sentences in which no additional cues in the form of quotation marks were added to sentence final words (i.e., within the first block). This positivity showed a centroparietal scalp distribution which was comparable to the late positive shifts seen in previous experiments, can be classified as P600 component. Moreover, an additional left anterior negativity was observed for irony in the same latency range of 500-900 ms. The topographic distribution of this negativity was confined to the most left anterior electrode positions, i.e., AF7, F7 and FT7, and resembled in its topography and morphology the sustained LAN seen in response to ironic sentences in the auditory domain (see Experiment 1). Although the ERPs showed a slightly enhanced early positivity on central electrode sites, this trend for a P200 component did not reach significance.

In case ironic interpretations were not any further constrained by the occurrence of quotation marks, early ERP effects related to the comprehension of irony did not reach significance level. This finding suggests that a P200 effect could not be replicated for the first block of this study as observed in response to irony in Experiment 2. An effect on the amplitude of the P200 component would have been expected for uncued ironic sentences, whenever contextual information per se were sufficient enough to point to non-literal interpretations and allowed for some kind of early semantic analysis. On the one hand, the absence of a P200 effect may indicate that discourse contexts presented

without any additional cueing are restricted in their influence on an initial stage of processing. On the other hand, the lack of an irony-related P200 component might be a consequence of the block design applied in the current study. In the first block, participants experienced only half as much of ironic items (i.e., 30 ironic discourses) than in Experiment 2. While the P200 effect obtained in Experiment 2 might have occurred as reflection of semantic analysis processes, a larger number of items seemed to be necessary before similar processes may reliably occur.

As seen previously in both Experiment 1 and 2, a P600 component in absence of an N400 component was elicited by ironic sentences. Surprisingly, in the 500-900 ms latency window an additional sustained left anterior negativity emerged in response to irony that was comparable to the sustained LAN previously found for irony (cf. Experiment 1). Albeit the former effect had an earlier latency onset (i.e., approximately 250 ms post-stimulus onset), both irony-related negativities were similar in morphology and scalp distribution which suggests a functional relationship between both ERP effects during this later processing stage. In absence of additional cueing the comprehension of visually presented irony seems to involve similar comprehension processes as seen for the auditory domain in showing a sustained LAN and P600 effect. As suggested (see section 4.5), the sustained LAN may be related to an extra load of working memory resources due to retrieval of further information from pragmatic and common world knowledge. In case no further constraining cues are available when encountering ironic sentences, additional information might be necessary for deriving appropriate non-literal interpretations. As comparable sustained negativity effects were observed for the comprehension of jokes (Coulson & Kutas, 2001; Coulson & Lovett, 2004), this suggests that an increased load of working memory resources seemed to be involved in processing utterances that require further interpretation. However, it is even possible that this negativity observed for irony is reflection of a late frontal modulation of the parietal positivity, since both ERP effects are sustained and occurred in the same latency range.

The emergence of a P600 in absence of an N400 component appeared to be a highly reliable ERP pattern in response to ironic language processing since it could be replicated once more in the present study. Accordingly, this late positive shift might be a reflection of more controlled processes involved in pragmatic interpretation of implied ironic meanings. In comprehending communicative intents conveyed by ironic utterances additional processing comprising inferences might be required in deriving appropriate interpretations. This process is possibly based on foregoing contextual information as well as pragmatic and common world knowledge, and appears to be more effortful than literal language comprehension.

Conclusion

Findings indicate that additional cueing by means of quotation marks can have an immediate impact on figurative language comprehension, if these cues are unambiguous as well as informative in their meaning. Moreover, the results also imply that both contextual strength (manipulated by occurrence of paraverbal cues in the form of quotation marks) can specify the way of how figurative meanings are processed. If additional information was provided for respective interpretations, the processing of contextually appropriate ironic sentence meanings seems to be initiated earlier than for ironic sentences that were not further constrained. By implication, processing literal and figurative language appeared to diverge in dependence of contextual constraints suggesting that explicit cueing of ironic interpretations can influence processing mechanisms underlying figurative language comprehension.

Chapter 6

Experiment 4: The influence of pragmatic knowledge on irony comprehension

6.1 Introduction

Experiment 4 was constructed to explore the influence of additional pragmatic knowledge on irony processing. As pointed out by Colston (2002, 2005), figurative language comprehension often requires contextual information as well as general world knowledge in order to derive appropriate and pragmatically acceptable interpretations. Moreover, pragmatic knowledge such as information about social relationships between two interlocutors, or believes and emotional states of speakers has been proposed to have an impact on the recognition as well as interpretation of sentence meanings (Blasko & Kazmerski, 2006; Katz, 2005; Pexman & Olineck, 2002). Evidence for an influence of speakers' occupation as a cue for intended sentence meanings stems from behavioral studies (Katz & Pexman, 1997; Pexman & Olineck, 2002). Pexman and Olineck (2002) suggested that the more sarcastic a speaker is believed to be, the more likely his or her comments are interpreted as ironic. Whether such pragmatic knowledge related to speakers has an influence on the comprehension of irony already during initial phases of processing, or whether such information is taken into account during later phases is still unclear. This question how and when this kind of information about speakers is incorporated during irony comprehension was pursued in the current experiment. In everyday communication pragmatic knowledge about a speaker is acquired by familiarity with this individual person. The way he or she expresses an attitude or reacts verbally on certain events characterizes a person's individual manner to communicate. If a certain communicative behavior occurs frequently enough, it is likely that specific pragmatic knowledge about this person is build up, and may facilitate the recognition of his or her communicative intents. For example, if one person uses very frequently irony, his or her utterances are possibly more easily interpreted as ironic than ironic utterances of another person who rarely says something ironic. One way to test potential influences of speakers' communicative style on the comprehension of figurative language, is to manipulate pragmatic knowledge about the characteristics of two partic-

ular speakers regarding their way to communicate. This can be realized by creating discourses in which two speakers interact with other interlocutors, and can be expected to comment on particular events in different ways, i.e., either ironically or literally. While one of the speakers appears to be highly ironic by making very frequently ironic statements, the other speaker appears to be a rather sincere and rarely ironic by replying less often ironically. In this sense, both interlocutors differ to each other in their communicative style in expressing attitudes. In order to avoid strategic processing whereby participants might focus on respective sentences uttered by one or the other speaker, speakers' characteristics are not explicitly introduced but need to be detected rather implicitly by attentive reading of the discourses. In this regard, the experimental setting used in the present experiment remains comparable to real life settings where a speaker's preferred way of expressing attitudes has to be noticed by the hearer.

Along with this, the present study addresses another question, namely to what extent such subtle pragmatic information is established as a reliable cue for perceiving and interpreting irony. In the following experiment it is explored whether speakers' communicative style once noticed had been memorized and can be retrieved for interpreting speakers' utterances. In particular, it was tested whether pragmatic information still had an impact on figurative language comprehension when a speaker's communicative style has noticeably changed (i.e., both speakers do not any longer behave in the acquainted manner but reply ironically as often as literally). To explore the persistence of pragmatic knowledge as a cue for comprehending irony, the experimental paradigm includes two sessions between which the speakers' communicative style in terms of their use of ironic statements (frequently vs. infrequently) was manipulated. Whereas in the first session a clear difference in the communicative style between both interlocutors could be perceived, this difference was balanced in the second session. Therein, the frequency of speakers' use of irony was the same, so that both interlocutors made equally often ironic and non-ironic statements.

In ERP studies that investigated anomalies of explicit contextual knowledge about a speaker mostly N400 effects have been reported (Fischler, Bloom, Childers, Achariyapaopan, & Perry, 1983; Van Berkum, van den Brink, Tesink, Kos, & Hagoort, 2008). After learning social facts of fictitious people (i.e., their occupation), ERPs revealed a larger amplitude of the N400 when pragmatic information was inconsistent with a speaker's occupation (Fischler, et al., 1983). In a recent study by Van Berkum et al. (2008) it was shown that information about a speaker's identity (i.e., a speaker's gender) provided by a male or female voice was immediately incorporated in sentence processing. An increase of the N400 component (with a latency onset between 200-300 ms) has been found for sentences that contrasted expected speakers' gender such as *I*

always rent movies with lots of violence in it uttered by a female voice. In contrast, a P600 effect has been obtained for violations of implicit speaker information (provided by a speaker's female or male voice) concerning stereotypically male or female utterances (Lattner & Friederici, 2003). Moreover, in a study by Osterhout, Bersick and McLaughlin (1997) stereotypical information about a male or female agent that was incongruent to a subsequent reflexive pronoun evoked an enhancement of the P600 component. According to the findings of these studies the following hypothesis can be derived for the two experimental sessions of the present study. Whenever information about speakers' use of irony is taken into account as a reliable cue for irony, then comparable N400 effects might be evoked for incongruent conditions as reported in previous studies (Fischler, et al., 1983; Van Berkum, et al., 2008). Since ironic sentences reliably elicited a P600 component in absence of an increased N400, the emergence of a potential N400 effect in response to irony uttered by a certain speaker would most likely be related to semantic expectancy. Particularly, if only the high ironic speaker is expected to reply ironically, then an increased N400 component might be seen for ironic comments of the low ironic speaker. An N400 effect in response to literal sentences of the high ironic speaker is not predicted, because it is rather unlikely that this speaker is perceived as entirely ironic who communicates in no other way. Moreover, a P600 component is expected in response to irony as seen in previous experiments (see sections 4.4, 5.1.4 and 5.2.4). A modulations of potential P600 effects is predicted by the presence of additional pragmatic information. If that information is considered as a relevant cue for the interpretation of ironic sentences, it possibly affects late processing stages in which different types of information are integrated (Lattner & Friederici, 2003). In principle, those predictions hold for both experimental sessions. Nonetheless, the primary purpose of Session 2 is to investigate whether particular pragmatic knowledge can be acquired implicitly, and whether it is integrated into the processing of sentence meanings when speakers' characteristics regarding their use of irony has changed. An interaction between pragmatic knowledge about speakers and different sentence types (i.e., ironic and literal sentences) should be obtained for Session 2, if the experimental manipulation in Session 1 was effective in setting distinct characteristics of the two speakers. Due to a lack of comparable ERP studies that investigated influences of implicit knowledge in this way, further predictions cannot be made.

6.2 Participants

Forty students (19 female, mean age 24.1 years (SD 2.61)) from the University of Leipzig participated in the experiment and were paid for their expenses. All were right handed, native speakers of German with normal or corrected-to-normal vision.

6.3 Methods

6.3.1 Stimulus material

Materials included 100 experimental sentences that were embedded in two types of discourse contexts that biased either an ironic or non-ironic interpretation of the target sentence (see Table 6.1). Due to the fact that the same two speakers had to interact in all of the discourses, a subset of experimental items used in the previous studies (see section 4.3.1) needed to be adapted. About 70% of the experimental materials were the same items as used in the previous experiments. Another 30% of items were newly created in the same way as conducted previously. All discourses consisted of two or three context sentences followed by a target sentence, and were presented visually.

Table 6.1: Example of an ironic and non-ironic target sentence embedded in foregoing discourse contexts that determined sentence interpretation.

Discourse context	*Target sentence*
Als Lars am Abend nach Hause fahren will, bemerkt er, dass jemand sein Fahrrad mit angeschlossen hat. Ratlos sieht er sich nach dem Besitzer um und meint verärgert:	(ironic) *Das ist ja ganz toll.*
Marcus hatte eine Kommilitonin gefragt, ob er ihre Ausarbeitungen zu dem Prüfungsthema ansehen könne. Als sie ihm die Unterlagen mitbringt, ist Marcus sehr dankbar und sagt:	*(non-ironic)* *Das ist ja ganz toll.*

In order to induce different speaker characteristics as being high ironic or low ironic, both types of target sentences were uttered by two individual speakers to varying extents. To differentiate both speakers, they were given proper names. Ironic target sentences were mainly expressed by the high ironic speaker (named 'Lars'), and occasionally by the low ironic speaker (named 'Marcus'). This proportion was reversed for non-ironic target sentences. Thus, in Session 1, the speakers' use of irony was manipulated in such a way that the high ironic speaker expressed 70% of all ironic sentences, and the low ironic speaker only 30% of it (see Table 6.2). For non-ironic utterances this proportion was reversed. Whereas the low ironic speaker uttered 70% of all non-ironic sentences, the high ironic speaker said 30% of it. In Session 2, the proportion of ironic and non-ironic sentences was balanced between both speakers thereby each speaker expressed 50% of each sentence type.

Table 6.2: The experimental design of the two sessions.

	SESSION 1		SESSION 2	
	Speaker		**Speaker**	
Context	***high ironic***	***low ironic***	***high ironic***	***low ironic***
ironic	70%	30%	50%	50%
non- ironic	30%	70%	50%	50%

Pretests. In order to test the experimental sentences on semantic-pragmatic expectancy as well as acceptability two pretests were carried out. A cloze procedure was conducted alike to that of Experiment 1 (cf. section 4.3.1.1). Twenty-two students (ten female, mean age 23.7 years (SD 2.68)) took part in this cloze test. On average the cloze probability of all experimental sentences was 92.0% (SD 8.04) which is comparable to previous cloze probability data. Sentence final words of ironic sentences were less expected (i.e., mean cloze probability of 87.4% (SD 12.87)) than literal sentence endings (i.e., mean cloze probability of 96.5% (SD 7.12)). The difference in expectancy of about 9% was significant ($t(99)=6.90$, $p<0.0001$). However, an average cloze probability of 87% for ironic sentences is still very high, and thus is less likely to cause substantial differences in the ERPs.

An additional pretest on sentence acceptability was performed to control for potential acceptability differences between ironic and non-ironic sentences that could possibly affect ERP responses. In that pretest 20 subjects (ten female, mean age of 23.6 years (SD 2.72), who did not take part in the cloze test) participated. Subjects were asked to evaluate each item either on its degree of acceptability, or to state whether an item was unacceptable. The degree of acceptability had to be rated on a 5-point scale (1 for less acceptable, 5 for high acceptable). On average ironic sentences were rated with 3.6 (SD 0.49), and non-ironic sentences with 3.8 (SD 0.67). The difference of about 0.2 was still significant ($t(99)=2.11$, $p<0.04$), and revealed that non-ironic sentences were slightly more acceptable than ironic sentences.

For experimental presentation the 100 items were pseudo-randomized and divided into two item versions (one for each session) that contained 50 ironic and non-ironic sentences each. Thus, each target sentence meaning only occurred once in each version. Each participant received both sentence types (within-subjects design), as well as both versions within an interval of 24 hours between the first and second session. The experimental factors *Context* (ironic/non-ironic) and *Speaker* (high ironic/low ironic) were fully crossed (see Table 6.2).

6.3.2 Procedure

The experimental procedure was identical to that of the previous experiments (cf. section 5.1.3). Session 1 and 2 were carried out in the same way except for an interval of 24 hours between EEG recordings. Instructions of the two experimental sessions included a short introduction of both speakers and two discourse examples. At the end of each session participants were asked to complete a questionnaire. In that post-test eight of the experimental discourses were presented without target sentences, which had to be filled in by the most appropriate utterance for the respective speakers. By means of this questionnaire a measure of participants' perception of the speakers' characteristics was obtained.

6.3.3 Data acquisition and analysis

The acquisition and analysis of the EEG was identical to the procedures performed for the previous experiments (see section 6.3.3). EEG rejections comprised about 9% of all trials for Session 1, and 10% for Session 2. Within-subject factors were *Context* (ironic/non-ironic) and *Speaker* (high ironic/low ironic).

6.4 Results

Behavioral and ERP data are described separately for Session 1 and 2 below.

6.4.1 Session 1: Behavioral and ERP data

Behavioral data. Behavioral results for all conditions are displayed in Table 6.3. The mean accuracy rate was 96.7% (SD 2.54) indicating that participants performed excellent. Statistical analysis did not reveal any main effects of Context nor Speaker ($F(1,39)=0.26\text{-}2.16$, n.s.) but showed a significant interaction between both factors ($F(1,39)=36.33$, $p<0.0001$). Further analyses for each speaker type separately revealed main effects of Context for both the high ironic, as well as the low ironic speaker ($F(1,39)=9.51\text{-}36.96$, $p<0.004$). Whenever sentence type was congruent with the respective speaker participants made slightly more errors than for incongruent conditions. This was possibly caused by the experimental paradigm in which the majority of items was congruent (i.e., 70% vs. 30% of incongruent ones) increasing the error probability.

Behavioral results of the post-test showed that the high ironic speaker was correctly perceived to about 78% (SD 0.42) of total number of participants (see Table 6.4). About 15% (SD 0.36) of the participants estimated the low ironic speaker as the more ironic one, and 5% (SD 0.22) none of both speakers as being more ironic than the other.

Table 6.3: Mean accuracy rates of all conditions obtained for Session 1 and 2.

	Accuracy rates (in % (SD))			
	SESSION 1		SESSION 2	
	Speaker		**Speaker**	
Context	***high ironic***	***low ironic***	***high ironic***	***low ironic***
ironic	97.0 (3.71)	97.8 (3.50)	94.9 (2.22)	94.9 (2.86)
non-ironic	96.0 (4.26)	96.8 (3.73)	97.1 (3.14)	98.5 (2.34)

Table 6.4: Mean perception of speakers' characteristics by their use of irony for Session 1 and 2 as obtained by the post-test questionnaire that was conducted after completion of the experimental sessions.

	Perception of speakers' use of irony (in % (SD))	
More ironic speaker	SESSION 1	SESSION 2
high ironic	78 (0.42)	43 (0.50)
low ironic	15 (0.36)	33 (0.47)
none	5 (0.22)	25 (0.44)

Electrophysiological data. Grand average ERPs seen for Session 1 are displayed in the Figures 6.1, 6.2 and 6.3. At the target sentence final word ERPs showed slightly enhanced amplitude of the P200 component on frontocentral electrode sites in response to ironic sentences (see Figure 6.1). An increased N400 component related to irony was not present. Instead a larger late positivity distributed over frontocentral and parietal electrode sites was evoked by ironic sentences relative to non-ironic ones. In comparison of the ERPs for both speakers, an irony-related late positivity appeared to be present for the low ironic speaker (see Figure 6.3). ERPs elicited by the high ironic speaker seem to be identical for his ironic and non-ironic sentences. Moreover, effects of Speaker seem to be evoked as well (see Figure 6.2). ERP responses for the low ironic speaker showed a larger frontocentral negativity in the time window of 300-500 ms. This negativity was followed by a late positivity for the high ironic speaker.

Statistical analyses of the **200-300 ms** latency window showed a three-way interaction of the factors Speaker, Context and ROI ($F(6,34)=5.49$, $p<0.001$). Follow-up analyses for the high and low ironic speaker separately revealed interactions of ROI and Context that were present for both the high and low ironic speaker ($F(6,34)=2.51$-3.56, $p<0.04$). In further analyses for each ROI separately significant effects of Context were neither found for the high ironic speaker, nor for the low ironic speaker in any ROI ($F(1,39)=0.19$-3.58, n.s.). The analyses indicate early interactions between Context and Speaker, which suggest that the ERPs for both the high and low ironic speaker were dependent on sentence type, and differed in scalp distribution. The slightly enhanced P200 component observed in response to irony (see Figure 6.1) was not significant.

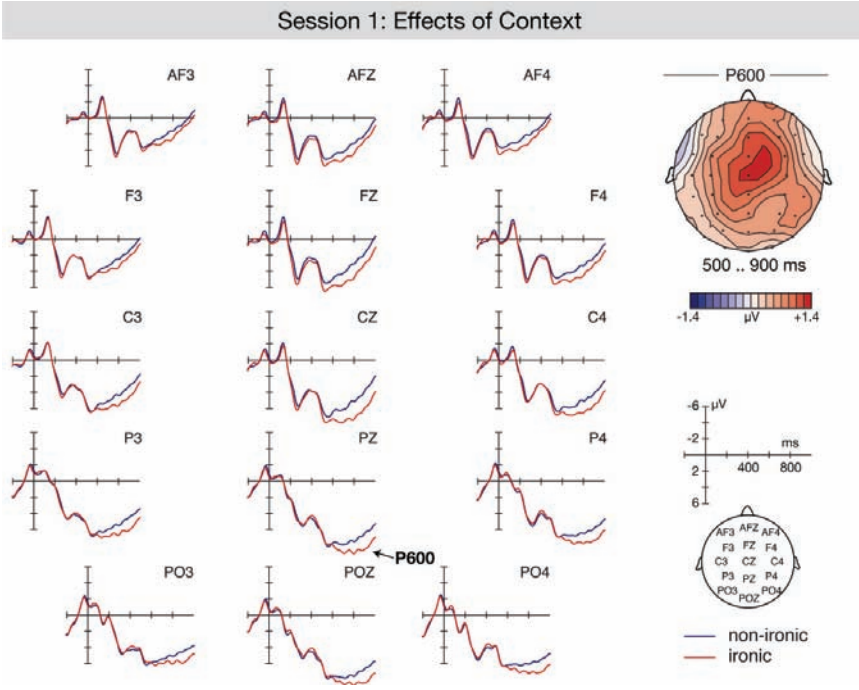

Figure 6.1. Grand average ERPs to sentence final words of non-ironic sentences (blue line), or ironic sentences (red line). The visual onset of the critical word is at 0 ms on the x-axis. In this and all succeeding figures negativity is plotted upwards. The topographic map on the right side displays the scalp distribution of the P600 effect in response to irony.

Within the latency window of **300-500 ms**, significant three-way interactions of Context with Anterior/Posterior and ROI ($F(6,34)=2.82$, $p<0.02$), as well as of Speaker with Anterior/Posterior and ROI ($F(6,34)=2.66$, $p<0.03$) were found. Resolving the former interaction with Context by Anterior/Posterior any further significant effects of Context were not obtained ($F(6,34)=0.26$-2.20, n.s.). The latter interaction with Speaker was resolved by Anterior/Posterior and showed a marginally significant interaction between Speaker and ROI ($F(6,34)=2.07$, $p<0.08$) for anterior sites. Separate analyses for anterior ROIs revealed a main effect of Speaker in the most central anterior ROI, i.e., A4 ($F(1,39)=9.62$, $p<0.004$). The analysis confirms that a frontocentral negativity was evoked in response to target sentences that were uttered by the low ironic speaker.

In the latency window of **500-900 ms**, a two-way interaction between Context and ROI ($F(6,34)=2.48$, $p<0.04$), as well as a three-way interaction of both factors with Anterior/Posterior ($F(6,34)=4.91$, $p<0.001$) were present. This two-way interaction of Context with ROI was resolved by separate analyses for each ROI. Significant effects of Context were obtained in the two most central ROIs, i.e., R4 and R5 ($F(1,39)=4.25$-4.53, $p<0.05$). The analysis confirms that an irony-related late positivity was present on

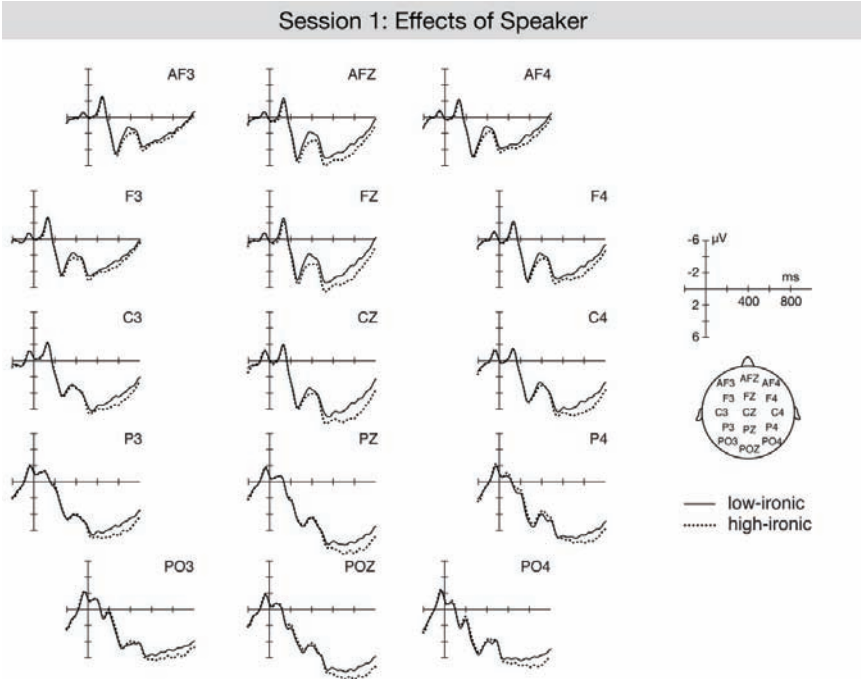

Figure 6.2. Grand average ERPs at the sentence final word in response to sentences uttered by the low ironic speaker (solid line) and the high ironic speaker (dotted line).

frontocentral and centroparietal scalp sites. Moreover, a further interaction of Context, Speaker and ROI ($F(6,34)=2.99$, $p<0.02$) was also obtained. On the basis of this interaction analyses for each speaker separately were performed. Significant two-way interactions of Context with ROI were found for both the high and low ironic speaker ($F(6,34)=3.82$-4.01, $p<0.005$). Separate analyses for each of the ROIs revealed effects of Context solely for the low ironic speaker in the three most central ROIs, i.e., R3, R4, and R5 ($F(1,39)=4.06$-9.08, $p<0.05$). For the high ironic speaker no effects of Context in any of the ROIs were found ($F(1,39)=0.03$-1.76, n.s.). The absence of main effects of Context indicates that the late positivity in response to the high ironic speaker were identical for ironic and non-ironic sentences. As displayed in Figure 6.3, an irony-related late positivity was elicited for the low ironic speaker, whereas for the high ironic speaker no such ERP effect was found. Furthermore, in this latency window an interaction of Speaker with the topographic factors Anterior/Posterior and ROI was also present ($F(6,34)=2.49$, $p<0.04$). The resolution of this interaction by Anterior/Posterior did not show any further significant effects of Speaker ($F(6,34)=0.45$-2.45, n.s.). Thus, the late positivity seen for the high ironic speaker (see Figure 6.3) could not be confirmed.

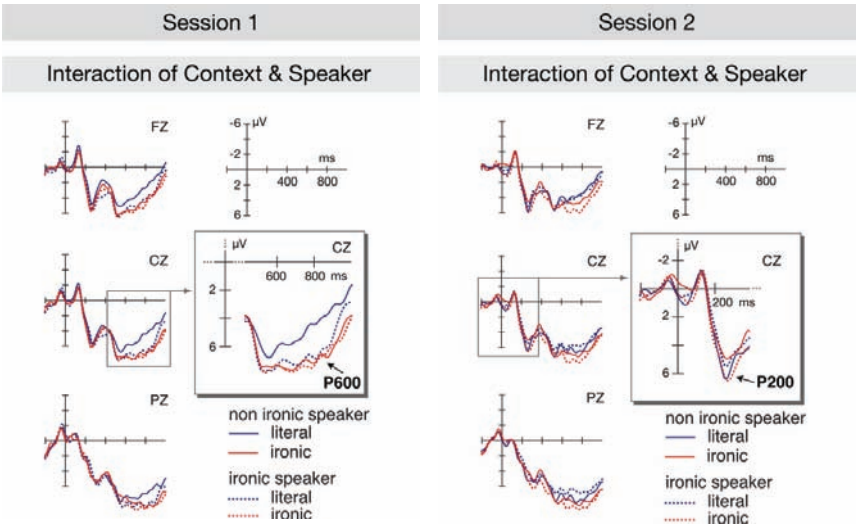

Figure 6.3. Grand average ERPs of Session 1 and 2 to critical words of ironic sentences (red line) and non-ironic sentences (blue line) uttered by the low ironic speaker (solid line) or the high ironic speaker (dotted line). Note that in Session 2 ironic and non-ironic utterances were balanced between both speakers.

6.4.2 Session 2: Behavioral and ERP data

In the second session the frequency of speakers' use of irony was balanced, so that their communicative style appeared to be identical.

Behavioral data. The mean accuracy rate for Session 2 was 96.3% (SD 1.33), which was comparable to that of Session 1 (see Table 6.1). The results revealed that participants' performance was excellent. The statistical analysis showed a main effect of Context ($F(1,39)=49.77$, $p<0.0001$) indicating that participants had more difficulties in responding to ironic discourses than to non-ironic ones. Additionally, a marginally significant interaction between Context and Speaker ($F(1,39)=3.13$, $p<0.08$) was also found. This interaction was resolved by Context and revealed a main effect of Speaker for non-ironic sentences only ($F(1,39)=5.44$, $p<0.02$). In case the low ironic speaker replied ironically slightly more errors were made than for his literal replies.

The results of the post-test revealed that participants' perception of the speakers' characteristics in Session 2 has changed. Only 25% (SD 0.44) of the participants correctly noticed that none of both speakers were more ironic than the other. In addition, 43% (SD 0.50) perceived the high ironic speaker and 33% (SD 0.47) the low ironic speaker as more ironic for this session. Compared to Session 1, the correct perception of speakers' use of irony was significantly reduced ($t(39)=5.55$, $p<0.0001$).

Electrophysiological data. Grand average ERPs for Session 2 are shown in the Figures 6.3, 6.4 and 6.5. Visual inspection of the ERPs (see Figure 6.4) suggests a larger amplitude of the P200 component when target sentence meanings were congruent with the respective speaker (i.e., the low ironic speaker replied in a non-ironic manner, and the high ironic speaker in an ironic manner). In the N400 latency range, a slightly increased negativity seems to be present for the low ironic speaker uttering an ironic statement compared to the high ironic speaker. As for Session 1 a late positivity in response to irony was also seen (see Figure 6.3). This irony-related late positivity seems to be present merely for the high ironic speaker but not for the low ironic speaker as seen for the first session. Effects of Speaker seem to be not anymore present (see Figure 6.5).

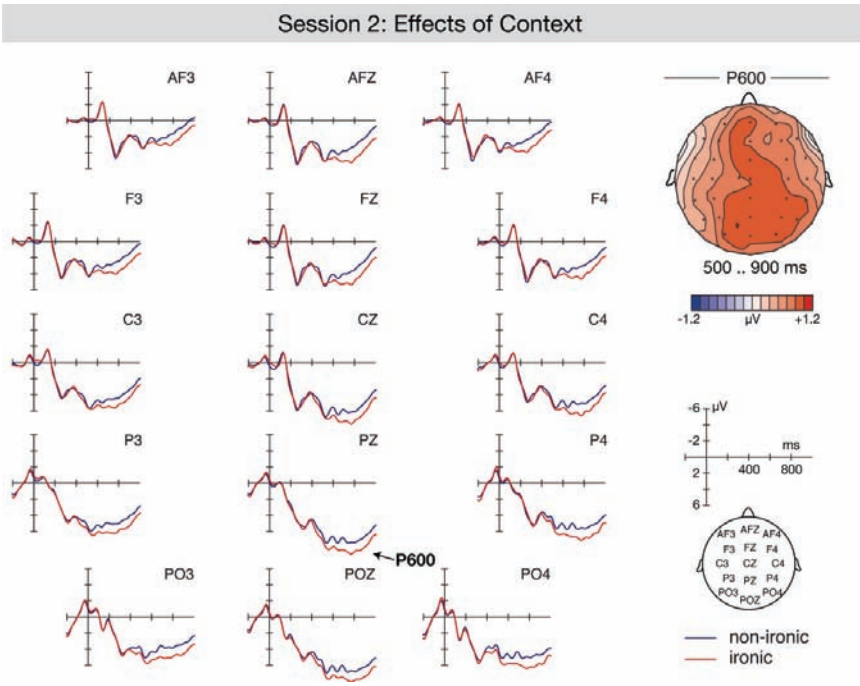

Figure 6.4. Grand average ERPs at the sentence final word, which indicated a non-ironic sentence meaning (blue line) or an ironic sentence meaning (red line). The topographic map on the right column illustrates the scalp distribution of the P600 effect evoked by ironic sentences.

In the latency window of **200-300 ms**, a three-way interaction of Context with Speaker and ROI ($F(6,34)=2.54$, $p<0.04$) was obtained. This interaction was resolved by subanalyses for each ROI separately. Significant interactions of Context with Speaker were present in all ROIs ($F(1,39)=5.53$-16.28, $p<0.02$). On the basis of these interac-

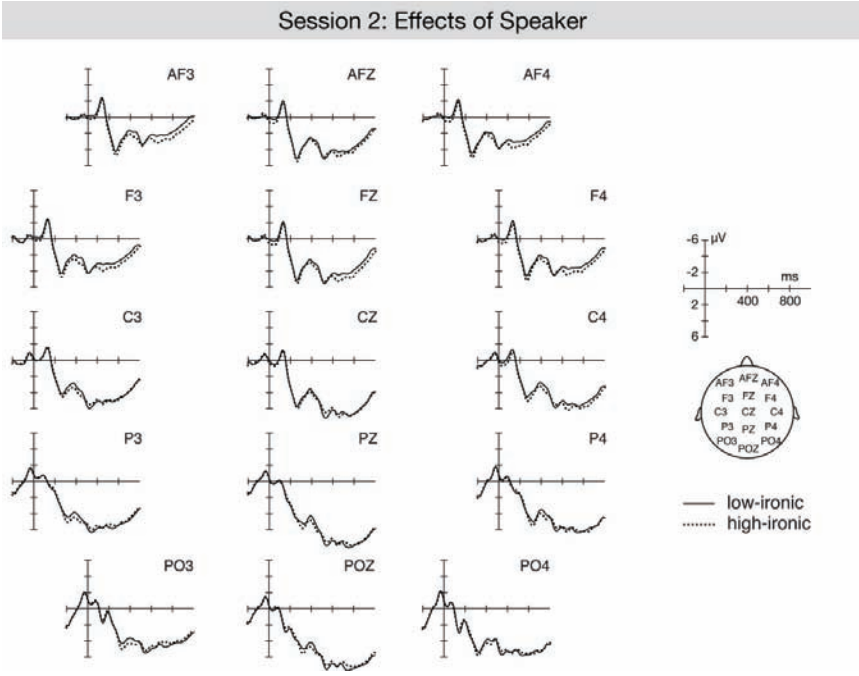

Figure 6.5. Grand average ERPs measured at the sentence final word for sentences that were uttered by the low-ironic speaker (solid line) and the high ironic speaker (dotted line).

tions, separate analyses were conducted for the high and low ironic speaker. Main effects of Context were found in all ROIs for the low ironic speaker ($F(1,39)=4.26$-$8.20 p<0.05$). For the high ironic speaker a significant effect of Context was obtained in the most central ROI, i.e., R4 ($F(1,39)=5.09$, $p<0.03$) and marginally significant effects in adjacent ROIs, i.e., R2, R3, and R5 ($F(1,39)=2.97$-3.56, $p<0.09$). This indicates that a larger P200 was evoked when speakers' characteristics were congruent to respective sentence meanings.

Statistical analyses of the **300-500 ms** time window showed a two-way interaction of Context and Speaker ($F(1,39)=5.98$, $p<0.02$). Follow-up analyses for each context type separately showed a significant effect of Speaker solely for ironic sentences ($F(1,39)=7.32$, $p<0.01$) but not for non-ironic sentences ($F(1,39)=0.25$, n.s.). The statistical analysis confirms that an N400-like effect was present for ironic sentences of the low ironic speaker compared to the high ironic speaker. Besides to the above mentioned two-way interaction, in this latency window a main effect of Speaker was revealed ($F(1,39)=4.08$, $p<0.05$). The ERPs in response to the low ironic speaker showed a slightly enhanced widespread negativity relative to the high ironic speaker.

In the time window of **500-900 ms** a significant three-way interaction of Context with Anterior/Posterior and ROI ($F(6,34)=2.58$, $p<0.04$), as well as a two-way interac-

tion of Context with Speaker ($F(1,39)=4.90$, $p<0.03$) were found. On the basis of the three-way interaction further analyses were carried out for anterior and posterior sites separately. For both sites main effects of Context were obtained ($F(1,39)=5.13$-12.56, $p<0.03$). In addition, on anterior electrode positions an interaction of Context with ROI was significant ($F(6,34)=3.95$, $p<0.004$). Analyses for each of the anterior ROIs separately revealed main effects of Context in the most central and right lateral anterior ROIs, i.e., A3, A4, A5, and A6 ($F(1,39)=4.71$-11.73, $p<0.04$). The analyses indicate that an irony-related late positivity could be replicated for Session 2. This positivity distributed over a central and right lateral anterior electrode sites, and more broadly over posterior electrode sites. Based on the above mentioned two-way interaction of Context with Speaker individual analyses for each speaker were carried out which showed a main effect of Context only for the high ironic speaker ($F(1,39)=14.61$, $p<0.001$). An effect of Context was not obtained in relation to the low ironic speaker ($F(1,39)=0.60$, n.s.). While for Session 1 an irony-related positivity was evoked by the low ironic speaker, this ERP pattern could not be replicated for the current session. Here, a late positivity in response to irony was solely elicited by the high ironic speaker, but not by the low ironic speaker.

6.4.3 Comparison of the ERP data obtained for Session 1 and 2

Between both experimental sessions the communicative style of the two speakers was varied concerning the frequency of their use of irony. In the first session a clear difference between the high and low ironic speaker could be noticed (i.e., speakers' use of irony varied in the proportion of 70% vs. 30%). This difference was balanced in Session 2, so that each speaker uttered the same amount of ironic and non-ironic sentences (i.e., 50% of each sentence type)..

For Session 1, early ERP components were not observed. Although between 200-300 ms a significant interaction of Context, Speaker and ROI was obtained, the resolution of this interaction revealed no further effects. Yet, this interaction suggests that ERPs in response to both speakers differed in dependence of sentence type, as well as in topographic distribution. By contrast, ERPs for Session 2 in the latency range of 200-300 ms showed an increase of the amplitude of the P200 in response to congruent conditions. In case the high ironic speaker replied in an ironic manner, and the low ironic speaker in a non-ironic manner a P200 component was elicited. While this P200 effect was obtained for Session 2, a comparable effect was not seen for Session 1.

Within the latency window of 300-500 ms, a frontocentral negativity in response to the low ironic speaker was evoked for Session 1. Though a slightly enhanced negativity was seen for Session 2, this negativity was clearly attenuated in amplitude and differed

in scalp distribution compared to the negativity obtained for Session 1. This effect seen for Session 2 might have resulted from an interaction of Speaker with Context in the same latency range (300-500 ms). The resolution of this interaction revealed a slightly increased N400-like effect for ironic sentences of the low ironic speaker in relation to that of the high ironic speaker. The amplitude of the negative ERP component showed a centroparietal and right lateral maximum which was distinct from the frontocentral negativity for the low-ironic speaker for Session 1.

An irony-related late positivity was observed for both experimental sessions, which resembled a P600 component in its electrophysiological characteristics. Between 500-900 ms late positivity effects that were comparable in morphology, sensitivity and largely in scalp distribution. Whereas for Session 1 this late positivity in response to irony occurred on frontocentral and centroparietal electrode positions, this effect was more broadly distributed over anterior and posterior sites for Session 2. Importantly, modulations of this positivity were observed in showing interactions between Context and Speaker for both sessions. In the first session, a P600 component elicited by irony was seen for the low ironic speaker but not for the high ironic speaker. Any differences on this late ERP effect for ironic and non-ironic sentences by the high ironic speaker were absent. Unlike this result, in Session 2 an irony-related P600 effect was obtained for the high ironic speaker but not for the low ironic speaker. Thus, the observed irony-related positivity appeared to be modulated by prior pragmatic knowledge about speakers' communicative style in using irony.

6.5 Discussion

The current ERP study aimed at the examination whether subtle pragmatic information about speakers has an impact on the processing of irony (Session 1). Whether such information is used as a reliable cue for the perception and interpretation of sentence meanings was tested by a second experimental session (Session 2). The ERP data for both sessions are discussed separately in the following sections.

Session 1: Implications for irony comprehension regarding pragmatic cueing

ERP data of Session 1 in which the frequency of speakers' use of irony was clearly imbalanced provide evidence that pragmatic information about speakers' communicative style has been perceived, and incorporated in the processing of ironic sentences. Within the latency range of 200-300 ms a significant interaction between Speaker, Context and ROI was found indicating that already during initial phases of processing pragmatic knowledge about speakers seemed to affect the processing of sentence meanings. Information about speakers' use of irony was taken into account, though this

information has been provided implicitly and needed to be extracted by attentive reading of discourses. This finding confirms the effectiveness of cueing by pragmatic information concerning speakers' characteristics as being highly or rarely ironic. With regard to the literature, such an early effect still remains surprising since an early effect of pragmatic information has only been reported for the auditory modality in a study by Van Berkum and colleagues (2008). In case gender specific utterances such as *If I only looked like Britney Spears* spoken in a male voice that were incongruent with the expected gender of the speaker, an early starting N400 component was found (i.e., having a latency onset of around 200 ms post-stimulus presentation). This ERP effect has been interpreted as evidence for an immediate impact of stereotypical information on language comprehension. Regarding the current ERP effect, even more subtle pragmatic knowledge seemed to exert an early influence on sentence processing in showing differences in the ERPs for both speakers. However, as no further effects were found when resolving this interaction, this early interaction cannot be interpreted in more detail.

Interestingly, in the N400 time window (300-500 ms) no effects of pragmatic information were found as reported in previous ERP studies (Fischler, et al., 1983; Van Berkum, et al., 2008). In case pragmatic knowledge about speakers mismatches with respective ironic and non-ironic sentence an N400 effect was not seen indicating that semantic information processing was unaffected by this additional information. While for more explicit pragmatic information about a speaker's gender (cf. Van Berkum, et al., 2008) or a speaker's occupation (cf. Fischler, et al., 1983) causing a semantic incongruency, an N400 component was obtained, in the current study this rather implicit information about speakers' characteristics seems to function differently. It may also be that pragmatic knowledge was still acquired during the first session, and therefore was not yet effective in yielding an influence.

Despite the absence of an N400 component, a late positivity that resembled a P600 component in morphology, latency and scalp distribution was observed for ironic sentences compared to equivalent literal sentences of the low ironic speaker. This late positivity emerged in response to irony as this was seen in previous studies (see Experiment 1-3), whereby it appeared to be modulated by pragmatic information. A P600 effect was only found for irony of the low ironic speaker but not for irony of the high ironic speaker. The results might imply that during later phases of processing (i.e., pragmatic interpretation of utterance meanings) an influence of speakers' communicative style affected the computation of appropriate sentence meanings. In comparison of the ERPs elicited by ironic and non-ironic sentences of the high ironic speaker no differences were observed between both sentence types within the 500-900 ms latency window. By implication, this suggests that an irony-related P600 effect did not emerge

in case a speaker frequently used irony. However, compared to literal sentences of the low ironic speaker P600 effects were present for both ironic and literal sentences of the high ironic speaker. One explanation for the absence of an irony-related late positivity for the hight ironic speaker might be that the frequent occurrence of ironic sentences of this speaker led to processing costs concerning the interpretation not only of his ironic but also non-ironic statements. Literal sentences of the high ironic speaker were possibly more extensively processed than those of the low ironic speaker, since that speaker very frequently uttered sentences that were non-literal conveying a different meaning than literally stated. Data of the post-test may indirectly support this explanation since the high ironic speaker was considered as the more ironic person to about 80% indicating that his utterances were largely associated with an ironic intent. However, it might also be possible that the emergence of a P600 component in response to incongruent conditions (i.e., for ironic sentences of the low ironic speaker, and non-ironic sentences of the high ironic speaker) was elicited by their lower probability of occurrence (i.e., each incongruent condition occurred only to 30% of all items). Differences in probability of stimulus occurrence were shown to modulate the amplitude of the P600 component (Coulson, et al., 1998b; Gunter, et al., 1997; Hahne & Friederici, 1999). The lower probability of a stimulus type evoked larger late positive effects relative to stimuli with a higher probability, which would suggest an alternative explanation for the current finding of a P600 effect. Yet, as ERPs in the 500-900 ms time window were identical for ironic and literal sentences uttered by the high ironic speaker, although both sentence types differed in probability (i.e., 70% ironic vs. 30% non-ironic sentences), it cannot be disentangled in how far probability of occurrence contributed to these ERP deflections. In order to identify such an impact of stimulus probability on the P600 related to irony, this needs to be explored in a future experiment.

Session 2: Implications for irony comprehension regarding recently acquired pragmatic knowledge

In Session 2, the frequency of speakers' use of irony was completely balanced across their communicative style. Both speakers replied equally often ironically and literally. Consequently, prior pragmatic knowledge about both interlocutors as being high or low ironic was not any further substantiated. The most important question addressed in this session was whether this previously perceived pragmatic information would be still used during sentence processing, and in how far such knowledge about these two speakers has been established.

Alike the first session, ERPs revealed an influence of speakers' communicative behavior on the comprehension of sentence meanings. Surprisingly, this influence occurred not only during later phases of processing when integrating various types of

information, but also during an initial phase. An increase in the amplitude of the P200 component was observed when both speakers' familiar communicative style was consistent with respective sentence interpretations (i.e., the low ironic speaker made a non-ironic statement, and the high ironic speaker made an ironic statement). This finding is very surprising, as it indicates that implicitly provided subtle pragmatic information was memorized, and affected sentence processing as early as 200 ms after stimulus onset. The emergence of this early positivity provides evidence for an immediate influence of pragmatic knowledge on initial processes of both literal and figurative language comprehension. In case perceived communicative style of both speakers was in line with respective sentence endings, this information about speakers' characteristics seemed to provide a cue for particular sentence meanings. With regard to the literature, behavioral evidence (by means of response times) for an immediate incorporation of stereotypical gender information into readers' representation of a person has been reported in a study by Oakhill, Garnham and Reynolds (2005). Reading certain role or profession terms were shown to affect response times for subsequent words, which set up congruent or incongruent word pairs with these occupation or role terms. So far, early ERP effects have only been reported for violations of explicit information about speakers' gender with respect to stereotypical messages (Van Berkum, et al., 2008). In this study an increased N400 component starting around 200 ms post-stimulus has been reported for such violations, and which has been related to a rapid extraction and usage of speakers' voice-inferred information during initial sentence comprehension. The current ERP data seem to extend this finding not only for the visual modality, but also for a more subtle information type that needed to be noticed in advance by attentive reading. The finding of an early ERP effect suggests an immediate influence of pragmatic knowledge that has been acquired shortly before (i.e., during the first session) on language processing. Thus, even such implicitly provided information seemed to set up certain pragmatic knowledge, on which participants might have been relied when interpreting sentence meanings. With regard to the results of Experiment 2, the present finding substantiates early effects of Context on the amplitude of the P200 (see section 5.1.4). In this previous study, a P200 effect was elicited by ironic relative to literal sentences. This effect was assumed to reflect early semantic analysis processes due to contextual information that biased a certain pragmatic interpretation. The present data partially support this interpretation in terms of an immediate influence of contextual information, i.e., in this case provided by pragmatic knowledge about speakers. Although P200 effects of the current and previous study are comparable in their electrophysiological characteristics, they seem to differ in their sensitivity. A P200 seen in the current study emerged by means of pragmatic information about speakers' use of irony,

and did not result from figurativity of sentences. Whenever prior perceived information about two interlocutors was consistent with respective sentence interpretations, a larger P200 component was found. This suggests that even subtle information about speakers' communicative style seems to provide additional constraints that apparently enable implicit categorization processes regarding speakers' utterances as consistent or inconsistent with pragmatic knowledge. By contrast to Experiment 2, subprocesses reflected by the amplitude of the P200 appear to be not specific for irony but rather seemed to be involved for both figurative and literal language comprehension.

In addition to the P200 effect, ERPs in response to irony revealed an increased N400-like component for the low ironic speaker compared to the high ironic one. Importantly, within the second session a larger N400 component has been seen in response to irony by the low compared to the high ironic speaker. However, a comparable ERP effect did not emerge within the first session. This finding indexes an impact of pragmatic information during the processing of semantic information. Whereas knowledge about both speakers' preferred communicative style might have been acquired during the first session, here it appeared to be widely established, and seemed to affect lexical-semantic information processing when encountering sentence final words. As the low ironic speaker primarily replied in a literal way, his ironic statements might have caused semantic processing difficulties. Behavioral data seem to support this observation. Participants made more errors in responding to the comprehension task for discourses ending in ironic sentences of the low ironic speaker than in literal sentences of that speaker. Moreover, results of the post-test showed that the majority of participants still perceived the high ironic speaker as the more ironic one (to about 44%), which implied that the low ironic speaker was rather expected to reply literally than ironically. As prior pragmatic information biased expectancy for irony of the high ironic speaker but not of the low ironic speaker, the observed negativity in response to irony by the low ironic speaker is most likely a reflection of lower semantic-pragmatic expectancy rather than semantic integration difficulties. Modulations of the N400 component by semantic expectancy have been reported by various ERP studies (see for example Kutas & Hillyard, 1984; St. George, et al., 1994). Findings further suggest that the comprehension of irony when embedded in rich supportive contexts does not entail semantic processing difficulties but seems to rely on additional cueing. The observation of an N400-like effect is therefore not in line with the results of two ERP studies on irony comprehension (Cornejo, et al., 2007; Katz, et al., 2004). Whereas in both studies an irony-related N400 has been obtained in relation to literal sentences, the current data showed a larger N400-like component for ironic statements of the low ironic speaker compared to the high ironic one. The processing of irony appears to be highly depen-

dent on contextual and pragmatic information, and consequently might most likely evoke differential ERP patterns depending on the availability of further constraining cues.

Moreover, an irony-related late P600 effect could not be replicated for the low speaker. Such an effect solely emerged for the high ironic speaker. This suggests that the occurrence of a P600 in response to irony seems to depend on prior pragmatic knowledge about speakers' frequent use of irony. While for the first experimental session a comparable P600 was evoked by irony expressed by the low ironic speaker, this effect disappeared for the second session. A possible explanation for the absence of this effect may be that an overlap of the ERPs of an earlier latency range occurred. As an N400-like component emerged in the latency window of 300-500 ms this ERP effect probably superimposed a potential irony-related P600 component for the low ironic speaker. Yet, replicating a P600 effect in response to irony further substantiates this ERP response as a reliable effect for figurative language comprehension. This positivity might be a function of pragmatic information processing whereby inferences seems to be involved in deriving appropriate sentence interpretations. A comparable P600 effect has been reported for inconsistencies of acoustic speaker information about speakers' gender with statements that stereotypically referred to female or male speaker (Lattner & Friederici, 2003). Sentences such as *I like to wear lipstick* spoken by a male speaker evoked no N400 effect, but a larger P600 amplitude in comparison to the same sentence expressed by a female speaker. Lattner and Friederici (2003) interpreted the P600 component as a function of the reintegration of semantic meaning and stereotypical beliefs that were based on extra-linguistic speaker information. Likewise, processes of reintegration could also be reflected in the irony-related P600 effects obtained for Session 1 and 2. Ironic sentences were pragmatically more complex by implying an opposite meaning than literally stated. As particular interpretations became obvious with respect to prior contextual information including pragmatic knowledge, different types of information might have to be reintegrated for computing appropriate sentence meanings. In order to build up an appropriate pragmatic representation of implied sentence meanings on the message level, semantic (literal) meanings as well as prior contextual and pragmatic information were possibly reintegrated. If a sentence interpretation appears to be pragmatically complex, further interpretation processes might become necessary for deriving an appropriate sentence representation (cf. Grice, 1975). Moreover, the currently seen P600 component emerged in addition to an earlier P200 effect suggesting that whenever additional pragmatic information about speakers' communicative style provides support for figurative sentence interpretation, comprehension processes diverge already during initial processing but also during late

processing stages. The present findings are in line with results of Experiment 3 in which P600 effects in response to irony have been modulated by additional cueing in the form of quotation marks. Late comprehension processes encompassing presumably pragmatic interpretation appeared to be affected by the presence of punctuation cues as well as subtle pragmatic cues like information about speakers' use of irony. The observed P600 effect might be a reflection of processing pragmatic information that appeared to be more effortful for interpretation of communicative intents conveyed by figurative utterances.

6.6 Conclusion

The current experiment showed an influence of subtle pragmatic information about speakers' characteristics (concerning their use of irony) on literal and figurative language processing. An impact on initial phases of processing was found as early as 200 ms which indicates that pragmatic information about speakers had an immediate influence when encountering sentence final words. Moreover, the findings imply that pragmatic knowledge about speakers affected the processing of both literal and figurative sentence meanings, and that this information once established seems to set up a reliable cue for potential interpretations of someone's remarks. ERPs also provided evidence that the processing of irony is influenced by pragmatic expectancy for ironic statements in showing a larger irony-related P600 for the high ironic speaker but not for the low ironic speaker in Session 2. This indicates that subtle information about speakers' characteristics (occurring in addition to contextual information) appeared to be established as a cue for potential sentence interpretations, and affected initial and late processing of sentence meanings. In case perceived characteristics of a speaker did not match with an expected sentence meaning a slightly increased N400-like effect occurred for the low compared to the high ironic speaker. Findings suggest that whenever a speaker is less expected to make an ironic utterance, at least partially distinct comprehension processes seemed to be involved in the processing of irony than when someone is expected to reply ironically by means of prior pragmatic knowledge.

Chapter 7

Specification of irony-related ERP effects

Findings of the ERP experiments conducted so far all revealed a late positivity that was consistently elicited in response to irony. This positivity resembled the P600 component in its electrophysiological characteristics, and was therefore classified as P600 effect. The amplitude of the P600 appeared to be modulated when irony was accompanied by the presence of additional visual cues leading to an earlier latency onset and a widespread topographic distribution of the late positivity (cf. Experiment 3). In availability of implicit cues such as pragmatic knowledge about speakers, the positivity was solely elicited in congruency of this information with an ironic comment (cf. Experiment 4). Moreover, the positive shift appeared to be also affected by the presentation modality of stimulus to some extent. When presenting acoustic stimuli the observed P600 component had a centroparietal distribution, whereas for the visual presentation modality this positivity extended over frontocentral electrode sites (cf. Experiment 1 and 3). From these findings it can be concluded, that the P600 is a robust effect for the processing of irony but at the same time seems to be dependent on specific experimental parameters. As a consequence, its exact electrophysiological and therewith functional characteristic cannot be defined with certainty on the basis of the present data. On the one hand, it is still unclear in how far the applied experimental paradigm (including task demands) contributed to the generation of this effect. On the other hand, for the functional specification of this ERP response it is important to examine whether it shares similarities with the P600 component evoked by syntactic anomalies. The following two experiments were conducted to explore the P600 in response to irony in more detail. The questions whether the irony-related positivity could have been influenced by task requirements, or whether this positivity probably resulted from strategic processing are investigated in Experiment 5. In Experiment 6 it is examined whether this late positivity could be a reflection of more structural processes similar to that indexed by the syntax-related P600 component.

7.1 Experiment 5: Influences of task demands and probability of occurrence

7.1.1 Introduction

So far the results of all previous experiments suggest that the processing of verbal irony does not involve processing difficulties reflected in the N400 component but rather in the amplitude of the P600. With respect to the experimental paradigm used in these studies, this late positivity might have been modulated by other variables than solely by the pragmatic manipulation. As reported by a variety of ERP studies, the amplitude of the late positive component is not only sensitive to language-related information but also to requirements of experimental tasks (Coulson, et al., 1998b; Hahne & Friederici, 2002; Kuperberg, 2007; Kuperberg, Caplan, Sitnikova, Eddy, & Holcomb, 2006). In particular, P600 effects have been usually reported for judgment tasks concerning the plausibility and acceptability of sentences. In a study by Kuperberg, Sitnikova and colleagues (2003), for instance, an enhanced P600 was observed when participants were required to pay attention to the acceptability of sentences, whereas no such effect was found in absence of these task demands. Regarding the late positivity in response to irony, it might be possible that the applied comprehension task[16] yielded similar effects as reported for judgment tasks. Requirements of this task concerned the overall intelligibility of the presented discourses by means of a content question that had to be judged on its correctness. Although an overt evaluation of irony was not required, task demands might still have affected comprehension processes. Compared to understanding irony in daily communication, questions about the contextual situation in which an ironic comment occurs are rarely asked. In consequence, this could have induced an unnatural comprehension situation during the experiment. Participants might have possibly focused more intensively on the content of the discourses since this information was sufficient in replying to subsequent questions. In this respect, the current study has the purpose to examine in how far requirements of the comprehension task contributed to the emergence of the late positivity. In order to evaluate potential effects of task, a block design consisting of two blocks was employed as experimental paradigm. In the first block participants were required to read discourses for comprehension only. To ensure that they were still paying attention to the stimuli, a post-test recognition task was included at the end of the block. In the second block a comprehension task was implemented as it was applied in the previous experiments (see section 5.3.2). The

[16] Applying this kind of experimental task aimed to ensure that participants were paying attention to the experimental stimuli, as well as to obtain behavioral measures of potential difficulties in comprehending experimental discourses.

order of the blocks was unbalanced to avoid biases of task demands on the stimulus processing during the first block. This block paradigm had the advantage of allowing for a comparison of ERP responses between the task-dependent and task-independent processing of irony.

In case the irony-related positivity is in fact evoked independently of task requirements, it is hypothesized that a similar positivity relative to irony should be replicated for the first block in absence of the comprehension task. An interaction of the experimental factors Context with Task should not be obtained, if different neural generators are involved in the processing of irony presented with or without a comprehension task.

A second aim of this study was to explore whether certain processing strategies could have been applied on the processing of irony. In the experiments reported so far only ironic or non-ironic sentences were presented as experimental material. Due to a lack of fillers this might have led to strategic processing whereby attention was directed to the discourse contexts as potential predictors for particular interpretations. Based on prior contextual information an expectation for either figurative or literal statements could have been generated. In view of the discussed psycholinguistic models of figurative language comprehension (see chapter 1), it is important to examine a potential impact of strategic processing as this may have distorted processing mechanisms involved in irony comprehension. For that reason, additional discourses corresponding to ironic discourse context were included as fillers but were completed with a non-ironic statement. To evaluate an impact of potential strategic processing, the ERP data of the present experiment were contrasted with the results of the first block of Experiment 3 (where irony occurred as frequent as literal sentences). This was possible since experimental parameters (i.e., task requirements, presentation modality and experimental items) between the two experimental blocks were identical despite of the probability manipulation by the occurrence of fillers in the present study. Thus, a conjoined analysis of the ERP results for both experimental blocks could be performed across experiments.

The following hypothesis can be made for potential ERP effects in response to irony. With respect to the probability manipulation due to fillers, it is possible that a P300 component is seen for ironic sentences as they occurred less often than literal statements. Since an increased P300 amplitude has been associated with detection and discrimination of unexpected or 'oddball' events (Ruchkin, Johnson, Canoune, Ritter, & Hammer, 1990), this component might emerge in response to irony as reflection of the lower probability of ironic sentences. In view of that, three predictions can be derived. Firstly, in case ironic sentences elicit an increased positivity resembling a P300

component and no further effects, this would imply that probability of occurrence has an impact on the processing of irony. More importantly, this finding would also challenge the functional significance of the irony-related P600 observed in previous experiments. Secondly, whenever a P300 effect is elicited in addition to a late positivity in response to irony, it is assumed that both positive ERP effects reflect distinct processes related to manipulations of probability as well as irony. Thirdly, it is hypothesized that whenever a similar ERP pattern is obtained across both experiments, this would provide evidence against strategy-specific processing. Moreover, such finding would suggest that the irony-related late positivity is indeed associated with figurative language comprehension, and is not a function of more general processes reflected in the P300.

7.1.2 Participants

Thirty (15 female, mean age 24.6 years (SD 2.61)) native German speaking students participated in the experiment. All participants had normal or corrected to normal vision, and were right-handed. Subjects were paid for their participation. For the conjoined analysis of the ERP data of the current experiment with those of Experiment 3, thirty participants (15 female, mean age of 23.3 (SD 1.99)) were chosen at random from this previous study.

7.1.3 Method

7.1.3.1 Stimulus material

Stimulus material was the same as used in Experiment 4 (cf. section 6.3.1) except for an extension of the set by 20 additional items as well as fillers. In total, 120 experimental items and 60 filler items were presented, in sum 180 items. Previously carried out pretests on the stimulus material (i.e., a cloze procedure and an acceptability test (see section 4.3.1.1 and 6.3.1)) revealed for this larger item set an average cloze probability of 91.8% (SD 8.15). Sentence final words of ironic sentences were slightly less expected (i.e., to about 8%) than that of literal sentences (paired t-test on items $t(119)=7.31$, $p<0.0001$). This semantic-pragmatic expectancy of the experimental items was comparable to prior experiments. Regarding the average acceptability of the stimuli, the experimental items showed an average acceptability of 3.7 (SD 0.41). Ironic and non-ironic sentences did not differ in acceptability (paired t-test on items $t(119)=1.22$, n.s.).

As fillers 60 discourses that were similar in discourse content and structure to the ironic items were included. Discourse contexts of these filler items described an unpleasant event on which a non-ironic sentence followed. This sentence corresponded to

the foregoing context and did not contradict it as within ironic discourses. Thus, on the basis of discourse contexts an upcoming ironic or non-ironic sentence could not be anticipated.

All 180 items were pseudo-randomized and distributed over two versions so that each target sentence occurred only once in each version. Both versions were divided into two blocks containing 60 experimental items and 30 fillers each.

7.1.3.2 Procedure

The experimental procedure was the same as for the previous studies (see section 5.1.3.1) except for the first block. Instead of employing a comprehension task, participants were asked to attentively read the stimuli and not to blink during the word-by-word presentation of the discourse final sentence. Participants were informed that there is a post-test consisting of a questionnaire in which they would be required to recognize some of the discourses. No other task demands were imposed. In the beginning of each block, participants received a short training of five trials to familiarize with the experimental procedure.

7.1.3.3 Data acquisition and analysis

The data acquisition and analysis of the EEG were identical to that of Experiment 2 (see chapter 5). The experimental factors were Context (ironic/non-ironic) and Task (with/without task). For statistical analysis of a potential P300 effect, the latency onset of the irony-related late positivity was measured using four latency ranges of 50 ms each beginning from 300 ms on and continuing until 500 ms. Behavioral data of the second block were analyzed using a paired t-test. ERP rejections due to ocular or technical artifacts comprised about 8% of all trials.

For the conjoined analysis of the ERPs for the two experiments (i.e., Experiment 3 and 5) the factor Experiment was inserted as between-subject variable, and Context (ironic/non-ironic) as within-subject variable. In order to evaluate distributional differences in the ERPs, the two topographic factors ROI (7) and Anterior/Posterior (2) (cf. section 4.3.3) were included in the analysis. Three latency windows (i.e., 200-300 ms, 300-500 ms, and 500-900 ms) that entered the analyses of the two experimental blocks under comparison were analyzed.

7.1.4 Results

In the beginning of this section behavioral and ERP data of the current experiment are described, before the results of the conjoined analysis will be reported.

Behavioral data. For the second block that comprised the comprehension task participants showed an excellent performance. The mean accuracy rate was 96.0% (SD 3.20). Accuracy rates were equally divided across both conditions as the statistical analysis revealed no significant difference (t(29)=0.64, n.s.).

Electrophysiological data. As displayed in the Figures 7.1 and 7.2, ERPs showed a slightly increased P200 and a larger P600 in response to irony. This late positivity was present for ironic sentences in both blocks independent of the presence of a comprehension task (see Figure 7.2). Alike previous experiments, an irony-related N400 effect was not observed. In absence of the comprehension task ERPs showed a long-lasting positivity starting around 200 ms with a broad scalp distribution (see Figure 7.3).

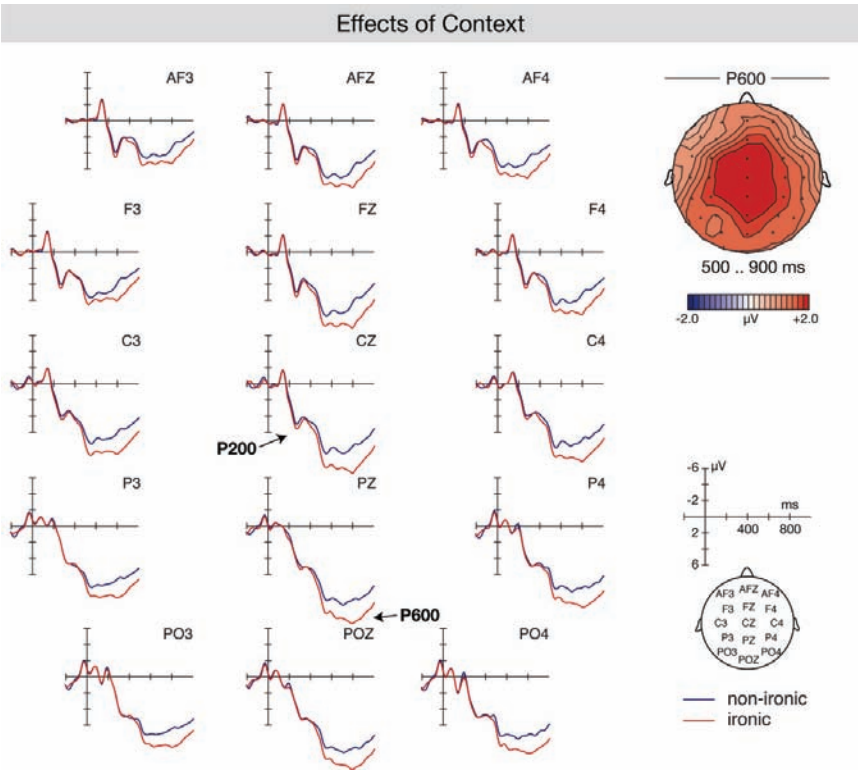

Figure 7.1. Grand average ERPs at the sentence final word that pointed to an ironic (red line), or non-ironic interpretation (blue line) regarding prior discourse contexts. The visual onset of critical words was at 0 ms on the x-axis. Negativity is plotted upwards in this and all succeeding figures. The map on the right shows the topographic distribution of the P600 component related to irony.

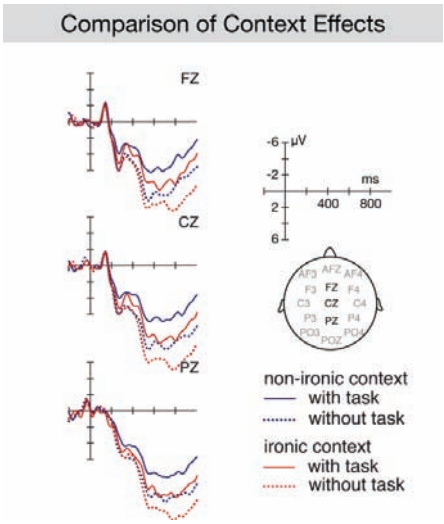

Figure 7.2. Grand average ERPs to critical words of ironic sentences (red lines) and non-ironic sentences (blue line) in presence (solid line) or absence (dotted line) of the comprehension task.

Statistical analyses of the **200-300 ms** latency window showed a marginally significant main effect of Context ($F(1,29)=3.27$, $p<0.08$), which indicate a P200 effect for ironic sentences compared to literal sentences. An effect of Task ($F(1,29)=5.89$, $p<0.02$), as well as an interaction of Task with ROI ($F(6,24)=5.49$, $p<0.001$) were also revealed. Resolving this interaction by ROI showed main effects of Task over central and right-lateral ROIs, i.e., R4, R5, R6, and R7 ($F(1,29)=5.97$-10.21, $p<0.02$). When no comprehension task had to be performed, an early starting positivity emerged. An interaction between Context and Task was not revealed ($F(1,29)=1.38$, n.s.).

In the latency window of **300-500 ms**, an effect of Task ($F(1,29)=15.55$, $p<0.001$) and an interaction of Task with Anterior/Posterior and ROI ($F(6,24)=6.62$, $p<0.0003$) were significant. Separate analyses for anterior and posterior sites showed interactions of Task with ROI for both sites ($F(1,29)=4.15$-6.98, $p<0.01$). Further subanalyses for anterior ROIs were carried out that showed main effects of Task in central and right-central anterior ROIs, i.e., A3, A4, A5, A6, and A7 ($F(1,29)=4.07$-28.54, $p<0.05$). Subanalyses for posterior ROIs revealed main effects of Task in central and right-lateral posterior ROIs, i.e., P3, P4, P5, P6, and P7 ($F(1,29)=9.53$-18.70, $p<0.01$). The early starting positivity obtained in absence of the comprehension task appeared to be a more sustained effect that was still present in this later time window of 300-500 ms. This positive shift was broadly distributed including frontocentral, centroparietal and right-temporal scalp sites. With regard to the processing of irony, a marginally significant effect of Context was found ($F(1,29)=2.99$, $p<0.09$) indicating a more positive ERP de-

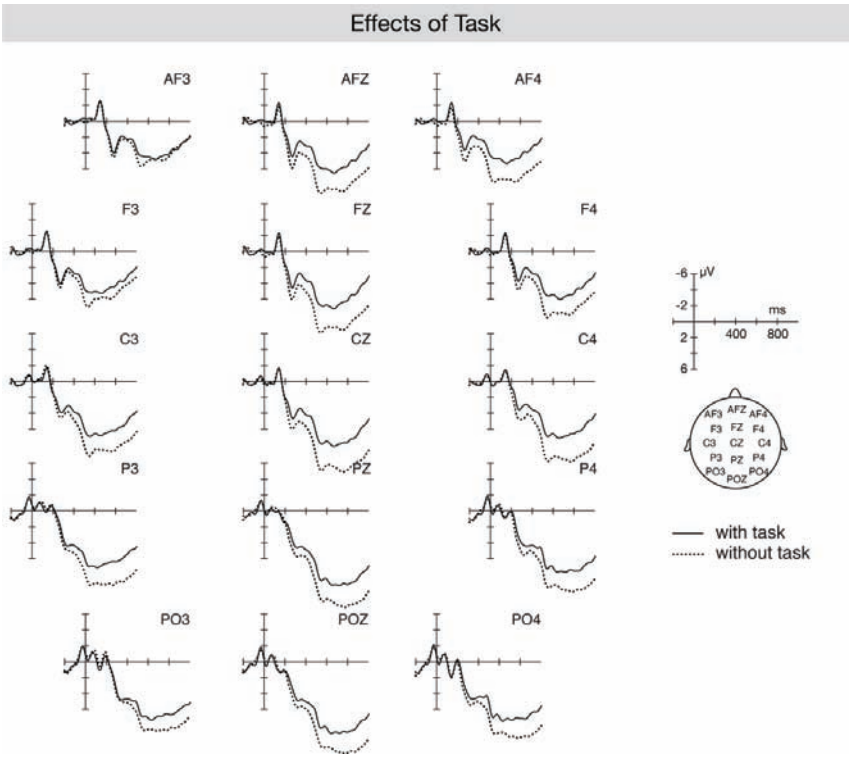

Figure 7.3. Grand average ERPs to sentence final words when participants need to perform the subsequent comprehension task (solid line), or when no such task was applied (dotted line).

flection for ironic sentences. An N400 effect in response to irony was not elicited. Moreover, the processing of both ironic and literal sentences appeared to be independent of Task since an interaction between Context and Task was not obtained ($F(1,29)=0.23$, n.s.).

The analysis in the **500-900 ms** latency range revealed effects of Context ($F(1,29)=20.81$, $p<0.0001$) and Task ($F(1,29)=23.81$, $p<0.0001$). Three-way interactions between Context, Anterior/Posterior and ROI ($F(6,24)=2.63$, $p<0.04$), as well as between Task, Anterior/Posterior and ROI ($F(6,24)=5.09$, $p<0.002$) were significant. Resolving both three-way interactions by Anterior/Posterior showed further interactions of Context with ROI ($F(6,24)=3.57$-3.61, $p<0.01$), and of Task with ROI ($F(6,24)=2.80$-6.83, $p<0.03$) for anterior and posterior sites. These two-way interactions were resolved by separate analyses for anterior and posterior ROIs. Significant effects of Context were revealed for all anterior and posterior ROIs ($F(1,29)=5.85$-29.85, $p<0.02$) replicating the late positivity for ironic sentences. With respect to an effect of Task, statistical analyses showed main effects of Task for central and right-lateral anterior ROIs, i.e.,

A4, A5, A6 and A7 ($F(1,29)=6.13-38.02$, $p<0.02$), as well as for all posterior ROIs ($F(1,29)=10.69-29.85$, $p<0.003$). Thus, the positivity evoked in absence of the comprehension task appeared to be a long-lasting effect (starting already about 200 ms), which displayed a widespread scalp distribution. As shown in the earlier latency windows, neither an interaction between Context and Task ($F(1,29)=0.02$, n.s.), nor an interaction between Context, Task and any topographic factor was found ($F(6,24)=0.73-1.04$, n.s.). Findings substantiate the observation that the processing of irony was unaffected by task demands.

To determine the latency onset of the irony-related positivity, statistical analyses were conducted for four successive latency ranges beginning from 300 ms on. In the earliest three latency ranges of 300-350 ms, 350-400 ms and 400-450 ms no significant effects of Context ($F(1,29)=0.26-2.87$, n.s.) were found. In the latency range of 450-500 ms an effect of Context was significant, which confirms that the irony-related positivity is in the range of the observed P600 effects of the previous experiments (cf. Experiment 1, 2, and 3).

Analyses of the ERPs across Experiment 3 and 5. To evaluate whether the lower probability of ironic sentences compared to literal ones had an influence on comprehension processes, a direct comparison of ERPs for the experimental blocks of Experiment 3 and 5 was carried out. For both experimental blocks irony was presented visually without any additional cues, and the employed experimental task (i.e., a comprehension task) was identical as well. A difference between both experimental blocks consisted in the probability manipulation. Whereas ironic sentences occurred to 50% of all items in Experiment 3, the same sentences had a lower probability in Experiment 5 (i.e., to about 30%). As displayed in Figure 7.4, for both experimental blocks similar late positivity effects were evoked by irony. Visual inspection suggests that no substantial differences in morphology, amplitude or scalp distribution were present between both effects.

In the latency window of **200-300 ms**, the conjoined statistical analysis of both experimental blocks showed a main effect of Context ($F(1,58)=6.62$, $p<0.01$) but did not reveal any interactions between Experiment and Context ($F(1,58)=0.02$, n.s.). An interaction of Context with ROI ($F(6,53)=3.36$, $p<0.01$) were found, which was resolved by separate analyses for the different ROIs and showed significant effects of Context for nearly all ROIs, i.e., R2-R7 ($F(1,58)=4.50-9.23$, $p<0.04$). The statistical analysis indicates that differences in the ERPs between both experiments were not present.

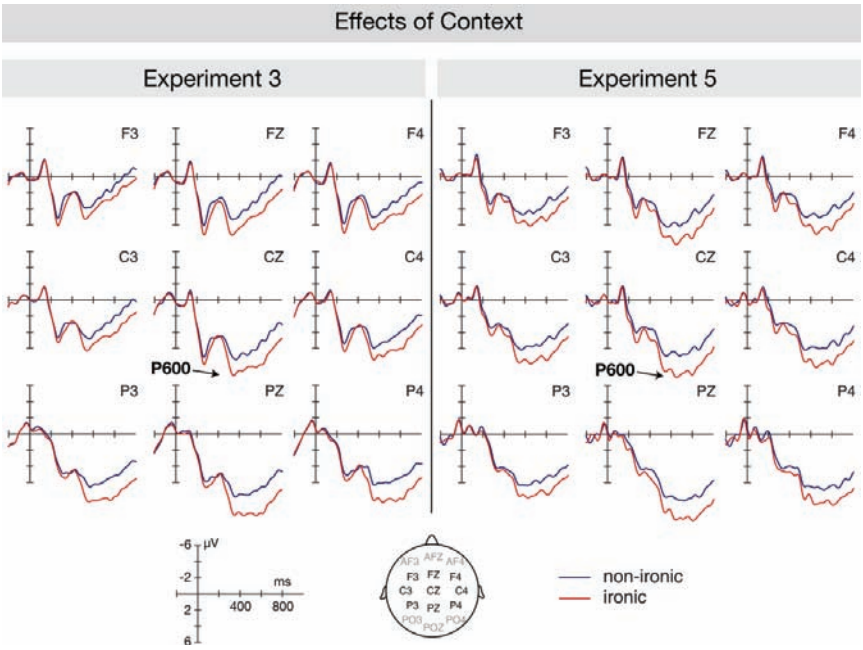

Figure 7.4. Comparison of grand average ERPs obtained for the different experimental blocks of Experiment 3 and 5. ERPs were elicited by the sentence final word which indicated a non-ironicinterpretation (blue line), or an ironic interpretation (red line).

The conjoined analysis of the **300-500 ms** latency range showed neither interactions between Experiment and Context (F(1,58)=0.00, n.s.), nor with any topographic factors (F(6,53)=0.28-0.91, n.s.). Thus, no differences in the ERPs across experimental blocks were seen in the N400 time window. As observed for the earlier latency window, a significant effect of Context (F(1,58)=4.22, p<0.04) and an interaction of Context with ROI (F(6,53)=2.55, p<0.03) were obtained. Subanalyses for each ROI separately revealed effects of Context in central and right-lateral ROIs, i.e., R4, R5 and R6 (F(1,58)=5.58-6.35, p<0.02).

In comparison of the ERPs within the **500-900 ms** latency window, an interaction of Experiment with Context (F(1,58)=0.00, n.s.) nor with any of the topographic factors (F(6,53)=0.75-2.77, n.s.) were not present. The analysis implies that the late positivity in response to irony did not differ in morphology, amplitude or scalp distribution across the two experimental blocks. Thus, the irony-related P600 effect seen in Experiment 5 appeared to be uninfluenced by the probability manipulation. The statistical analysis of this latency window revealed an effect of Context (F(1,58)=26.41, p<0.0001) as well as a three-way interaction of Context with Anterior/Posterior and ROI (F(6,53)=3.43, p<0.01). By resolving of this interaction by Anterior/Posterior further interactions of Context with ROI for anterior and posterior sites (F(6,53)=3.61-7.80, p<0.004) were

shown. For subanalyses of anterior and posterior ROIs separately significant effects of Context on anterior ROIs, i.e., A2-A7 ($F(1,58)=3.97$-19.12, $p<0.05$) and on all posterior ROIs, i.e., P1-P7 ($F(1,58)=27.53$-39.51, $p<0.0001$) were obtained.

7.1.5 Discussion

The present experiment examined whether the occurrence of an irony-related P600 component obtained in previous experiments could have been modulated by task requirements, or strategic processing induced by the absence of fillers. Findings suggest that in response to irony a similar ERP pattern was evoked in absence and presence of a comprehension task. This pattern was composed of a marginal effect on the P200 amplitude followed by an enhanced P600 for ironic sentences. Moreover, an increased N400 component related to irony was not observed. In comparison to previously obtained ERP data (cf. Experiment 1-4), the current results suggest a replication of the irony-related P600 component. In addition, this positivity appeared to be uninfluenced by expectancy since a reduction in probability of occurrence of ironic sentences elicited a comparable P600 effect. Findings will be discussed in detail in the following sections.

ERP effects related to task requirements

Regarding the question whether the irony-related P600 was dependent of task requirements, the results do not provide evidence for an influence of the comprehension task on the emergence of a P600 effect. An irony-related late positivity was evoked irrespective of task requirements by the comprehension task. This observation was confirmed by the absence of a significant interaction between the experimental factors Context and Task in the latency window of 500-900 ms. Moreover, as interactions between Context and Task were also not seen in earlier latency windows (i.e., 200-300 ms and 300-500 ms) this implies that neither early nor late ERP effects related to irony varied as a function of task demands. Similar neural generators contributing to the emergence of the P600 effect seemed to be involved in processing pragmatic information associated with irony independent of task demands. The current findings are in accordance with previous ERP studies that reported a task-independence of the P600 component (Hagoort, et al., 1993; Hagoort, Wassenaar, & Brown, 2003; Kolk, et al., 2003; Osterhout & Hagoort, 1999; Osterhout, et al., 1996). In a study by Kolk and colleagues (2003) a ‘semantic P600’ effect was observed for semantic reversal anomalies when applying a judgment task but also for a passive reading task. Therein, the semantic P600 appeared to be a reflection of language comprehension processes rather than of response-related processes. However, other studies reported an influence of judgment tasks on the amplitude of the P600 component in response to syntactic anomalies

(Hahne & Friederici, 2002) as well as conceptual anomalies (Geyer, Holcomb, Kuperberg, & Pearlmutter, 2006). When participants were asked to focus on semantic coherence of syntactically violated sentences, the amplitude of the P600 component was reduced (Hahne & Friederici, 2002). Similarly, in many cases semantic P600 effects were evoked in presence of plausibility or acceptability judgments (Kemmerer, et al., 2007; Kuperberg, Holcomb, et al., 2003; Kuperberg, Sitnikova, et al., 2003). As the comprehension task applied in the current experiment demands primarily attentive reading of discourse contexts whereby figurativity of sentences was not pertinent, this might not have resulted in an evaluation of sentence meanings as it would be required by plausibility judgments. The occurrence of a larger P600 in response to irony suggests that responding to a comprehension question does not draw participants' attention to certain experimental manipulations away from target sentence interpretations. Accordingly, ERPs provide strong evidence for a functional relation of the irony-related P600 to the processing of figurative language.

Although the comprehension task did not yield an influence on irony comprehension, an effect of Task was still obtained. In absence of that task ERPs for both ironic and non-ironic sentences revealed a sustained positive shift starting at around 200 ms after stimulus presentation. This result indicates that task requirements affected the overall processing of the stimuli, even though this was not solely the case for ironic sentences. As the comprehension task did not require focusing on the figurativity of sentence interpretations, it appeared to be an appropriate measure of participants' attention to the stimuli. Thereby, attraction to relevant experimental manipulations as well as task-directed processing was avoided. The finding of a larger positivity in absence of the comprehension task is still surprising as an impact of task normally elicits larger ERP effects compared to experimental paradigms that do not include such tasks. It might be possible that the observed effect of a larger positivity in absence of a comprehension task resulted from more intensive processing of critical words since participants were not required to concentrate on foregoing contextual information.

Effects related to the probability manipulation

The present study also addressed the question whether strategic processing could have been contributed to the generation of a P600 component seen for irony. By including additional discourses as filler items the influence of a potential processing strategy was prevented. On the basis of prior contextual information, an ironic or non-ironic interpretation of target sentences could not be predicted. In comparison of the current ERP data with those of Experiment 3 in which such kind of prediction could theoretically been possible, no evidence for strategic processing was found. The P600 component in response to irony did not differ remarkably in its electrophysiological characteristics

across both experimental blocks. Whenever strategic processing would have been applied to the comprehension of irony, this did not affect the amplitude of the P600 in response to irony. Moreover, the results of the conjoined analysis imply that the irony-related late positivity was not modulated by probability of occurrence. Although filler items were included in the experimental set that reduced the proportion of ironic sentences (i.e., approximately 30%) compared to non-ironic sentences (i.e., approximately 70%), the irony-related positivity appears to be unaffected by this manipulation. This finding provides strong evidence for a differentiation of this ERP response from the P300 component. If the P600 in response to irony would have been a reflection of domain-general processes, then it should have been sensitive to the lower probability in showing an enhancement in amplitude. Such an effect caused by infrequency of a certain type of stimuli has typically been observed on the amplitude of the P300 component (Coulson, et al., 1998b; Donchin, 1981). By contrast, amplitude size of the irony-related P600 did not increase due to the lower probability of irony, and morphology, overall latency and scalp distribution of this effect remained consistently. The latency onset of the current P600 effect revealed a slight difference, i.e., starting 50 ms earlier compared to the P600 effects seen in previous experiments. Since the P600 most likely reflects controlled processes, it is rather unlikely that this somewhat earlier onset of this late ERP effect implies a relevant temporal shifting, nor an engagement of distinct cognitive processes. Based on the current ERP data it seems most likely that the irony-related late positivity is a replication of the P600 effect found in Experiment 3. This late positive shift elicited by ironic sentences seems to be a reflection of comprehension processes related to the processing of figurative language, which did not appeared to be driven by strategic processing.

In sum, in this experiment ERPs revealed a P600 component in response to irony that was neither affected by requirements of the comprehension task, nor by lower probability of ironic sentences relative to non-ironic sentences. The absence of major differences in electrophysiological characteristics of the P600 compared to earlier findings provides support the interpretation that this ERP effect is most likely a reflection of figurative language processing.

7.2 Experiment 6: Comparison of irony- and syntax-related P600 effects

7.2.1 Introduction

The present experiment was aimed to further specify the electrophysiological and functional characteristics of the P600 effect obtained for irony. In all of the experiments conducted so far, the ERPs in response to ironic sentences revealed a late positivity starting around 500 ms post-stimulus onset with a centroparietal scalp distribution. This positivity bears some resemblance to the P600 component that was reported for syntactically anomalous or complex sentences. Despite showing similarities in amplitude, latency and scalp distribution, the P600 effect seen for irony was modulated by figurativity of sentences in absence of any syntactic anomalies. This gives rise to the questions whether late positivities in response to pragmatic (i.e., irony) and syntactic manipulations reflect similar neurocognitive processes, or whether both ERP responses are rather functionally distinct from each other. While similar 'non-syntactic' P600 effects have been reported for semantic and thematic anomalies amongst other manipulations (cf. chapter 2), up to now it could not conclusively be answered in how far these diverse ERP effects are related to each other concerning their sensitivity.

Based on observations of P600 modulations different theoretical positions on the P600 came up, which are usually classified as domain-general and domain-specific views. Evidence for a domain-specific view of the P600 was provided by studies that revealed a sensitivity of this ERP component to violations of syntactic constraints such as subcategorization, phrase structure or morphosyntactic anomalies (Friederici, et al., 1996; Hagoort, et al., 1993; Neville, et al., 1991; Osterhout, 1997; Osterhout & Hagoort, 1999). The occurrence of a P600 related to syntactic information processing was found to be independent of outright syntactic violations, as this ERP component was also elicited by syntactic ambiguity and complexity (Friederici, et al., 2002; Kaan, et al., 2000). As this ERP component appeared to be sensitive to various aspects of syntactic information processing, its function has been associated with structural repair and reanalysis processes. This functional interpretation has been challenged by studies, which showed that the amplitude of the P600 was also modulated by various non-syntactic anomalies. As described in detail in chapter 2, the observation of a P600 effect in response to manipulations of probability of stimulus occurrence or semantic expectancy led to a rather domain-general interpretation of this ERP component (Coulson, et al., 1998b; Gunter, et al., 2000; Gunter, et al., 1997; Martin-Loeches, Nigbur, Casado, Hohlfeld, & Sommer, 2006). While the results of Experiment 5 indi-

cate that the irony-related P600 was neither modulated by task demands nor by probability of occurrence, this component rather seems to be associated with the processing of pragmatic information. However, its functional significance regarding the relatedness to syntax-related P600 effects is still unclear. This issue is theoretically important in order to identify what kind of cognitive processes might be reflected in this ERP response, and whether they can be distinguished from structural processes reflected in the syntax-related P600 effects. One way to investigate the electrophysiological and thus functional relatedness of the various P600 effects is to combine two distinct experimental variables which have shown to reliably trigger such ERP effects. Therefore, in the current study both pragmatic and syntactic manipulations were applied as well as an additional manipulation consisting of a combination of both single manipulations. Employing such an experimental design enables a comparison of ERPs in response to the combined condition with those in response to the single pragmatic and syntactic conditions.

With regard to the electrophysiological characteristics of potential ERP effects the following predictions can be made. A P600 component should be replicated for ironic sentences relative to their literal equivalents as seen in the Experiments 1-5. Moreover, a P600 component is expected in response to syntactic anomalies as reported for agreement violations (Coulson, et al., 1998b; Hagoort, et al., 1993; Kaan, et al., 2000). For the combined condition the following ERP patterns are predicted according to Helmholtz's Law of Superposition[17]. If P600 effects elicited by the single pragmatic and the single syntactic manipulation resulted from different neural generators, than their topographic distribution on the scalp surface should differ. If the neural activity in response to the combined condition summates in the ERPs relative to those for the single conditions, again this would imply a functional distinction of the irony-related and syntax-related P600. In this case the amplitude of the P600 for the combined pragmatic and syntactic condition should reveal an additive effect. By contrast, a non-additive effect (i.e., supra- or super-additive effect) is expected for the combined condition, if the irony-related and syntax-related positivities were generated by the same (or at least partially overlapping) neural sources. If so, than the processing of both kinds of information would not be fully independent of each other, and might be driven by functionally similar cognitive processes.

[17] In transferring Helmholtz's Law of Superposition to the ERP methodology the neural activity reflected in the ERP responses can be expected to summate if different neural generators contributed to their occurrence.

7.2.2 Participants

Forty students (20 female, mean age 25.1 years (SD 2.19)) from the University of Leipzig participated in the experiment and received 14 Euro for their participation. All were right handed, native speakers of German with normal or corrected-to-normal vision.

7.2.3 Methods

7.2.3.1 Stimulus material and procedure

The experimental items were the same as used in Experiment 5, and consisted of 120 sentences. In order to induce a syntactic anomaly, an additional syntactic manipulation at the target sentence final word was included. Critical words of ironic and non-ironic sentences were syntactically violated that led to four experimental conditions (see Table 7.1). About all target sentences were predicative sentences that consisted of complex predicates (i.e., a copula verb followed by an uninflected predicative noun or adjective phrase). For the syntactic anomaly, an agreement violation was induced between the nominative noun phrase (i.e., subject) and its predicative completion (i.e., verb). The syntactic anomaly consisted either of number or case disagreements that were realized by inflection (i.e., plural or oblique case marking) on the predicative noun or adjective phrases, e.g., **Das ist ja großartigen*. Consequently, target sentence final word included either single manipulations of *Syntax* or *Context*, or a combined manipulation of both factors.

Table 7.1. The four experimental conditions as applied in Experiment 6.

	Syntax	
Context	***correct***	**incorrect**
ironic	ironic correct	*ironic incorrect*
non-ironic	*non-ironic correct*	*non-ironic incorrect*

The 120 experimental sentences were pseudo-randomized and divided into four versions containing 60 ironic and 60 non-ironic discourses each. Again it was ensured that each target sentence meaning only occurred once in each version. The versions contained all four stimulus types to an equal amount (i.e., 30 items each). Every participant received only one of the versions. The experimental manipulations *Context* (ironic /non-ironic) and *Syntax* (correct/incorrect) were fully crossed.

The experimental procedure was comparable to Experiment 2. After reading discourse contexts participants need to respond to a comprehension question (i.e., the comprehension task) that had to be replied with a yes or no response.

7.2.3.2 Data acquisition and analysis

The data acquisition and analysis of the EEG was identical to all previous experiments. In the statistical analyses the within-subject factors Context (2) and Syntax (2) were used. In total, about 8% of all trials were rejected from the analysis.

7.2.4 Results

Behavioral data. The mean accuracy rate was 96.9% (SD 1.83) indicating that participants performed excellent and carefully attended the stimuli. A marginally significant effect of Context ($F(1,39)=3.28$, $p<0.08$) was found, which shows that participants made slightly more errors (i.e., about 1%) for non-ironic discourses (mean accuracy rate 96.4% (SD 2.50)) compared to ironic ones (mean accuracy rate 97.3% (SD 2.38)). No further effects or interactions were seen ($F(1,39)<1.66$, n.s.).

Electrophysiological data. Grand average ERPs at the sentence final word are shown in the Figures 7.5, 7.6 and 7.7. As observed in previous experiments, a late positivity occurred for ironic compared to literal sentences, and which resembled a P600 component (see Figure 7.5). An additional P200 component seemed to be elicited by ironic sentences, while an irony-related N400 component was not present. In response to syntactically anomalous sentences an enhanced anterior negativity peaking around 400 ms followed by a late positivity was evoked (Figure 7.6). When comparing the late positivities for ironic sentences and syntactically anomalous sentences, they seemed to differ in morphology as well as scalp distribution. While the late positivity in response to the syntactic anomaly condition displayed a widespread scalp distribution, the P600 evoked by irony showed an amplitude maximum on frontocentral and centroparietal electrode positions. For the combined condition a similar late positivity emerged as for the syntactic anomaly condition suggesting that a non-additive effect was present.

In the **200-300 ms** latency range, the statistical analysis showed a two-way interaction between Context and ROI ($F(6,34)=2.66$, $p<0.03$). Follow-up analyses for all ROIs separately revealed significant effects of Context in the most central ROIs, i.e., R3, R4 and R5 ($F(1,39)=4.32$-6.07, $p<0.04$). The analyses confirm that in response to irony a P200 effect was evoked, which was distributed on central electrode positions.

In the latency window of **300-500 ms**, a significant effect of Syntax ($F(1,39)=6.22$, $p<0.02$) as well as a three-way interaction between Syntax, Anterior/Posterior and ROI ($F(6,34)=3.26$, $p<0.01$) were obtained. Resolving this interaction by Anterior/Posterior revealed a main effect of Syntax ($F(1,39)=6.83$, $p<0.01$) and a two-way interaction of

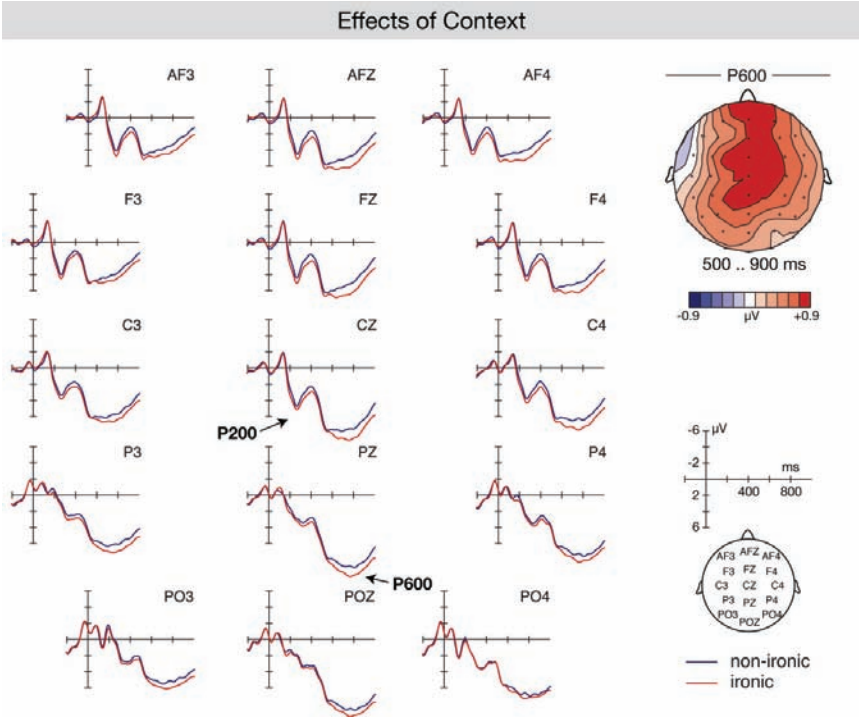

Figure 7.5. Grand average ERPs elicited by sentence final words that pointed to a non-ironic sentence meaning (blue line), or an ironic meaning (red line) with respect to the foregoing discourse context. The topographic map on the right displays the scalp distribution of the P600 component.

Syntax with ROI ($F(1,39)=6.92$, $p<0.001$) for anterior sites only. Separate analyses for the anterior ROIs showed main effects of Syntax on the most central and right anterior ROIs, i.e., A3-A6 ($F(1,39)=4.70$-13.18, $p<0.04$). The analyses substantiate the fronto-centrally distributed negativity observed for syntactic anomalous sentences. In this latency range, another three-way interaction between Context with Syntax and Anterior/Posterior ($F(1,39)=6.34$, $p<0.02$) was significant. This interaction was resolved by Syntax and revealed a marginally significant interaction between Context and Anterior/Posterior for syntactic anomalous sentences ($F(1,39)=3.77$, $p<0.06$). Follow-up analyses for anterior and posterior sites showed a marginally significant effect of analyses for anterior and posterior sites showed a marginally significant effect of Context on anterior sites only ($F(1,39)=3.24$, $p<0.08$). This finding demonstrates that the observed anterior negativity for the syntactic anomaly was slightly more prominent for literal sentences than ironic sentences.

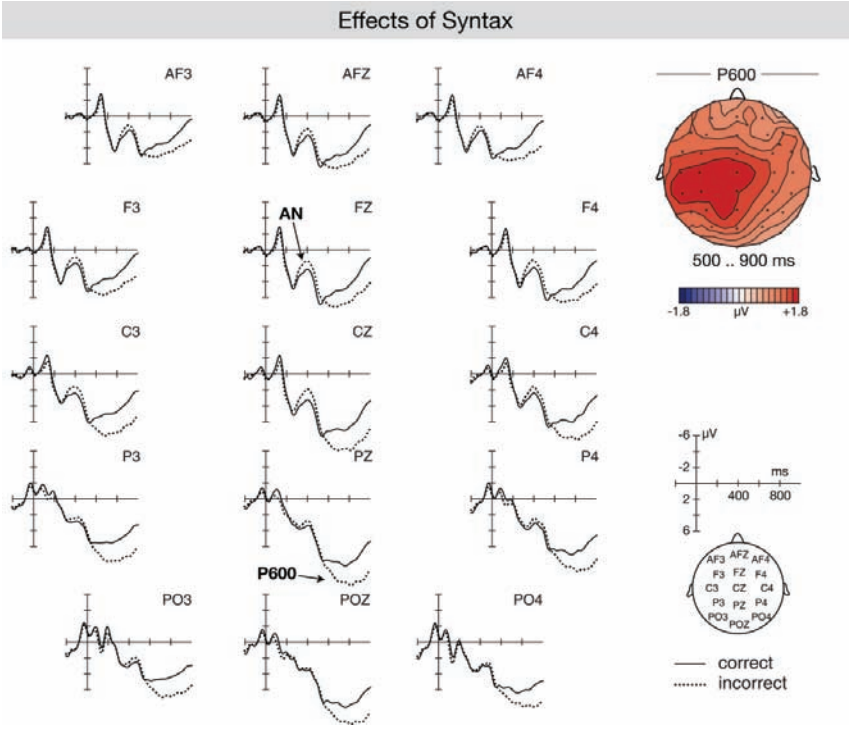

Figure 7.6. Grand average ERPs elicited by sentence final words for syntactically correct sentences (solid line) and syntactically incorrect sentences (dotted line). The topographic map of the scalp distribution of the syntax-related P600 effect is illustrated on the right column.

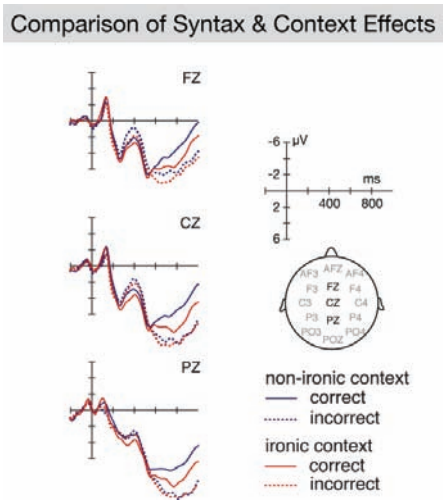

Figure 7.7. Grand average ERPs to critical words of ironic (red line) and non-ironic sentences (blue line) that were syntactically correct (solid line) or incorrect (dotted line).

The statistical analysis of the **500-900 ms** latency window showed a main effect of Syntax ($F(1,39)=25.14$, $p<0.0001$), and a marginally significant effect of Context ($F(1,39)=3.40$, $p<0.07$). A significant three-way interaction between Context, Syntax and Anterior/Posterior ($F(1,39)=4.34$, $p<0.04$) was also revealed, which implies differences in scalp distribution and morphology between the irony- and syntax-related positivity effects. In separate analyses for syntactically correct and incorrect sentences, a main effect of Context ($F(1,39)=4.50$, $p<0.04$) was obtained for syntactically correct sentences but not for incorrect ones ($F(1,39)=0.40$, n.s.). This finding indicates that the syntax-related positivity was not influenced by sentence type, and thus was independent of figurativity of sentences. Besides, the overall analysis also revealed a two-way interactions that were significant between Context and ROI ($F(6,34)=3.59$, $p<0.01$), and marginally significant between Syntax and ROI ($F(6,34)=2.22$, $p<0.06$) substantiate topographic differences of both late positive ERP effects. In separate analyses for each ROI, main effects of Context were found in the most central and right-lateral ROIs, i.e., R3, R4, R5 and R6 ($F(1,39)=3.95$-7.40, $p<0.05$), whereas effects of Syntax were significant in all ROIs ($F(1,39)=16.28$-34.82, $p<0.0002$). The analyses confirm that both late positivities related to irony and syntax displayed differences in scalp distribution.

7.2.5 Discussion

In the present ERP experiment the functional significance of the irony-related late positivity was further investigated. Thereby the question was persecuted whether this late positivity may reflect similar comprehension processes as the syntax-related P600 component, or whether both positivities are reflections of rather distinct processes that are sensitive to pragmatic and syntactic information processing. ERPs in response to irony showed an increased P200 followed by a P600 component. In response to syntactically anomalous sentences ERPs revealed a biphasic pattern consisting of an anterior negativity that preceded a widespread late positivity in the P600 time window. Comparing the late positive shifts in response to ironic sentences and syntactically anomalous sentences ERPs revealed differences in scalp distribution of both effects in showing an interaction between the experimental factors Context, Syntax and Anterior/Posterior in the latency range of 500-900 ms. While the irony-related late positivity displayed an amplitude maximum on central electrode positions, the syntax-related late positivity was broadly distributed with an amplitude maximum on centroparietal electrode positions (see Figure 7.5 and 7.6). This distributional difference suggests a dissociation of P600 effects since different neural generators might have contributed to both effects. Distributional topography of both effects suggests that neural generators underlying the processing of irony and syntax overlapped merely to some part. This observation was

seemingly entangled regarding the ERPs for the combined condition. Syntactically anomalous sentences evoked comparable ERP responses irrespective of figurativity, i.e., whether sentences achieved an ironic or non-ironic meaning. The late positivity in response to the combined condition (containing both a pragmatic and syntactic manipulation) resembled the late positive shift for the single syntactic condition in showing similarities in amplitude size, morphology, latency and scalp distribution. In the following section the ERP data for the single and combined conditions are discussed with regard to implications for functional interpretations of the late positive ERP effects.

Additivity or non-additivity? Implications for the classification of the irony-related P600 component

Current findings revealed a late positivity for the combined condition that appeared to be foremost affected by the syntactic anomaly. This result would imply a non-additive effect (in particular a supra-additive effect) suggesting that the processing of pragmatic and syntactic information is somehow related. Though, this interpretation is not supported by the scalp distribution of the ERPs in response to the single conditions. The distributional difference between the late positivity for ironic sentences and syntactically anomalous sentences suggests that different neural generators were most likely involved in the emergence of both effects. Based on the assumption that evoked potentials distributed over different brain regions imply the involvement of distinct neurocognitive processes, findings suggest that the processing of both types of information seems to engage distinct functional processes. Whereas the syntax-related positivity displayed a widespread scalp distribution, the irony-related positivity was more restricted in its topography to central electrode positions. Thus, both positivities might have been driven by at least partially different neural generators contributing to the processing of pragmatic and syntactic information. However, this would imply that an additive effect on the ERPs for the combined condition within the P600 time window should have been occurred. Nevertheless such an effect was not seen. It might be possible that a non-additivity (in this case a supra-additive effect) was obtained due to a ceiling effect on the ERPs. The late positivity for the single syntactic condition possibly reached a maximum of brain activity that could not be further summate by ERPs in response to an additional pragmatic manipulation of the combined condition, and thus did not result in an additive effect. But most importantly, the observation of distributional difference suggests a dissociation of both late positivities as being rather specifically involved in the processing of different types of information. The current findings are in accordance with the suggestion that the P600 is not a unitary component but comprises diverse subcomponents (Friederici, et al., 2002; Friederici, et al., 2001). While differential late positivities have been observed in response to syntactically

complex and syntactically anomalous sentences, the late positivity seen for irony indicates that there seems to be another subcomponent reflecting aspects of conceptual-pragmatic information processing. With regard to the literature, this finding is in line with 'semantic P600' effects that have been reported for various kinds of semantic and pragmatic anomalies (see section 2.3.5 Table 2.1). For example, a P600 component was found in response to semantically incoherent continuations of a story character presented in larger discourse contexts (Nieuwland & Van Berkum, 2005). As the P600 has been interpreted as a reflection of late, more careful interpretation processes based on the detection of a semantic anomaly, it still remains open whether the irony-related P600 might reflect similar processes. On the one hand, ERP studies reporting 'semantic P600' effects often included animacy violations concerning thematic roles, which are distinct from the pragmatic complexity manipulation (ironic vs. non-ironic sentences) that has been applied in the experiments of this thesis. On the other hand, in the current study the irony-related late positivity displayed a more central scalp distribution that comprised frontocentral and centroparietal electrodes, and which is somewhat different from the parietal distribution of the P600 reported for semantically incoherent continuations (see Nieuwland & Van Berkum, 2005). Regarding the topographic distribution of the irony-related P600, this ERP component would rather resemble P600 effects obtained for syntactically complex or ambiguous sentences (Friederici, et al., 2002; Kaan & Swaab, 2003). This latter P600 effects displayed a more frontocentral scalp distribution as this was also seen for the processing of irony in the present as well as previous studies (cf. Experiment 2 and 4). A late positive ERP component in response to garden path sentences has been interpreted as a function of revision processes that involve reanalysis of the preferred syntactic structure (Friederici, et al., 2002). Moreover, in a study by Kaan and Swaab (2003) a frontal P600 was found for complex ambiguous sentence structures compared to grammatical unambiguous ones. Hence, the observed frontal positivity has been associated with ambiguity resolution, or an increase in discourse complexity. While ironic sentences were more complex than non-ironic sentences on a pragmatic level and not in sentence structure, functional similarities between the complexity-related and irony-related late positivity still remain speculative. As complexity-related positivities were modulated by syntactic information, and ambiguity in sentence structure occurred locally, the observed irony-related positivity seems to be a reflection of rather different subprocesses. In case of irony, an increase in sentence complexity occurred globally with respect to prior discourse contexts, and concerned pragmatic interpretation of implied utterance meanings. Therefore, correspondence of the irony-related positivity to the complexity-related P600 still needs to be investigated in more detail in order to identify potential common functional cha-

racteristics. The result of topographically different late ERP effects in response to pragmatic and syntactic manipulations rather provides further evidence for the observation that the P600 seems to include various subcomponents.

ERP effects in response to irony

The currently observed ERP pattern for ironic compared to literal sentences comprised an enhanced P200 followed by a late positivity, which replicates previous results seen for irony comprehension in the visual presentation modality (cf. Experiment 2, 4 and 5).

In the present study an enhanced P200 component with a central scalp distribution was observed in response to irony. This ERP effect suggests that initial comprehension processes for critical words of ironic sentences differed from those of literal sentences. As discourse contexts provided strong contextual support for respective sentence interpretations, it might be possible that this effect is a reflection of extended early semantic analysis processes. When encountering sentence final words that point to a figurative sentence interpretation, processing costs seem to be caused that possibly concern the analysis of lexical-semantic information of these words in the current context. As for critical words of ironic interpretations no lexical entries with contextually appropriate word meanings might be found in the mental lexicon, this might have resulted in an extensive semantic analysis starting already after 200 ms post-stimulus onset. Alternatively, one might argue that the P200 component preceding a late P600 effect in response to irony indicates the onset of a sustained positive effect. However, visual inspection of the waveforms suggests a dissociation of early and late ERP effects between 400-500 ms after stimulus presentation. The statistical analysis of the 300-500 ms time window confirmed this observation in showing no effects of Context, and thereby substantiates the biphasic ERP pattern consisting of a P200 component followed by a late positivity in response to irony.

The late positivity resembled a P600 observed in previous studies (cf. Experiment 2, 4, and 5), and appeared to be strongly related to aspects of pragmatic information processing. On the one hand, the amplitude of this late positive ERP component was neither modulated by requirements of the comprehension task, nor by probability of stimulus occurrence (see Experiment 5). On the other hand, a distributional difference was seen in comparison of the irony-related and syntax-related late positivity, which implies that both effects reflect at least partially distinct comprehension processes. These findings indicate that the irony-related P600 can be considered as reflection of sentence processing on the message-level. Comprehending irony has been assumed to involve making inferences about a speaker's communicative intent, as well as deriving an appropriate sentence interpretation (Grice, 1975). As ironic sentences were pragmatically more complex than their literal equivalents, it is likely that this effect may be

associated with pragmatic information processing involved in deriving implied sentence meanings as well as communicative intents conveyed by an ironic utterance.

ERP effects in response to syntactic anomalies

Syntactic agreement anomalies elicited a biphasic ERP pattern that consisted of an anterior negativity and a subsequent late positivity. This anterior negativity was seen in the in latency window of 300-500 ms, and was bilaterally distributed. The amplitude of this negative ERP response was slightly more enhanced for the single syntactic condition than the combined condition. Since for ironic sentences a P200 component occurred, this earlier effect might have overlapped with a subsequent processing phase, and possibly caused an attenuation of the syntax-related negativity in the combined condition. This ERP pattern of an anterior negativity followed by a late positivity is comparable to the ERP responses reported for syntactic anomalies such as violations of subject-verb agreement or verb-argument structure (Friederici, et al., 1996; Gunter, et al., 1997; Kutas & Hillyard, 1983). LAN components in response to (morpho)syntactically anomalous sentences often showed a left lateralized scalp distribution, but also revealed a bilateral scalp distribution (Hagoort, et al., 2003; Münte, Matzke, & Johannes, 1997; Silva-Pereyra & Carreiras, 2007). The anterior negativity observed in the present study showed some resemblance to LAN effects seen for subject-verb disagreements (Osterhout & Mobley, 1995; Penke, et al., 1997). In the current experiment an agreement error was induced between the subject and verb by inflecting the predicative completion at the target sentence final word. As predicative completions are normally uninflected, such inflectional marking caused a disagreement in number or case between the subject and verb. Therefore, the observed anterior negativity in response to syntactically anomalous sentences seems to be in accordance with LAN effects of former ERP studies. As the LAN has been associated with the analysis and detection of syntactic errors (Friederici, 1995; Friederici, et al., 1996), the current effect might be a function of the detection of an inflectional error at the sentence final word.

In addition to the anterior negativity, a late positivity was elicited by syntactically anomalous sentences. This late positive ERP response occurred in the latency range of 500-900 ms, and had a widespread topographic distribution. Regarding its latency, morphology and sensitivity this positivity shows close resemblance to syntax-related P600 effects. Such late positivities have been reported for various kinds of syntactic violations, can be related to repair processes (Friederici, et al., 1993; Neville, et al., 1991). Following an anterior negativity this late positivity might be a reflection of syntactic repair processes of the anomalous sentence structure. After detecting an agreement anomaly, this late ERP response seems to reflect processing costs of constructing a coherent syntactic structure of the sentence. Although the late positivity is

most likely a reflection of repair processes, its large amplitude size and widespread scalp distribution differs somewhat from typical syntax-related P600 effects. Yet, such large late positivities have sometimes been reported for number violations concerning subject-verb agreement as in sentences like *The elected officials hopes to succeed* (Osterhout & Mobley, 1995). While in the present study subject-verb disagreements have been applied to predicative sentences, this possibly set up an outright syntactic anomaly since solely uninflected adjective or noun phrases were allowed as predicative completions. After the copula verb was encountered uninflected sentence completions might be expected, so that an inflectional error at the sentence final position might have profoundly disrupted sentence processing.

7.3 Conclusion

The purpose of the present experiments was to further specify P600 effects observed for the processing of irony. Experiment 5 aimed at the evaluation of an impact of task requirements as well as probability of stimulus occurrence on comprehension processes involved in comprehending irony. Experiment 6 was constructed to compare the irony-related P600 with the syntax-related P600 in order to examine underlying cognitive processes reflected in these ERP components.

Findings of Experiment 5 revealed that neither the comprehension task, nor the lower probability of occurrence of irony modulated the amplitude of the P600. Thus, potential influences of the experimental parameters on the occurrence of this ERP effect could be excluded. Moreover, the results imply that the P600 component in response to irony seems to be sensitive to processing aspects of pragmatic information. Hence, the observation that the irony-related P600 appears to be rather domain-specific than domain-general component was further substantiated by the results of Experiment 6. Therein, the P600 elicited by irony displayed a differential topographic distribution than the P600 evoked by sentences that contained a syntactic agreement anomaly. The current ERP data suggest that both late positivities are functions of at least partially distinct cognitive processes. While the irony-related P600 seems to be a reflection of aspects of pragmatic information processing, the syntax-related P600 appeared to be sensitive to repair processes due to an outright violation of syntactic constraints. By implication, the findings are in accordance with domain-specific interpretations of P600 effects.

Chapter 8

General discussion

This dissertation explored the comprehension of verbal irony, and in this context the processing of pragmatic aspects of language. This research question arose from an ongoing debate in the literature whether figurative and literal language comprehension involves similar or different processing mechanisms, and whether specific comprehension processes differ during initial or late phases of processing. Comprehending figurative language requires interpreting sentences beyond semantic and syntactic information, as well as constructing speaker-intended meanings by incorporating pragmatic knowledge about language use and common world knowledge. This highly complex process has been assumed to require grasping incongruency between what has been stated literally, and what has been meant figuratively by an ironic comment (Grice, 1975, 1989; Schwoebel, et al., 2000). According to the *standard pragmatic model* transferred from the work of Grice (1975, 1989) the literal meaning of an ironic sentence is activated initially before a contextually appropriate meaning (i.e., an ironic meaning) can be derived. Hence, ironic and literal sentences are assumed to involve qualitatively different comprehension processes. In contrast, the *direct access view* (Gibbs, 1994, 2002) assumes similar processing mechanisms for both figurative and literal language comprehension by assigning a prevailing influence to contextual information. In case rich contextual information is available that constrains respective interpretations this can lead to a direct access of intended ironic meanings. A parallel account, the *graded salience hypothesis*, has been proposed by Giora (1997, 1999) in which priority is ascribed to the salience of sentence meanings. Following this model, salient meanings are processed initially regardless of sentence literality or contextual fit. In case a sentence meaning is non-salient, additional inferential processes are assumed for computing the intended figurative meanings.

Most ERP studies on figurative language comprehension focused on the processing of metaphors and proverbs (Ferretti, et al., 2007; Pynte, et al., 1996; Tartter, et al., 2002), or the understanding of jokes (Coulson & Kutas, 2001). Until now the processing of irony has mainly been addressed by behavioral studies that reported conflicting findings in favor of the diverse psycholinguistic models on figurative language com-

prehension. Moreover, the influence of varying contextual constraints by using language-accompanying cues regarding figurative language processing has not been examined thus far. The studies of this thesis aimed to shed light on these two issues. Investigating the comprehension of irony had the purpose to test the predictions of three psycholinguistic models, and to present electrophysiological evidence on aspects of pragmatic information processing.

Figurative language processing in case of irony was examined by means of ERP methodology, which is a time sensitive measurement within the range of milliseconds and allows a differentiation between underlying comprehension processes. One of the most frequent forms of verbal irony, namely ironic statements, was chosen as experimental manipulation. Two types of sentences (literal vs. ironic) were embedded in discourse contexts to which they expressed a speaker's attitude, and achieved either an ironic or literal meaning. As ironic sentences conveyed different meanings than literally stated including concealed speakers' attitudes, such sentences were pragmatically more complex than literal sentences. Experimental sentences were constructed in such way that the target sentence final word was critical for respective sentence interpretations. At this position of the sentence an N400 component would have been expected, if critical words of ironic sentences caused semantic integration difficulties. Besides, Experiments 1–4 addressed the influence of different kinds of language-accompanying cues that further constrained ironic interpretations, i.e., prosody, quotation marks and pragmatic knowledge about speakers' communicative style, on irony comprehension. Experiments 5 and 6 were carried out to further specify irony-related ERP effects obtained in these earlier studies.

In **Experiment 1**, participants listened to ironic and literal sentences that contained differential prosodic patterns. Sentence prosody was either congruent or incongruent with ironic interpretations, just as with literal interpretations of the same sentence. ERP data at the target sentence final word revealed a sustained left anterior negativity (i.e., sustained LAN) starting around 200 ms post-stimulus onset that was followed by an increased P600 component in response to ironic sentences. The results were interpreted as evidence for an engagement of distinct processing mechanisms involved in comprehending irony relative to literal language. An irony-related N400 component was not seen suggesting that semantic integration difficulties were not present. While at this sentence position an effect of Prosody was absent, such an effect was observed at target sentence beginning where ironic prosody elicited an N100 component and a later negativity. From this finding it was concluded that differences in prosodic features were perceived, even though prosodic information did not affect the processing of critical words when respective sentence interpretations became clear. It might be possible that

prosody was a less constraining cue at sentence offset since there seems to exist some variability between prosodic features accompanying irony (see Anolli, et al., 2000; Rockwell, 2000, 2007).

Whereas in Experiment 1 ERP effects were obtained for the auditory modality, **Experiment 2** explored whether the biphasic pattern consisting of a sustained LAN followed by a P600 could be replicated in the visual domain. Another aim persecuted was to examine whether more explicit cueing by punctuation marks would affect irony comprehension. The same experimental sentences were presented whereby prosodic information was replaced by visual cues in the form of quotation marks. Note that cueing information was not available before target sentence final words, and that it had been induced to both ironic and literal sentences. The ERP pattern seen in Experiment 1 could be partly replicated regarding late occurring ERP effects. In the visual domain an increase of the P600 amplitude in response to irony was consistently observed, while a sustained LAN could not be replicated. Instead an increased P200 was elicited by ironic compared to equivalent literal sentences. As for the auditory modality, an irony-related N400 effect was not present indicating that semantic information processing seemed to be unaffected by figurativity. Moreover, an interaction between Quotations and Context was not found in any latency window. This suggests that participants did not rely on cueing by quotation marks in perceiving and interpreting sentence meanings. As ironic and literal interpretations were both cued by quotation marks, these cues might have been less informative in their functional meaning. In order to further investigate effects of cueing by punctuation **Experiment 3** was carried out. Therein, along with literal sentences, cued and uncued irony was presented in different blocks. Whereas in the first block no additional cues were applied to irony, in the second block ironic sentences were put into quotation marks so that respective sentence interpretations were explicitly signaled. Within the latency range of 500-900 ms ERPs for uncued irony revealed a left anterior negativity and a P600 component compared to equivalent literal sentences. Any earlier effects were not seen. ERPs for cued irony within the second block showed a sustained positivity with a widespread scalp distribution that had its onset around 200 ms post-stimulus. The results suggest that the presence of additional cues had an immediate impact on the processing of irony. Explicit cueing by quotation marks seemed to facilitate the detection of irony, and might have initiated more profound interpretation including the computation of pragmatic aspects of sentence meaning.

In **Experiment 4**, the comprehension of irony was further examined with regard to the influence of pragmatic knowledge about a speaker's use of irony. Frequent occurrence of certain utterance types by a familiar speaker possibly gives some hints about potential interpretations of his or her utterances. This issue was addressed by introduc-

ing two speakers whose communicative styles varied in terms of replying more often ironically or literally, so that these speakers appeared as either high ironic or low ironic. The experiment consisted of two sessions whereby within the first session the frequency of speakers' ironic and non-ironic sentences was clearly imbalanced (i.e., the high ironic speaker uttered 70% of all ironic sentences, and the low ironic speaker only 30% of it). This manipulation was induced in order to set up particular pragmatic knowledge about speakers. The imbalance was adjusted within the second session, in which both speakers made equally often ironic and literal utterances. This session aimed to explore in how far pragmatic knowledge acquired shortly before is used as a cue for the perception and interpretation of someone's remarks. ERPs of Session 1 revealed an enhanced P600 component for the low ironic speaker in replying ironically than literally. For the high ironic speaker no differences in ERPs were found when making an ironic or literal comment. Moreover, within the 200-300 time window an interaction between Speaker and Context was found indicating that a speaker's communicative style had an impact on initial processing of ironic and literal interpretations. ERPs of Session 2 showed an increase of the P600 amplitude for ironic sentences by the high ironic speaker. A comparable effect was not seen for the low ironic speaker. Within an earlier time window of 200-300 ms a larger P200 was observed when respective sentence types were compatible with a speaker's communicative style, i.e., for the high ironic speaker replying ironically, and the low ironic speaker replying literally. The observed ERPs imply that pragmatic knowledge has been established as reliable cue, and was able to influence initial as well as later processing of irony.

In all studies conducted thus far an enhanced P600 reliably emerged in response to irony in absence of an N400 effect. This ERP pattern was seen across modalities as well as in presence and absence of additional cueing that further constrained ironic interpretations. Still, the question remained in how far this P600 resulted from applied experimental parameters such as task requirements or probability of occurrence. **Experiment 5** aimed to clarify whether the obtained P600 was in fact related to the processing of irony, or whether it was rather driven by requirements of the comprehension task used in the experiments. In addition, it was also explored if some kind of strategic processing could have been occurred due to the relatively high probability of irony occurrence (i.e., 50% of the trials). In this study a block design consisting of two experimental blocks was employed. In the first block participants were asked to read the discourses carefully, while in the second block participants had to respond to a comprehension question concerning discourse contents as applied in the previous studies. Comparison of the ERPs for both blocks allowed to control for potential task effects. To examine whether strategic processing was present, filler discourses were enclosed that impeded

anticipation of ironic sentences on the basis of prior contextual information. ERPs for both blocks showed P600 effects in response to ironic sentences irrespective of task demands. A P200 component was also elicited for ironic relative to literal sentences. In addition, a conjoined comparison of the currently obtained P600 effect to previous findings revealed that the probability variation in occurrence of irony did not affect the amplitude of this late positivity. The findings therefore suggest that the P600 related to irony was neither driven by task requirements nor by strategic processing. Even if an impact of experimental parameters on the emergence of the P600 could be excluded, the functional interpretation of this ERP effect remained speculative to some extents. Therefore, **Experiment 6** was constructed to gain further insights into the sensitivity of this late occurring ERP component seen for irony. As P600 effects are predominantly associated with aspects of syntactic information processing, this study examined whether similar cognitive processes might be reflected in the irony-related P600 component. An additional syntactic manipulation (i.e., subject-verb agreement violation) was adopted to target sentence final words that led to syntactically correct and incorrect sentences. This paradigm included a combined condition (i.e., syntactically incorrect ironic sentences) in order to test whether an additive effect occurred on the P600 amplitude. If the irony-related and syntax-related positivity would be driven by different neural generators both effects should be additive, or alternatively display a differential topographic distribution on the scalp. ERPs in response to irony revealed an increased P200 preceding a P600 component with a central amplitude maximum. ERPs for syntactically incorrect sentences demonstrated a biphasic ERP pattern consisting of a bilaterally distributed anterior negativity followed by a widespread late positivity (i.e., syntax-related P600). The observation of an interaction between the factors Context, Syntax and Anterior/Posterior in the P600 latency range indicated that these positivities seen for irony and syntactically anomalous sentences differed in scalp distribution. This finding suggests that at least partially different neural generators contributed to the irony-related and syntax-related P600, and that both ERP responses seem to reflect functionally distinct processes. In the following paragraphs, all experimental findings are interpreted with respect to implications for the above mentioned psycholinguistic models of figurative language comprehension, as well as for the necessity of additional cueing in expressing irony.

8.1 Implications for psycholinguistic models of figurative language comprehension

According to the *standard pragmatic model* (Grice, 1975) the processing of figurative and literal language has been proposed to involve similar processing mechanisms with regard to initial processing of lexical information but not so during later processing of semantic-pragmatic information. In view of the *graded salience hypothesis* (Giora, 1997, 1999), involved processing mechanisms primarily rely on salience of meaning, and may not diverge if literal and figurative meanings are similar in salience. Moreover, for non-salient figurative meanings inferential processes are assumed during late phases of processing. ERPs for ironic sentences compared to equivalent literal sentences diverged during both initial phases as well as late phases of processing. The main results obtained in the Experiments 1, 2 and 5 are outlined in Table 8.1. Ironic sentences elicited early ERP effects (i.e., P200 component in the visual modality and an early starting sustained LAN in the acoustic modality) followed by a P600 effect. This positivity was identified as P600 component since it had a latency onset of around 500 ms after stimulus presentation, and appeared to be insensitive to variations in probability of stimulus occurrence as well as task demands. In addition, this positivity displayed most robustly a centroparietal scalp distribution, though its distribution extended to fronto-central sites dependent on presentation modality. Thus, findings of early ERP effects followed by a P600 component clearly showed divergence in processing mechanisms for ironic and literal sentences. Most importantly, this divergence has not been found for processing of lexical-semantic information located between 300-500 ms as an irony-related N400 effect was not seen in any of the experiments. This suggests that semantic integration of critical words into sentences achieving an ironic interpretation was not more difficult than for equivalent literal interpretations. Note that semantic-pragmatic expectancy of both sentence types was comparable to each other.

Table 8.1. Summary of the main findings obtained in the Experiments 1, 2 and 5.

Experiment	ERPs in response to irony	
Experiment 1 (auditory processing: prosody)	sustained LAN	P600
Experiment 2 (visual processing: quotations)	P200	P600
Experiment 5 (task demands & probability variation)	P200	P600

The absence of an N400 component provides evidence that ironic interpretations were not contextually incompatible, even though they relied on a contrast between what has been said and meant. As processing of semantic information appears to be specifi-

cally linguistic, the truth value of figurative sentences seemed to be not decisive for integrating sentence final word with prior contextual information. N400 effects were seen for sentence interpretations that were semantically anomalous with global discourse contexts (Van Berkum, Zwitserlood, et al., 2003), as well as for metaphors and idioms (Coulson & Van Petten, 2002; Laurent, et al., 2006). Compared to other types of figurative language the processing of irony seemed to differ from that reported for metaphors or idioms. Comprehending intended ironic meanings was shown to cause processing costs during late phases of processing indicated by P600 but not during processing of semantic information. The P600 in response to irony has been interpreted as reflection of rather controlled processes engaged in pragmatic interpretation. Following from Grice (1975) additional processing has been proposed for deriving figurative meanings, that involves later semantic-conceptual revision of literal meanings and understanding of speakers' beliefs and intentions. This process appeared to be not specifically linguistic in nature as modulations of the P600 were found due to the presence of paraverbal cues accompanying irony (see Experiment 3 and 4). This implies that contextual information as well as pragmatic information about speakers has been implemented in processing sentence meanings. Appropriate interpretation of irony seems to require suppression of some aspects of the literal meaning of ironic utterances, and computation of further non-lexicalized aspects of meaning in taking previous contextual information and speakers' communicative intents into account. As ironic sentence meanings were pragmatically more complex in expressing different and in many cases novel meanings, it is most likely that appropriate sentence meanings need to be derived with regard to contextual information and common world knowledge. The observed ERP data provide support for the view that comprehending figurative language is more effortful in terms of processing pragmatic information. However, the ERP data do not confirm the view of an initially context-independent processing leading to a semantic incongruency. With respect to the psycholinguistic models the current findings are partly in accordance with the assumptions of the *standard pragmatic model* (Grice, 1975) and the *graded salience hypothesis* (Giora, 1997, 1999), but not with those of the *direct access view* (Gibbs, 1994, 2002).

The finding of increased processing costs related to pragmatic interpretation supports to some extent the predictions of the ***standard pragmatic model*** (Grice, 1975). Contextual information has been assumed to affect later phases of processing after activation of literal meanings of figurative sentences. Figurative language comprehension is assumed to require additional inferential processes (i.e., conversational implicature) that enable the construction of contextually appropriate meanings as they were intended by a speaker. However, Grice (1975) suggests that this process is initiated

after an incompatibility has been detected in integrating the literal sentence meaning into wider discourse context. As such processing difficulty should have resulted in an increased amplitude of the N400 in response to irony, the findings of the present experiments do not provide evidence for more demanding processing during semantic integration. This suggests that recognizing violation of truth condition seems to be no prerequisite for figurative language comprehension in case of irony. If ironic statements are supported by rich contextual information constraining potential sentence interpretations, the processing of implied figurative meanings merely involves processing costs reflecting pragmatic interpretation of ironic utterances. Moreover, ERPs showed an occurrence of early effects of Context (i.e., 200-300 ms post-stimulus presentation) on the amplitude of the P200 and sustained LAN, respectively. These results indicate that the processing of literal and figurative meanings diverged already during initial phases of processing, and do not accord with the predictions of the standard model of pragmatics. A larger amplitude of the P200 in response to irony might reflect an extended early lexical-semantic analysis of word meanings when embedded in discourse contexts that biased novel, figurative sentence interpretations. Similar P200 effects have been observed for processing of semantic relationships between word pairs (Coulson, et al., 2005; Landi & Perfetti, 2007), which indicates that this early positivity is sensitive to some aspects of lexical-semantic information processing. The findings suggest that distinct processing mechanisms were engaged during initial processing of irony. By implication, in order to explain the current data the *standard pragmatic model* needs to be adapted in terms of proposed lexical-semantic processes. Contextual information appeared to affect initial phases of processing, which suggests that analyzing word meanings of critical words of ironic sentences involved different processing mechanisms. While an extended semantic analysis seems to be required, integration of word meanings into global contexts appeared to be effortless. Note that the P200 effect was also modulated by pragmatic information, and in this context possibly reflects some kind of general mechanism such as implicit categorization (see section 6.5). As P200 effects were rarely reported for semantic or pragmatic manipulations, the functional significance of this ERP component cannot be conclusively determined yet, and needs further investigation.

With regard to the ***direct access view*** (Gibbs, 1994, 2002), the ERP data do not support the assumptions of similar processing mechanisms for figurative and literal language comprehension as made by this model. Differences in the ERPs at several points in time during figurative and literal language processing imply that even rich supportive contexts did not allow for direct comprehension of figurative meanings. Contextual information had an impact on initial processing phases in showing a P200

component for ironic relative to literal sentences in the visual domain. Additional processing appeared to be necessary for comprehending figurative meanings as indicated by the emergence of a P600 component in response to irony. Still, the predictions of this model can be confirmed with respect to nonappearance of an incompatibility phase indicated by the absence of an irony-related N400 component. The comprehension of irony does not seem to rely on the perception of a disparity between literal and figurative meanings. Moreover, as predicted by Gibbs (1994, 2002) contextual information immediately affected the processing of figurative language, but still implied that during initial processing of figurative meanings processing costs occurred compared to literal language. Apparently during later phases of processing additional pragmatic interpretation was involved in comprehending irony. As appropriate ironic meanings seemed to be derived by inferential processes, the assumptions of the *direct access view* cannot be proved.

As for the standard model of pragmatics, the predictions of the ***graded salience hypothesis*** (Giora, 1997, 1999) can be supported for late phases of processing but not for initial phases. Ironic instances applied in the experiments consisted of non-salient meanings, which have been distinguished from salient ones in prototypicality, frequency and familiarity (Giora, 1999). Non-salient meanings are usually not coded in the mental lexicon, so that most salient meanings were assumed to be activated before non-salient meanings. Accordingly, when encountering unconventional ironic sentences, their salient literal meanings are assumed to be accessed initially. In case activated literal meanings are incompatible with prior contextual information, extra inferential processes and strong contextual support are required. As it holds for the *standard pragmatic model*, the observation of P600 effects in response to irony supports the proposed involvement of additional comprehension processes compared to processing higher salient literal meanings. Processing costs might be associated with effortful pragmatic interpretation involving inferential processes for deriving non-salient figurative meanings. The observed early ERP effects in response to irony are still not compatible with assumptions of initially encapsulated lexical-semantic processes. Findings of an early starting sustained LAN and P200 effect related to irony show that on basis of contextual information initial processing of figurative meanings varied irrespective of salience.

To conclude, the present findings can be taken as evidence for an involvement of distinct processing mechanisms in figurative and literal language comprehension. As initially some aspects of the literal meaning of ironic sentences might be activated, additional processing seemed to be required for deriving implied ironic meanings. Apparently pragmatic interpretation may have involved inferences related to the com-

putation of implied meanings that are in accordance with foregoing discourse contexts. However, pragmatic interpretation was initiated without preceding detection of a semantic incongruency during integration of word meanings with prior contextual information.

8.2 The influence of cueing on the processing of irony

When making an ironic comment, the implied figurative meaning intended by the speaker is not explicitly stated but need to be constructed on the basis of pragmatic knowledge and common world knowledge. Beside the investigation of processing mechanisms underlying the comprehension of irony, a further question addressed in this thesis was in how far additional cues can facilitate the perception and interpretation of such implied figurative meanings. The comprehension of irony has been investigated with regard to the presence of additional cues provided on three processing levels (i.e., the word, sentence and discourse level). In Experiment 2 and 3, the target sentence final word was put in quotation marks that allowed cueing of ironic interpretations on the word level. Quotations were presented simultaneously with critical information for respective sentence interpretations. While in the visual modality such precise local cueing was possible, prosodic cues present in natural connected speech are suprasegmental (i.e., they are normally not confined to one speech segment), and are provided by certain prosodic realizations. For that reason, in the acoustic modality in Experiment 1 prosodic cues were available throughout the target sentence, and consisted of different prosodic patterns for ironic and literal interpretations. Relative to normal prosody, ironic sentences were characterized by variations in duration, pitch contour and intensity (see section 5.3.1.2). In addition, the influence of subtle pragmatic knowledge in cueing implied meanings was examined in Experiment 4. While this way of cueing was based on speakers' communicative style, pragmatic cues could be perceived already during discourse contexts by attendance of the two speakers within discourses. Main findings of cueing effects are summarized in Table 8.2.

Differences in the ERPs at target sentence onset confirmed that prosodic characteristics of ironic prosody have been perceived in showing an increase on the N100 component followed by a later negativity. The absence of an interaction between irony and prosody at this position of the sentence is not too surprising since semantic information about potential sentence interpretations is not available before sentence offset. Still, at sentence final position the influence of prosodic cues on the perception of irony was rather limited. There may be several explanations for this finding based on cueing characteristics as well as experimental parameters. As perceptual studies on sarcasm showed that different prosodic characteristics can accompany sarcastic utterances, this

Table 8.2. Summary of ERP effects in response to irony in presence of different types of language-accompanying cues.

Type of cueing	Interactions and effects between cues and irony	
Experiment 1 (prosody)	no interaction with prosody	
Experiment 2 (both sentence types with quotations)	no interaction with quotation marks	
Experiment 3 (uncued vs. cued irony by quotations)	uncued irony: sustained LAN & P600	cued irony: sustained positivity (from 200 ms on)
Experiment 4 (pragmatic knowledge)	Session 1 (70/30): early interaction & P600 (Context x Speaker x ROI)	Session 2 (50/50): P200 & P600

suggests that some variability exists in realizing sarcastic prosody (Anolli, et al., 2000; Rockwell, 2000, 2007). It might be possible that prosodic information was less informative for interpreting implied meanings compared to other constraining information. The fact that prosodic cues were already perceived at sentence onset could have caused a redundancy in information content. Moreover, it might be possible that prosodic realizations were less reliable in cueing as they were presented with both ironic and literal sentences. Further experiments that systematically vary prosodic features in their function of cueing certain interpretations may provide an answer on the efficiency of prosodic cues for comprehending irony.

Influences of cueing by punctuation marks in the form of quotations were observed in ERPs at target sentence offset. Similar to Experiment 1, only main effects of Quotations but not interactions with Context were obtained in applying a 2-by-2 experimental design in Experiment 2. As critical words of literal and ironic sentences were put in quotations, their functional meaning in cueing certain interpretations possibly appeared to be equivocal. In Experiment 3 this potential explanation was tested by a direct comparison of influences of cueing on irony comprehension. When using quotations in an unambiguous fashion they clearly affected the processing of irony from an initial stage on. In comparison to uncued irony, the processing of ironic sentence interpretations that were further constrained by the presence of quotations was facilitated in showing a sustained positivity starting around 200 ms post-stimulus presentation. This finding confirms that comprehending irony is influenced by the presence of additional cues when clearly perceivable and functionally univocal. Moreover, the way of cueing appeared to vary the effectiveness of language-accompanying cues since effects of cueing were only seen in Experiment 3 but not so in Experiment 2. If ironic sentences contained quotations perception and interpretation of implied ironic meanings seemed to be initiated earlier, and possibly included some kind of deeper processing. This interpretation is based on the observation of an early occurring large positivity for cued

irony in Experiment 3. Providing additional cues concurrently with critical information for potential interpretations might have forced the processing system into more extensive operations on lexical-semantic and pragmatic aspects of sentence meaning.

Besides, pragmatic knowledge about a speaker's communicative style in replying ironically or literally was shown to provide an additional cue for comprehending sentence meanings, as well as to set up reliable cues for potential sentence interpretations. This conclusion is based on the ERP data of Experiment 4 that consisted of two sessions between which speakers' use of irony was varied. If one speaker responded to a larger extent ironically than literally (i.e., in Session 1), his literal utterances were processed alike his ironic utterances and seemed to require further pragmatic interpretation. This conclusion is based on the absence of a P600 for ironic compared to literal sentences of the high ironic speaker. ERPs for the high ironic speaker in the P600 latency range were indistinguishable from an irony-related P600 effect seen for the low ironic speaker. Although subtle pragmatic cueing was provided implicitly and needed to be noticed by careful reading the discourses, this information has been rapidly established as reliable cue for perceiving and interpreting speakers' utterances. Despite changing speakers' characteristics in using irony, previously noticed pragmatic knowledge about speakers continued to affect the comprehension of their utterances (i.e., in Session 2). A P600 in response to ironic sentences was only seen when uttered by the speaker who appeared to be highly ironic during the first session. Most importantly, for the second session larger P200 amplitudes were observed when pragmatic knowledge was congruent with speakers' particular style of communicating (i.e., for the high ironic speaker saying something ironic, and for the low ironic speaker replying literally). Literal and figurative language comprehension was clearly affected by prior pragmatic knowledge leading to different comprehension processes for sentences of the high and low ironic speaker. An early occurring P200 effect might reflect some kind of implicit categorization based on prior cueing of two speakers' communicative behaviors. Subsequent processing of semantic and pragmatic information also diverged dependent on pragmatic knowledge. While ironic comments by the high ironic speaker elicited a P600 component, no comparable effect was seen for ironic sentences of the low ironic speaker. Thus, pragmatic interpretation of irony occurred to be influenced on whether a speaker was expected to reply ironically or not.

The findings imply that the presence of additional cues for perceiving and interpreting irony influenced neurocognitive processes underlying the comprehension of irony. Providing cues such as quotation marks or pragmatic knowledge had an impact on aspects of lexical-semantic as well as pragmatic information processing. However, participants only benefited from such additional information in case it was univocal in

its functional meaning and clearly constrained certain interpretations. The observed differences in the effectiveness of irony-accompanying cues seemed to result from variability in cue strength and cue type, as well as their occurrence on respective levels of language.

8.3 Concluding remarks

The present dissertation focused on the comprehension of irony with regard to pragmatic information processing. The findings obtained in a series of ERP experiments showed that comprehending irony requires additional processing, but still did not involve the recognition of a semantic incongruency in meaning. This work extends the existing literature, since it was shown that ERPs are more sensitive to specific difficulties in processing irony than behavioral measures. Moreover, evidence was provided that additional cueing either by quotation marks or subtle pragmatic information can facilitate figurative language comprehension.

As processing costs were observed during late phases of processing, the current findings are partly in accordance with the assumptions of the *standard pragmatic model* (Grice, 1975) as well as the *graded salience hypothesis* (Giora, 1997, 1999). In showing most reliably an enhanced P600 component for ironic sentences compared to equivalent literal sentences suggesting that pragmatic interpretation of implied ironic meanings was more effortful and seemed to involve further inferential processes for deriving contextually appropriate meanings. However, the observation of additional early ERP effects starting in the latency window of 200-300 ms suggests that contextual information already had an immediate influence on the initial processing of irony. As in none of the experiments evidence for difficulties in processing semantic information was found, it can be concluded that irony comprehension does not require the rejection of literal meanings but may rely on them for computing implied meanings.

Moreover, it was shown that figurative and literal language comprehension is influenced by additional cueing that constrained sentence interpretations. In particular, presenting irony with quotation marks that explicitly cued ironic interpretations revealed that this information was immediately taken into account for the perception, as well as later interpretation of implied ironic meanings. In addition, even subtle pragmatic information about a speaker's use of irony immediately affected not only the processing of irony but also of literal sentences. Such information once noticed appears to establish reliable cues for comprehending someone's utterances. Hence, the comprehension of speaker intended meanings seems to rely on an interplay between linguistic information and pragmatic knowledge.

References

Ahrens, K., Liu, H. L., Lee, C. Y., Gong, S. P., Fang, S. Y., & Hsu, Y. Y. (2007). Functional MRI of conventional and anomalous metaphors in Mandarin Chinese. *Brain and Language, 100*, 163-171.

Amante, D. J. (1981). The theory of ironic speech acts. *Poetics Today, 2*, 77-96.

Anderson, J. E., & Holcomb, P. J. (2005). An electrophysiological investigation of the effects of coreference on word repetition and synonymy. *Brain and Language, 94*, 200-216.

Angeleri, R., Bosco, F. M., Zettin, M., Sacco, K., Colle, L., & Bara, B. G. (2008). Communicative impairment in traumatic brain injury: A complete pragmatic assessment. *Brain and Language, In Press, Corrected Proof*.

Anolli, L., Ciceri, R., & Infantino, M. G. (2000). Irony as a game of implicitness: acoustic profiles of ironic communication. *Journal of Psycholinguistic Research, 29*, 275-311.

Arzouan, Y., Goldstein, A., & Faust, M. (2007). Brainwaves are stethoscopes: ERP correlates of novel metaphor comprehension. *Brain Research, 1160*, 69-81.

Attardo, S. (2000). Irony as relevant inappropriateness. *Journal of Pragmatics, 32*, 793-826.

Attardo, S., Eisterhold, J., Hay, J., & Poggi, I. (2003). Multimodal markers of irony and sarcasm. *International Journal of Humor Research, 2*, 243-260.

Azizian, A., Watson, T. D., Parvaz, M. A., & Squires, N. K. (2006). Time course of processes underlying picture and word evaluation: An event-related potential approach. *Brain Topography, 18*, 213-222.

Bara, B. G., Tirassa, M., & Zettin, M. (1997). Neuropragmatics: Neuropsychological constraints on formal theories of dialogue. *Brain and Language, 59*, 7-49.

Barbe, K. (1995). *Irony in context*. Amsterdam: John Benjamins.

Barlow, J. S. (1993). *The electroencephalogram: Its patterns and origins*. Cambridge, MA: MIT Press.

Besson, M., Kutas, M., & Van Petten, C. (1992). An event-related potential (ERP) analysis of semantic congruity and repetition effects. *Journal of Cognitive Neuroscience, 4*, 132-149.

Bibby, H., & McDonald, S. (2005). Theory of mind after traumatic brain injury. *Neuropsychologia, 43*, 99-114.

Birbaumer, N., & Schmidt, R. F. (2003). *Biologische Psychologie*. Berlin: Springer.

Blanchet, S., Gagnon, G., & Bastien, C. (2007). Event-related potential study of dynamic neural mechanisms of semantic organizational strategies in verbal learning. *Brain Research, 1170*, 59-70.

Blasko, D. G., & Connine, C. M. (1993). Effects of familiarity and aptness on metaphor processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 295-308.

Blasko, D. G., & Kazmerski, V. A. (2006). ERP correlates of individual differences in the comprehension of nonliteral language. *Metaphor and Symbol, 21*, 267-284.

Boddy, J., & Weinberg, H. (1981). Brain potentials, perceptual mechanisms and semantic categorisation. *Biological Psychology, 12*, 43-61.

Bookheimer, S. (2002). Functional MRI of language: New approaches to understanding the cortical organization of semantic processing. *Annual Review of Neuroscience, 25*, 151-188.

Bottini, G., Corcoran, R., Sterzi, R., Paulesu, E., Schenone, P., Scarpa, P., et al. (1994). The role of the right hemisphere in the interpretation of figurative aspects of language A positron emission tomography activation study. *Brain, 117*, 1241-1253.

Bouaffre, S., & Faita-Ainseba, F. (2007). Hemispheric differences in the time-course of semantic priming processes: Evidence from event-related potentials (ERPs). *Brain and Cognition, 63*, 123-135.

Bowdle, B. F., & Gentner, D. (2005). The career of metaphor. *Psychological Review, 112*, 193-216.

Brown, C. M., & Hagoort, P. (1993). The processing nature of the N400: Evidence from masked priming. *Journal of Cognitive Neuroscience*, 34-44.

Brownell, H. H. (1998). Appreciation of metaphoric and connotative word meaning by brain-damaged patients. In C. Chiarello (Ed.), *Right hemisphere contributions to lexical semantics* (pp. 19-31). Berlin: Springer.

Brownell, H. H., Simpson, T. L., Bihrle, A. M., Potter, H. H., & Gardener, H. (1990). Appreciation of metaphoric alternative word meanings by left and right brain-damaged patients. *Neuropsychologia, 28*, 375-383.

Channon, S., Pellijeff, A., & Rule, A. (2005). Social cognition after head injury: Sarcasm and theory of mind. *Brain and Language, 93*, 123-134.

Chwilla, D. J., Brown, C. M., & Hagoort, P. (1995). The N400 as a function of the level of processing. *Psychophysiology, 32*, 274-285.

Clark, H. H., & Gerrig, R. J. (1984). On the pretense theory of irony. *Journal of Experimental Psychology: General, 113*, 121-126.

Clyne, M. (1974). Einige Überlegungen zu einer Linguistik der Ironie. *Zeitschrift für Deutsche Philologie, 93*, 343-355.

Coles, M. G. H., & Rugg, M. D. (1997). Event-related brain potentials: An introduction. In M. D. Rugg & M. G. H. Coles (Eds.), *Electrophysiology of Mind: Event-related brain potentials and cognition* (pp. 1-39). New York: Oxford University Press.

Colston, H. L. (2002). Contrast and assimilation in verbal irony. *Journal of Pragmatics, 34*, 111-142.

Colston, H. L. (2005). Social and cultural influences on figurative and indirect language. In H. L. Colston & A. N. Katz (Eds.), *Figurative language comprehension: Social and cultural influences* (pp. 99-130). Mahwah: Lawrence Erlbaum Associates.

Colston, H. L., & O'Brien, J. (2000). Contrast and pragmatics in figurative language: Anything understatement can do, irony can do better. *Journal of Pragmatics, 32*, 1557-1583.

Cornejo, C., Simonetti, F., Aldunate, N., Ibanez, A., Lopez, V., & Melloni, L. (2007). Electrophysiological evidence of different interpretative strategies in irony comprehension. *Journal of Psycholinguistic Research, 36*, 411-430.

Coulson, S. (2001). *Semantic Leaps: Frame-shifting and conceptual blending in meaning construction*. New York: Cambridge University Press.

Coulson, S., Federmeier, K. D., Van Petten, C., & Kutas, M. (2005). Right Hemisphere Sensitivity to Word- and Sentence-Level Context: Evidence From Event-Related Brain Potentials. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 129-147.

Coulson, S., King, J. W., & Kutas, M. (1998a). ERPs and domain specificity: Beating a straw horse. *Language and Cognitive Processes, 13*, 653-672.

Coulson, S., King, J. W., & Kutas, M. (1998b). Expect the unexpected: Event-related brain response to morphosyntactic violations. *Language and Cognitive Processes, 13*, 21.

Coulson, S., & Kutas, M. (2001). Getting it: Human event-related brain response to jokes in good and poor comprehenders. *Neuroscience Letters, 316*, 71-74.

Coulson, S., & Lovett, C. (2004). Handedness, hemispheric asymmetries, and joke comprehension. *Cognitive Brain Research, 19*, 275-288.

Coulson, S., & Van Petten, C. (2002). Conceptual integration and metaphor: An event-related potential study. *Memory and Cognition, 30*, 958-968.

Coulson, S., & Van Petten, C. (2007). A special role for the right hemisphere in metaphor comprehension?: ERP evidence from hemifield presentation. *Brain Research, 1146*, 128-145.

Coulson, S., & Williams, R. F. (2005). Hemispheric asymmetries and joke comprehension. *Neuropsychologia, 43*, 128.

Coulson, S., & Wu, Y. C. (2005). Right hemisphere activation of joke-related information: An event-related brain potential study. *Journal of Cognitive Neuroscience, 17*, 494-506.

Courchesne, E., Hillyard, S. A., & Galambos, R. (1975). Stimulus novelty, task relevance and visual evoked-potential in man. *Electroencephalography and Clinical Neurophysiology, 39*, 131-143.

Crowley, K. E., & Colrain, I. M. (2004). A review of the evidence for P2 being an independent component process: age, sleep and modality. *Clinical Neurophysiology, 115*, 732-744.

Dambacher, M., Kliegl, R., Hofmann, M., & Jacobs, A. M. (2006). Frequency and predictability effects on event-related potentials during reading. *Brain Research, 1084*, 89-103.

Deutsch, A., & Bentin, S. (2001). Syntactic and semantic factors in processing gender agreement in Hebrew: Evidence from ERPs and eye movements. *Journal of Memory and Language, 45*, 200-224.

Dews, S., Kaplan, J., & Winner, E. (1995). Why not say it directly? The social functions of irony. *Discourse Processes, 19*, 347-367.

Dews, S., & Winner, E. (1999). Obligatory processing of literal and non-literal meanings in verbal irony. *Journal of Pragmatics, 31*, 1579-1599.

Donchin, E. (1981). Surprise...Surprise? *Psychophysiology, 18*, 493-513.

Donchin, E., & Coles, M. G. H. (1988). Is the P300 component a manifestation of context updating. *Behavioral and Brain Sciences, 11*, 357-374.

Dudenredaktion (2006). *Duden: Die deutsche Rechtschreibung*. Mannheim: Dudenverlag.

Dunn, B. R., Dunn, D. A., Languis, M., & Andrews, D. (1998). The relation of ERP components to complex memory processing. *Brain and Cognition, 36*, 355-376.

Eggs, E. (1979). Eine Form des 'uneigentlichen' Sprechens: Die Ironie. *Folia Linguistica, 13*, 413-435.

Ericsson, E., Olofsson, J. K., Nordin, S., Rudolfsson, T., & Sandstrom, G. (2008). Is the P600/SPS affected by the richness of semantic content? A linguistic ERP study in Swedish. *Scandinavian Journal of Psychology, 49*, 1-9.

Eviatar, Z., & Just, M. A. (2006). Brain correlates of discourse processing: An fMRI investigation of irony and conventional metaphor comprehension. *Neuropsychologia, 44*, 2348-2359.

Faust, M., & Chiarello, C. (1998). Sentence context and lexical ambiguity resolution by the two hemispheres. *Neuropsychologia, 36*, 827-835.

Federmeier, K. D., & Kutas, M. (1999). A rose by any other name: Long-term memory structure and sentence processing. *Journal of Memory and Language, 41*, 469-495.

Ferretti, T. R., Schwint, C. A., & Katz, A. N. (2007). Electrophysiological and behavioral measures of the influence of literal and figurative contextual constraints on proverb comprehension. *Brain and Language, 101*, 38-49.

Ferstl, E. C., Neumann, J., Bogler, C., & von Cramon, D. Y. (2008). The extended language network: A meta-analysis of neuroimaging studies on text comprehension. *Human Brain Mapping, 29*, 581-593.

Ferstl, E. C., Rinck, M., & von Cramon, Y. D. (2005). Emotional and temporal aspects of situation model processing during text comprehension: An event-related fMRI study. *Journal of Cognitive Neuroscience, 17*, 724-739.

Ferstl, E. C., & von Cramon, D. Y. (2001). The role of coherence and cohesion in text comprehension: an event-related fMRI study. *Cognitive Brain Research, 11*, 325-340.

Fischler, I., Bloom, P. A., Childers, D. G., Achariyapaopan, T., & Perry, N. W. (1983). Brain potentials related to stages of sentence verification. *Psychophysiology, 20*, 400-409.

Friederici, A. D. (1995). The time course of syntactic activation during language processing: A model based on neuropsychological and neurophysiological data. *Brain and Language, 50*, 259-281.

Friederici, A. D. (1999). The neurobiology of language comprehension. In A. D. Friederici (Ed.), *Language Comprehension: A biological perspective* (pp. 265-304). Heidelberg: Springer.

Friederici, A. D. (2002). Towards a neural basis of auditory sentence processing. *Trends in Cognitive Sciences, 6*, 78-84.

Friederici, A. D., & Frisch, S. (2000). Verb argument structure processing: The role of verb-specific and argument-specific information. *Journal of Memory and Language, 43*, 476-507.

Friederici, A. D., Gunter, T. C., Hahne, A., & Mauth, K. (2004). The relative timing of syntactic and semantic processes in sentence comprehension. *Neuroreport, 15*, 165-169.

Friederici, A. D., Hahne, A., & Mecklinger, A. (1996). Temporal structure of syntactic parsing: Early and late event-related brain potential effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 1219-1248.

Friederici, A. D., Hahne, A., & Saddy, D. (2002). Distinct neurophysiological patterns reflecting aspects of syntactic complexity and syntactic repair. *Journal of Psycholinguistic Research, 31*, 45-63.

Friederici, A. D., Mecklinger, A., Spencer, K. M., Steinhauer, K., & Donchin, E. (2001). Syntactic parsing preferences and their on-line revisions: a spatio-temporal analysis of event-related brain potentials. *Cognitive Brain Research, 11*, 305-323.

Friederici, A. D., & Meyer, M. (2004). The brain knows the difference: Two types of grammatical violations. *Brain Research, 1000*, 72-77.

Friederici, A. D., Pfeifer, E., & Hahne, A. (1993). Event-related brain potentials during natural speech processing: effects of semantic, morphological and syntactic violations. *Cognitive Brain Research, 1*, 183-192.

Friederici, A. D., Steinhauer, K., & Frisch, S. (1999). Lexical integration: Sequential effects of syntactic and semantic information. *Memory and Cognition, 27*, 438-453.

Friederici, A. D., Steinhauer, K., Mecklinger, A., & Meyer, M. (1998). Working memory constraints on syntactic ambiguity resolution as revealed by electrical brain responses. *Biological Psychology, 47*, 193-221.

Friederici, A. D., & Weissenborn, J. (2007). Mapping sentence form onto meaning: The syntax-semantic interface. *Brain Research, 1146*, 50-58.

Frisch, S., Kotz, S. A., von Cramon, D. Y., & Friederici, A. D. (2003). Why the P600 is not just a P300: the role of the basal ganglia. *Clinical Neurophysiology, 114*, 336-340.

Frisson, S., & Pickering, M. J. (1999). The processing of metonymy: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 1366-1383.

Frith, C. D., & Frith, U. (1999). Interacting minds - A biological basis. *Science, 286*, 1692-1695.

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society B: Biological Sciences, 358*, 459-473.

Gallagher, H., & Frith, C. D. (2003). Functional imaging of 'theory of mind'. *Trends in Cognitive Sciences, 7*, 77-83.

Gernsbacher, M. A., Keysar, B., Robertson, R. R. W., & Werner, N. K. (2001). The Role of Suppression and Enhancement in Understanding Metaphors. *Journal of Memory and Language, 45*, 433-450.

Gerrig, R. J., & Goldvarg, Y. (2000). Additive effects in the perception of sarcasm: Situational disparity and echoic mention. *Metaphor and Symbol, 15*, 197-208.

Gerrig, R. J., & Horton, W. S. (2005). Contextual expressions and common ground. In H. L. Colston & A. N. Katz (Eds.), *Figurative language comprehension: Social and cultural influences* (pp. 43-70). Mahwah: Lawrence Erlbaum Associates.

Geyer, A., Holcomb, P., Kuperberg, G. R., & Pearlmutter, N. J. (2006). Plausibility and sentence comprehension. An ERP study. *Journal of Cognitive Neuroscience, Supplement*, 226.

Gibbs, R. W. (1986). On the psycholinguistics of sarcasm. *Journal of Experimental Psychology: General, 115*, 3-15.

Gibbs, R. W. (1994). Figurative thought and figurative language. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 411-446). San Diego: Academic Press.

Gibbs, R. W. (1999a). Interpreting what speakers say and implicate. *Brain and Language, 68*, 466-485.

Gibbs, R. W. (1999b). Speakers' intuitions and pragmatic theory. *Cognition, 69*, 355-359.

Gibbs, R. W. (2001). Evaluating contemporary models of figurative language understanding. *Metaphor and Symbol, 16*, 317-333.

Gibbs, R. W. (2002). A new look at literal meaning in understanding what is said and implicated. *Journal of Pragmatics, 34*, 457-486.

Gibbs, R. W., & Moise, J. F. (1997). Pragmatics in understanding what is said. *Cognition, 62*, 51-74.

Gibbs, R. W., & O'Brien, J. (1991). Psychological aspects of irony understanding. *Journal of Pragmatics, 16*, 523-530.

Gibbs, R. W., O'Brien, J., & Doolittle, S. (1995). Inferring meanings that are not intended: Speaker's intentions and irony comprehension. *Discourse Processes, 20*, 187-203.

Giessmann, U. (1977). Ironie in sprachwissenschaftlicher Sicht. *Sprachwissenschaft, 2*, 411-421.

Giora, R. (1995). On irony and negation. *Discourse Processes, 19*, 239-264.

Giora, R. (1997). Understanding figurative and literal language: The graded salience hypothesis. *Cognitive Linguistics, 7*, 183-206.

Giora, R. (1999). On the priority of salient meanings: Studies of literal and figurative language. *Journal of Pragmatics, 31*, 919-929.

Giora, R. (2002). Literal versus figurative language: Different or equal? *Journal of Pragmatics, 34*, 487-506.

Giora, R. (2003). *On our mind: Salience, context, and figurative language*. New York: Oxford University Press.

Giora, R., & Fein, O. (1999a). Irony: Context and salience. *Metaphor and Symbol, 14*, 241-257.

Giora, R., & Fein, O. (1999b). On understanding familiar and less-familiar figurative language. *Journal of Pragmatics, 31*, 1601-1618.

Giora, R., Fein, O., Ganzi, J., Alkeslassy, L., & Sabah, H. (2005). On negation as mitigation: The case of negative irony. *Discourse Processes, 39*, 81-100.

Giora, R., Zaidel, E., Soroker, N., Batori, G., & Kasher, A. (2000). Differential effect of right- and left-hemisphere damage on understanding sarcasm and metaphor. *Metaphor and Symbolic Activity, 15*, 63-83.

Glucksberg, S. (1998). Understanding metaphors. *Current Directions in Psychological Science, 7*, 39-43.

Glucksberg, S. (2001). *Understanding figurative language: From metaphors to idioms*. Oxford: Oxford University Press.

Glucksberg, S. (2003). The psycholinguistics of metaphor. *Trends in Cognitive Sciences, 7*, 92-96.

Glucksberg, S., & Keysar, B. (1990). Understanding metaphorical comparisons: Beyond similarity. *Psychological Review, 97*, 3-18.

Grice, P. H. (1975). Logic and conversation. In P. Cole & J. L. Morgan (Eds.), *Speech acts: Syntax and semantics* (pp. 41-58). New York: Academic Press.

Grice, P. H. (1989). *Studies in the way of words*. Cambridge, MA: Harvard University Press.

Groeben, N., & Scheele, B. (1986). *Produktion und Rezeption von Ironie - Band 1: Pragmalinguistische Beschreibung und psycholinguistische Erklärungsmodelle*. Tübingen: Gunter Narr Verlag.

Gunter, T. C., & Friederici, A. D. (1999). Concerning the automaticity of syntactic processing. *Psychophysiology, 36*, 126-137.

Gunter, T. C., Friederici, A. D., & Schriefers, H. (2000). Syntactic gender and semantic expectancy: ERPs reveal early autonomy and late interaction. *Journal of Cognitive Neuroscience, 12*, 556-568.

Gunter, T. C., Stowe, L. A., & Mulder, G. (1997). When syntax meets semantics. *Psychophysiology, 34*, 660.

Hagoort, P. (2003). Interplay between syntax and semantics during sentence comprehension: ERP effects of combining syntactic and semantic violations. *Journal of Cognitive Neuroscience, 15*, 883-899.

Hagoort, P., Brown, C., & Groothusen, J. (1993). The syntactic positive shift as an ERP measure of syntactic processing. *Language and Cognitive Processes, 8*, 439.

Hagoort, P., & Brown, C. M. (2000). ERP effects of listening to speech: semantic ERP effects. *Neuropsychologia, 38*, 1518-1530.

Hagoort, P., Brown, C. M., & Osterhout, L. (1999). The neurocognition of syntactic processing. In C. Brown & P. Hagoort (Eds.), *Neurocognition of language* (pp. 273-316). Oxford: Oxford University Press.

Hagoort, P., Hald, L., Bastiaansen, M., & Petersson, K. M. (2004). Integration of word meaning and world knowledge in language comprehension. *Science, 304*, 438-441.

Hagoort, P., Wassenaar, M., & Brown, C. A. (2003). Syntax-related ERP-effects in Dutch. *Cognitive Brain Research, 16*, 38-50.

Hahne, A., & Friederici, A. D. (1999). Electrophysiological evidence for two steps in syntactic analysis: Early automatic and late controlled processes. *Journal of Cognitive Neuroscience, 4*, 64.

Hahne, A., & Friederici, A. D. (2002). Differential task effects on semantic and syntactic processes as revealed by ERPs. *Cognitive Brain Research, 13*, 339-356.

Haiman, J. (1998). *Talk is cheap. Sarcasm, alienation, and the evolution of language*. Oxford: Oxford University Press.

Hald, L. A., Steenbeek-Planting, E. G., & Hagoort, P. (2007). The interaction of discourse context and world knowledge in online sentence comprehension. Evidence from the N400. *Brain Research, 1146*, 210-218.

Hansen, J. C., Dickstein, P. W., Berka, C., & Hillyard, S. A. (1983). Event-related potentials during selective attention to speech sounds. *Biological Psychology, 16*, 211-224.

Hartung, M. (1998). *Ironie in der Alltagssprache: Eine gesprächsanalytische Untersuchung*. Opladen: Westdeutscher Verlag.

Haverkate, H. (1990). A speech act analysis of irony. *Journal of Pragmatics, 14*, 77-109.

Herbert, C., Kissler, J., Junghöfer, M., Peyk, P., & Rockstroh, B. (2006). Processing of emotional adjectives: Evidence from startle EMG and ERPs. *Psychophysiology, 43*, 197-206.

Hillyard, S. A., & Münte, T. F. (1984). Selective attention to color and location - An analysis with event-related brain potentials. *Perception and Psychophysics, 36*, 185-198.

Hoeks, J. C. J., Stowe, L. A., & Doedens, G. (2004). Seeing words in context: the interaction of lexical and sentence level information during reading. *Cognitive Brain Research, 19*, 59-73.

Hoen, M., Deprez, V., & Dominey, P. F. (2007). Do you agree? Electrophysiological characterization of online agreement checking during the comprehension of correct French passive sentences. *Journal of Neurolinguistics, 20*, 395-421.

Holcomb, P. J., & Neville, H. J. (1991). Natural speech processing: An analysis using ERPs. *Psychobiology 19*, 286-300.

Holtgraves, T. M. (2001). *Language as social action: Social psychology and language use*. Mahwah: Lawrence Erlbaum Associates.

Holtgraves, T. M. (2005). Diverging interpretations associated with the perspectives of the speaker and recipient in conversations. *Journal of Memory and Language, 53*, 551-566.

Iakimova, G., Passerieux, C., Laurent, J.-P., & Hardy-Bayle, M.-C. (2005). ERPs of metaphoric, literal, and incongruous semantic processing in schizophrenia. *Psychophysiology, 42*, 380-390.

Ivanko, S. L., & Pexman, P. M. (2003). Context incongruity and irony processing. *Discourse Processes, 35*, 241-279.

Japp, U. (1999). *Theorie der Ironie*. Frankfurt/a.M.: Vittorio Klostermann.

Jasper, H. H. (1958). The ten-twenty electrode system of the international federation. *Electroencephalography and Clinical Neurophysiology, 10*, 371-375.

Jorgensen, J., Miller, G. A., & Sperber, D. (1984). Test of the mention theory of irony. *Journal of Experimental Psychology: General, 113*, 112-120.

Juottonen, K., Revonsuo, A., & Lang, H. (1996). Dissimilar age influences on two ERP waveforms (LPC and N400) reflecting semantic context effect. *Cognitive Brain Research, 4*, 99-107.

Kaan, E., Harris, A., Gibson, E., & Holcomb, P. (2000). The P600 as an index of syntactic integration difficulty. *Language and Cognitive Processes, 15*, 159.

Kaan, E., & Swaab, T. Y. (2002). The brain circuitry of syntactic comprehension. *Trends in Cognitive Sciences, 6*, 350-356.

Kaan, E., & Swaab, T. Y. (2003). Repair, revision, and complexity in syntactic analysis: An electrophysiological differentiation. *Journal of Cognitive Neuroscience, 15*, 98-110.

Kanske, P., & Kotz, S. A. (2007). Concreteness in emotional words: ERP evidence from a hemifield study. *Brain Research*, 138-148.

Kaplan, J. A., Brownell, H. H., Jacobs, J. R., & Gardener, H. (1990). The effects of right hemisphere brain damage on the pragmatic interpretation of conversational remarks. *Brain and Language, 38*, 315-333.

Katz, A. N. (2005). Discourse and sociocultural factors in understanding nonliteral language. In H. L. Colston & A. N. Katz (Eds.), *Figurative language comprehension: Social and cultural influences*. Mahwah: Lawrence Erlbaum Associates.

Katz, A. N., Blasko, D. G., & Kazmerski, V. A. (2004). Saying what you don't mean. *Current Directions in Psychological Science, 13*, 186-189.

Katz, A. N., & Ferretti, T. (2001). Moment-by-moment comprehension of proverbs in discourse. *Metaphor and Symbol, 16*, 193-221.

Katz, A. N., & Pexman, P. M. (1997). Interpreting figurative statements: Speaker occupation can change metaphor to irony. *Metaphor and Symbol, 12*, 19-41.

Kaufer, D. S. (1981). Understanding ironic communication. *Journal of Pragmatics, 5*, 495-510.

Kazmerski, V. A., Blasko, D. G., & Dessalegn, B. G. (2003). ERP and behavioral evidence of individual differences in metaphor comprehension. *Memory and Cognition, 31*, 673-689.

Kemmerer, D., Weber-Fox, C., Price, K., Zdanczyk, C., & Way, H. (2007). Big brown dog or brown big dog? An electrophysiological study of semantic constraints on prenominal adjective order. *Brain and Language, 100*, 238-256.

King, J. W., & Kutas, M. (1995). Who did what and when - Using word-level and clause-level ERPs to monitor working-memory usage in reading. *Journal of Cognitive Neuroscience, 7*, 376-395.

Kircher, T. T. J., Leube, D. T., Erb, M., Grodd, W., & Rapp, A. M. (2007). Neural correlates of metaphor processing in schizophrenia. *NeuroImage, 34*, 281-289.

Kluender, R., & Kutas, M. (1993). Bridging the gap: Evidence from ERPs on the processing of unbounded dependencies. *Journal of Cognitive Neuroscience, 5*, 196-214.

Kok, A. (2001). On the utility of P3 amplitude as a measure of processing capacity. *Psychophysiology, 38*, 557-577.

Kolk, H. H. J., & Chwilla, D. (2007). Late positivities in unusual situations. *Brain and Language, 100*, 257-261.

Kolk, H. H. J., Chwilla, D. J., van Herten, M., & Oor, P. J. W. (2003). Structure and limited capacity in verbal working memory: A study with event-related potentials. *Brain and Language, 85*, 1-36.

Kotz, S. A., Schubotz, R. I., Sakreida, K., Friederici, A. D., & von Cramon, D. Y. (2006). The P300/P600 revisited: ERP evidence from basal ganglia lesion patients. *Journal of Cognitive Neuroscience, Supplement*, 126.

Kreuz, R. J., & Glucksberg, S. (1989). How to be sarcastic: The echoic reminder theory of verbal irony. *Journal of Experimental Psychology: General, 118*, 374-386.

Kreuz, R. J., Long, D. L., & Church, M. B. (1991). On being ironic - Pragmatic and mnemonic implications. *Metaphor and Symbolic Activity, 6*, 149-162.

Kumon-Nakamura, S., Glucksberg, S., & Brown, M. (1995). How about another piece of pie: The allusional pretense theory of discourse irony. *Journal of Experimental Psychology: General, 124*, 3-21.

Kuperberg, G. R. (2007). Neural mechanisms of language comprehension: Challenges to syntax. *Brain Research, 1146*, 23-49.

Kuperberg, G. R., Caplan, D., Sitnikova, T., Eddy, M., & Holcomb, P. (2006). Neural correlates of processing syntactic, semantic, and thematic relationships in sentences. *Language and Cognitive Processes, 21*, 489-530.

Kuperberg, G. R., Holcomb, P. J., Sitnikova, T., Greve, D., Dale, A. M., & Caplan, D. (2003). Distinct patterns of neural modulation during the processing of conceptual and syntactic anomalies. *Journal of Cognitive Neuroscience, 15*, 272-293.

Kuperberg, G. R., Sitnikova, T., Caplan, D., & Holcomb, P. J. (2003). Electrophysiological distinctions in processing conceptual relationships within simple sentences. *Cognitive Brain Research, 17*, 117-129.

Kutas, M., & Dale, A. M. (1997). Electrical and magnetic readings of mental functions. In M. D. Rugg (Ed.), *Cognitive Neuroscience*. Cambridge, MA: MIT Press.

Kutas, M., & Federmeier, K. D. (2000). Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Sciences, 4*, 463.

Kutas, M., & Hillyard, S. A. (1980a). Reading between the lines: Event-related brain potentials during natural sentence processing. *Brain and Language, 11*, 354-373.

Kutas, M., & Hillyard, S. A. (1980b). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science, 207*, 203-205.

Kutas, M., & Hillyard, S. A. (1983). Event-related brain potentials to grammatical errors and semantic anomalies. *Memory and Cognition, 11*, 539-550.

Kutas, M., & Hillyard, S. A. (1984). Brain potentials during reading reflect word expectancy and semantic association. *Nature, 307*, 161.

Kutas, M., Van Petten, C. K., & Kluender, R. (2006). Psycholinguistics electrified II (1994-2005). In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 659-724). San Diego: Academic Press.

Landi, N., & Perfetti, C. A. (2007). An electrophysiological investigation of semantic and phonological processing in skilled and less-skilled comprehenders. *Brain and Language, 102*, 30-45.

Langdon, R., & Coltheart, M. (2004). Recognition of metaphor and irony in young adults: the impact of schizotypal personality traits. *Psychiatry Research, 125*, 9-20.

Lapp, E. (1992). *Linguistik der Ironie*. Tübingen: Gunter Narr Verlag.

Lattner, S., & Friederici, A. D. (2003). Talker's voice and gender stereotype in human auditory sentence processing - evidence from event-related brain potentials. *Neuroscience Letters, 339*, 191-194.

Laurent, J.-P., Denhieres, G., Passerieux, C., Iakimova, G., & Hardy-Bayle, M.-C. (2006). On understanding idiomatic language: The salience hypothesis assessed by ERPs. *Brain Research, 1068*, 151-160.

Lee, S. S., & Dapretto, M. (2006). Metaphorical versus literal word meanings: fMRI evidence against a selective role of the right hemisphere. *NeuroImage, 29*, 536-544.

Luck, S. J., & Hillyard, S. A. (1994). Electrophysiological correlates of feature analysis during visual search. *Psychophysiology, 31*, 291-308.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). Lexical Nature of Syntactic Ambiguity Resolution. *Psychological Review, 101*, 676-703.

Martin-Loeches, M., Hinojosa, J. A., Casado, P., Munoz, F., & Fernandez-Frias, C. (2004). Electrophysiological evidence of an early effect of sentence context in reading. *Biological Psychology, 65*, 265-280.

Martin-Loeches, M., Nigbur, R., Casado, P., Hohlfeld, A., & Sommer, W. (2006). Semantics prevalence over syntax during sentence processing: A brain potential study of noun-adjective agreement in Spanish. *Brain Research, 1093*, 178-189.

Martin, I., & McDonald, S. (2003). Weak coherence, no Theory of Mind, or executive dysfunction? Solving the puzzle of pragmatic language disorders. *Brain and Language, 85*, 451-466.

Martin, I., & McDonald, S. (2005). Evaluating the causes of impaired irony comprehension following traumatic brain injury. *Aphasiology, 19*, 712-730.

Mashal, N., Faust, M., & Hendler, T. (2005). The role of the right hemisphere in processing nonsalient metaphorical meanings: Application of Principal Components Analysis to fMRI data. *Neuropsychologia, 43*, 2084-2100.

Mashal, N., Faust, M., Hendler, T., & Jung-Beeman, M. (2007). An fMRI investigation of the neural correlates underlying the processing of novel metaphoric expressions. *Brain and Language, 100*, 115-126.

Mason, R. A., & Just, M. A. (2004). How the brain processes causal inferences in text - A theoretical account of generation and integration component processes utilizing both cerebral hemispheres. *Psychological Science, 15*, 1-7.

Mason, R. A., & Just, M. A. (2007). Lexical ambiguity in sentence comprehension. *Brain Research, 1146*, 115-127.

McClelland, J. L., St. John, M., & Taraban, R. (1989). Sentence comprehension: A parallel distributed processing approach. *Language and Cognitive Processes, 4*, 287-336.

McDonald, S. (1992). Pragmatic language skills after closed head injury: Ability to comprehend conversational implicature. *Applied Psycholinguistics, 13*, 295-312.

McDonald, S. (1999). Exploring the process of inference generation in sarcasm: A review of normal and clinical studies. *Brain and Language, 68*, 486-506.

McDonald, S. (2000a). Exploring the cognitive basis of right-hemisphere pragmatic language disorders. *Brain and Language, 75*, 82-107.

McDonald, S. (2000b). Neuropsychological studies of sarcasm. *Metaphor and Symbol, 15*, 85-98.

McDonald, S., & Pearce, S. (1996). Clinical insights into pragmatic theory: Frontal lobe deficits and sarcasm. *Brain and Language, 53*, 81-104.

Mo, S., Su, Y., Chan, R. C. K., & Liu, J. (2008). Comprehension of metaphor and irony in schizophrenia during remission: The role of Theory of Mind and IQ. *Psychiatry Research, 157*, 2129.

Muecke, D. C. (1986). *Irony and the ironic*. New York: Methuen & Co.

Münte, T. F., Heinze, H.-J., Matzke, M., Wieringa, B. M., & Johannes, S. (1998). Brain potentials and syntactic violations revisited: No evidence for specificity of the syntactic positive shift. *Neuropsychologia, 36*, 217-226.

Münte, T. F., Heinze, H. J., & Mangun, G. R. (1993). Dissociation of brain activity related to syntactic and semantic aspects of language. *Journal of Cognitive Neuroscience, 5*, 335-344.

Münte, T. F., Matzke, M., & Johannes, S. (1997). Brain activity associated with syntactic incongruencies in words and pseudo-words. *Journal of Cognitive Neuroscience, 9*, 318-329.

Münte, T. F., Schiltz, K., & Kutas, M. (1998). When temporal terms belie conceptual order. *Nature, 395*, 71-73.

Neville, H. J., Nicol, J. L., Barss, A., Forster, K. I., & Garrettdew, M. F. (1991). Syntactically based sentence processing classes: Evidence from event-related brain potentials. *Journal of Cognitive Neuroscience, 3*, 151-165.

Nieuwland, M. S., & Van Berkum, J. J. A. (2005). Testing the limits of the semantic illusion phenomenon: ERPs reveal temporary semantic change deafness in discourse comprehension. *Cognitive Brain Research, 24*, 691-701.

Norrick, N. R. (2003). Issues in conversational joking. *Journal of Pragmatics, 35*, 1333-1359.

Nunez-Pena, M. I., & Honrubia-Serrano, M. L. (2004). P600 related to rule violation in an arithmetic task. *Cognitive Brain Research, 18*, 130-141.

Oakhill, J., Garnham, A., & Reynolds, D. (2005). Immediate activation of stereotypical gender information. *Memory and Cognition, 33*, 972-983.

Osterhout, L. (1997). On the brain response to syntactic anomalies - Manipulations of word position and word class reveal individual differences. *Brain and Language, 59*, 494-522.

Osterhout, L., Bersick, M., & McLaughlin, J. (1997). Brain potentials reflect violations of gender stereotypes. *Memory and Cognition, 25*, 273-285.

Osterhout, L., & Hagoort, P. (1999). A superficial resemblance does not necessarily mean you are part of the family: Counterarguments to Coulson, King and Kutas (1998) in the P600/SPS-P300 debate. *Language and Cognitive Processes, 14*, 1.

Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language, 31*, 785-806.

Osterhout, L., & Holcomb, P. J. (1993). Event-related potentials and syntactic anomaly - Evidence of anomaly detection during the perception of continuous speech. *Language and Cognitive Processes, 8*, 413-437.

Osterhout, L., Holcomb, P. J., & Swinney, D. A. (1994). Brain potentials elicited by garden-path sentences: Evidence of the application of verb information during parsing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 786.

Osterhout, L., McKinnon, R., Bersick, M., & Corey, V. (1996). On the language specificity of the brain response to syntactic anomalies: Is the syntactic positive shift a member of the P300 family? *Journal of Cognitive Neuroscience, 8*, 507-526.

Osterhout, L., & Mobley, L. A. (1995). Event-Related brain potentials elicited by failure to agree. *Journal of Memory and Language, 34*, 739.

Otten, M., & Van Berkum, J. J. A. (2007). What makes a discourse constraining? Comparing the effects of discourse message and scenario fit on the discourse-dependent N400 effect. *Brain Research, 1153*, 166-177.

Palolahti, M., Leino, S., Jokela, M., Kopra, K., & Paavilainen, P. (2005). Event-related potentials suggest early interaction between syntax and semantics during on-line sentence comprehension. *Neuroscience Letters, 384*, 222-227.

Patel, A. D., Gibson, E., Ratner, J., Besson, M., & Holcomb, P. J. (1998). Processing syntactic relations in language and music: An event-related potential study. *Journal of Cognitive Neuroscience, 10*, 717-733.

Peleg, O., Giora, R., & Fein, O. (2001). Salience and context effects: Two are better than one. *Metaphor and Symbol, 16*, 173-192.

Penke, M., Weyerts, H., Gross, M., Zander, E., Münte, T. F., & Clahsen, H. (1997). How the brain processes complex words: an event-related potential study of German verb inflections. *Cognitive Brain Research, 6*, 37-52.

Penolazzi, B., Hauk, O., & Pulvermüller, F. (2007). Early semantic context integration and lexical access as revealed by event-related brain potentials. *Biological Psychology, 74*, 374-388.

Pernet, C., Basan, S., Doyon, B., Cardebat, D., Demonet, J. F., & Celsis, P. (2003). Neural timing of visual implicit categorization. *Cognitive Brain Research, 17*, 327-338.

Pexman, P. M., & Olineck, K. M. (2002). Understanding irony - How do stereotypes cue speaker intent? *Journal of Language and Social Psychology, 21*, 245-274.

Pfeifer, W. (1995). *Etymologisches Wörterbuch des Deutschen*. München: Deutscher Taschenbuch-Verlag.

Picton, T. W. (1992). The P300 wave of the human event-related potential. *Journal of Clinical Neurophysiology, 9*, 456-479.

Picton, T. W., & Hillyard, S. A. (1974). Human auditory evoked potentials. II: Effects of attention. *Electroencephalography and Clinical Neurophysiology, 36*, 191-200.

Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology, 118*, 2128-2148.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a Theory of Mind? *Behavioural Brain Research, 1*, 515-526.

Pritchard, W. S. (1981). Psychophysiology of P300. *Psychological Bulletin, 89*, 506-540.

Pulvermüller, F. (2001). Brain reflections of words and their meaning. *Trends in Cognitive Sciences, 5*, 517-524.

Pynte, J., Besson, M., Robichon, F.-H., & Poli, J. (1996). The time-course of metaphor comprehension: An event-related potential study. *Brain and Language, 55*, 293-316.

Raney, G. E. (1993). Monitoring changes in cognitive load during reading: An event-related brain potential and reaction time analysis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 51-69.

Rapp, A. M., Leube, D. T., Erb, M., Grodd, W., & Kircher, T. T. J. (2007). Laterality in metaphor processing: Lack of evidence from functional magnetic resonance imaging for the right hemisphere theory. *Brain and Language, 100*, 142-149.

Ritchie, G. (2004). *The linguistic analysis of jokes*. London: Routledge.

Rockwell, P. (2000). Lower, slower, louder: Vocal cues of sarcasm. *Journal of Psycholinguistic Research, 29*, 483-495.

Rockwell, P. (2001). Facial expression and sarcasm. *Perceptual and motor skills 93*, 47-50.

Rockwell, P. (2007). Vocal features of conversational sarcasm: A comparison of methods. *Journal of Psycholinguistic Research, 36*, 361-369.

Rösler, F., Pechmann, T., Streb, J., Röder, B., & Hennighausen, E. (1998). Parsing of sentences in a language with varying word order: Word-by-word variations of processing demands are revealed by event-related brain potentials. *Journal of Memory and Language, 38*, 150-176.

Rösler, F., Putz, P., Friederici, A. F., & Hahne, A. (1993). Event-related brain potentials while encountering semantic and syntactic constraint violations. *Journal of Cognitive Neuroscience, 5*, 345-362.

Rossi, S., Gugler, M. F., Hahne, A., & Friederici (2005). When word category information encounters morphosyntax: An ERP study. *Neuroscience Letters, 384*, 228-233.

Ruchkin, D. S., Johnson, R., Canoune, H. L., Ritter, W., & Hammer, M. (1990). Multiple sources of P3b associated with different types of information. *Psychophysiology, 27*, 157-176

Salmon, N., & Pratt, H. (2002). A comparison of sentence- and discourse-level semantic processing: An ERP study. *Brain and Language, 83*, 367-383.

Sanders, L. D., & Neville, H. J. (2003). An ERP study of continuous speech processing: I. Segmentation, semantics, and syntax in native speakers. *Cognitive Brain Research, 15*, 228-240.

Schapkin, S. A., Gusev, A. N., & Kuhl, J. (2000). Categorization of unilaterally presented emotional words: an ERP analysis. *Acta Neurobiologiae Experimentalis, 60*, 17-28.

Schwoebel, J., Dews, S., Winner, E., & Srinivas, K. (2000). Obligatory processing of the meaning of ironic utterances: Further evidence. *Metaphor and Symbol, 15*, 47-61.

Searle, J. R. (1969). *Speech acts: An essay in the philosophy of language*. Cambridge: Cambridge University Press.

Searle, J. R. (1979). *Expression and meaning*. Cambridge: Cambridge University Press.

Searle, J. R. (1997). *Sprechakte: Ein sprachphilosophischer Essay (R. & R. Wiggershaus, Trans.)*. Frankfurt/a.M.: Suhrkamp.

Seto, K. (1998). On non-echoic irony. In R. Carston & S. Uchida (Eds.), *Relevance theory: Applications and implications* (pp. 239-255). Amsterdam: John Benjamins.

Shallice, T., & Burgess, P. (1996). The domain of supervisory processes and temporal organization of behaviour. *Philosophical Transaction of the Royal Society B: Biological Sciences, 351*, 1405-1411.

Shamay-Tsoory, S. G., Tomer, R., & Aharon-Peretz, J. (2005). The neuroanatomical basis of understanding sarcasm and its relationship to social cognition. *Neuropsychology, 19*, 288-300.

Shamay, S. G., Tomer, R., & Aharon-Peretz, J. (2002). Deficit in understanding sarcasm in patients with prefronal lesion is related to impaired empathic ability. *Brain and Cognition, 48*, 558-563.

Sharbrough, F., Chatrian, G., Lesser, R., Luders, H., Nuwer, M., & Picton, T. (1991). American electroencephalographic society guidelines for standard electrode position nomenclature. *Journal of Clinical Neurophysiology, 8*, 200-202.

Shibata, M., Abe, J.-i., Terao, A., & Miyamoto, T. (2007). Neural mechanisms involved in the comprehension of metaphoric and literal sentences: An fMRI study. *Brain Research, 1166*, 92-102.

Silva-Pereyra, J. F., & Carreiras, M. (2007). An ERP study of agreement features in Spanish. *Brain Research, 1185*, 201-211.

Sotillo, M., Carretie, L., Hinojosa, J. A., Tapia, M., Mercado, F., Lopez-Martin, S., et al. (2004). Neural activity associated with metaphor comprehension: spatial analysis. *Neuroscience Letters, 373*, 5-9.

Sperber, D., & Wilson, D. (1981). Irony and the use-mention distinction. In P. Cole (Ed.), *Radical Pragmatics* (pp. 295-318). New York: Academic Press.

Sperber, D., & Wilson, D. (1998). Irony and relevance: A reply to Seto, Hamamoto and Yamanashi. In R. Carston & S. Uchida (Eds.), *Relevance theory: Applications and implications* (pp. 283-293). Amsterdam: John Benjamins.

St. George, M., Kutas, M., Martinez, A., & Sereno, M. I. (1999). Semantic integration in reading: Engagement of the right hemisphere during discourse processing. *Brain, 122*, 1317-1325.

St. George, M., Mannes, S., & Hoffman, J. E. (1994). Global semantic expectancy and language comprehension. *Journal of Cognitive Neuroscience, 6*, 70-83.

St. George, M., Mannes, S., & Hoffman, J. E. (1997). Individual differences in inference generation: An ERP analysis. *Journal of Cognitive Neuroscience, 9*, 776-787.

Steinhauer, K. (2003). Electrophysiological correlates of prosody and punctuation. *Brain and Language, 86*, 142-164.

Stojanovic, D. (1991). *Ironie und Bedeutung*. Frankfurt/a.M.: Peter Lang.

Stringaris, A. K., Medford, N. C., Giampietro, V., Brammer, M. J., & David, A. S. (2007). Deriving meaning: Distinct neural mechanisms for metaphoric, literal, and non-meaningful sentences. *Brain and Language, 100*, 150-162.

Sutton, S., & Ruchkin, D. S. (1984). The late positive complex - Advances and new problems. *Annals of the New York Academy of Sciences, 425*, 1-23.

Swaab, T. Y., Brown, C., & Hagoort, P. (2003). Understanding words in sentence contexts: The time course of ambiguity resolution. *Brain and Language, 86*, 326-343.

Swaab, T. Y., Camblin, C. C., & Gordon, P. C. (2004). Electrophysiological evidence for reversed lexical repetition effects in language processing. *Journal of Cognitive Neuroscience, 16*, 715-726.

Tartter, V. C., Gomes, H., Dubrovsky, B., Molholm, S., & Stewart, R. V. (2002). Novel metaphors appear anomalous at least momentarily: Evidence from N400. *Brain and Language, 80*, 488-509.

Taylor, W. L. (1953). "Cloze Procedure": a new tool for measuring readability. *Journalism Quarterly, 30*, 415-433.

Thoma, P., & Daum, I. (2006). Neurocognitive mechanisms of figurative language processing-Evidence from clinical dysfunctions. *Neuroscience and Biobehavioral Reviews, 30*, 1182-1205.

Thornton, A. R. D., Harmer, M., & Lavoie, B. A. (2007). Selective attention increases the temporal precision of the auditory N100 event-related potential. *Hearing Research, 230*, 73-79.

Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influences on parsing - Use of thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language, 33*, 285-318.

Turner, N., & Katz, A. (1997). The availability of conventional and of literal meaning in comprehension of proverbs. *Pragmatics and Cognition, 5*, 99-133.

Uchiyama, H., Seki, A., Kageyama, H., Saito, D. N., Koeda, T., Ohno, K., et al. (2006). Neural substrates of sarcasm: A functional magnetic-resonance imaging study. *Brain Research, 1124*, 100-110.

Ullsperger, P., Metz, A. M., & Gille, H. G. (1988). The P300 component of the event-related brain potential and mental effort. *Ergonomics, 31*, 1127-1137.

Utsumi, A. (2000). Verbal irony as implicit display of ironic environment: Distinguishing ironic utterances from nonirony. *Journal of Pragmatics, 32*, 1777-1806.

Van Berkum, J. J. A., Brown, C. M., Hagoort, P., & Zwitserlood, P. (2003). Event-related brain potentials reflect discourse-referential ambiguity in spoken language comprehension. *Psychophysiology, 40*, 235-248.

Van Berkum, J. J. A., Hagoort, P., & Brown, C. M. (1999). Semantic Integration in Sentences and Discourse: Evidence from the N400. *Journal of Cognitive Neuroscience, 11*, 657-671.

Van Berkum, J. J. A., van den Brink, D., Tesink, C. M. J. Y., Kos, M., & Hagoort, P. (2008). The neural integration of speaker and message. *Journal of Cognitive Neuroscience, 20*, 580-591.

Van Berkum, J. J. A., Zwitserlood, P., Hagoort, P., & Brown, C. M. (2003). When and how do listeners relate a sentence to the wider discourse? Evidence from the N400 effect. *Cognitive Brain Research, 17*, 701-718.

van Herten, M., Kolk, H. H. J., & Chwilla, D. J. (2005). An ERP study of P600 effects elicited by semantic anomalies. *Cognitive Brain Research, 22*, 241-255.

van Petten, C., Coulson, S., Rubin, S., Plante, E., & Parks, M. (1999). Time course of word identification and semantic integration in spoken language. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 394-417.

Van Petten, C., & Kutas, M. (1990). Interactions between sentence context and word frequency in event-related brain potentials. *Memory and Cognition*, 380-393.

van Petten, C., Kutas, M., Kluender, R., Mitchiner, M., & McIsaac, H. (1991). Fractionating the word repetition effect with event-related brain potentials. *Journal of Cognitive Neuroscience, 3*, 131-150.

Vasey, M. W., & Thayer, J. F. (1987). The continuing problem of false positives in repeated measures ANOVA in psychophysiology: A multivariate solution. *Psychophysiology, 24*, 479-486.

Verleger, R., Jaskowski, P., & Wascher, E. (2005). Evidence for an integrative role of P3b in linking reaction to perception. *Federation of European Psychophysiology Society, 19*, 165-181.

Vissers, C. T. W. M., Chwilla, D. J., & Kolk, H. H. J. (2006). Monitoring in language perception: The effect of misspellings of words in highly constrained sentences. *Brain Research, 1106*, 150-163.

Wakusawa, K., Sugiura, M., Sassa, Y., Jeong, H., Horie, K., Sato, S., et al. (2007). Comprehension of implicit meanings in social situations involving irony: A functional MRI study. *NeuroImage, 37*, 1417-1426.

Weinrich, H. (1966). *Linguistik der Lüge*. Heidelberg: Lambert Schneider.

Williams, J. P. (1984). Does mention (or pretense) exhaust the concept of irony? *Journal of Experimental Psychology: General, 113*, 127-129.

Wilson, D. (2006). The pragmatics of verbal irony: Echo or pretence? *Lingua, 116*, 1722-1743.

Winner, E., Brownell, H., Happe, F., Blum, A., & Pincus, D. (1998). Distinguishing lies from jokes: Theory of Mind deficits and discourse interpretation in right hemisphere brain-damaged patients. *Brain and Language, 62*, 89-106.

Zempleni, M.-Z., Haverkort, M., Renken, R., & Stowe, L. A. (2007). Evidence for bilateral involvement in idiom comprehension: An fMRI study. *NeuroImage, 34*, 1280-1291.

List of Figures

2.1 Electrode configuration 21
2.2 EEG recording and ERP quantification 21
2.3 Left anterior negativity effects 24

3.1 fMRI data by Eviatar and Just (2006) 42

4.1 Illustration of an experimental trial (Experiment 1) 55
4.2 Definition of Region of Interest (ROIs) 57
4.3 Grand average ERPs: normal vs. ironic prosody 58
4.4 Grand average ERPs: non-ironic vs. ironic sentences 59

5.1 Illustration of an experimental trial (Experiment 2, 3, 4, 6) 70
5.2 Grand average ERPs: non-ironic vs. ironic sentences 71
5.3 Grand average ERPs: sentences with vs. without quotations 72
5.4 Grand average ERPs: uncued and cued irony 81

6.1 Grand average ERPs for Session 1: non-ironic vs. ironic sentences 94
6.2 Grand average ERPs for Session 1: low-ironic vs. high ironic speaker 95
6.3 Grand average ERPs for Session 1 & 2:: Interaction of Context with Speaker 96
6.4 Grand average ERPs for Session 2: non-ironic vs. ironic sentences 97
6.5 Grand average ERPs for Session 2: low-ironic vs. high ironic speaker 98

7.1 Grand average ERPs: non-ironic vs. ironic sentences 112
7.2 Grand average ERPs: Comparison of context effects dependent on task 113
7.3 Grand average ERPs: with vs. without comprehension task 114
7.4 Grand average ERPs: Comparison of context effects of Experiment 3 and 5 116
7.5 Grand average ERPs: non-ironic vs. ironic sentences 124
7.6 Grand average ERPs: syntactically correct vs. incorrect sentences 125
7.7 Grand average ERPs: Comparison of Context and Syntax effects 125

List of Tables

3.1 Overview of ERP studies reporting non-syntactic P600 effects 29-31

4.1 Example of an experimental item..... 51
4.2 Experimental conditions (Exp. 1)..... 51
4.3 Acoustic analysis data: Duration..... 54
4.4 Acoustic analysis data: F0..... 54
4.5 Acoustic analysis data: Intensity 54

5.1 Experimental conditions (Exp. 2)..... 69
5.2 Experimental conditions (Exp. 3)..... 79

6.1 Example of an experimental item..... 90
6.2 Experimental conditions (Exp. 4)..... 91
6.3 Behavioral data: Accuracy rates for Session 1 and 2 93
6.4 Post-test data for Session 1 and 2..... 93

7.1 Experimental conditions (Exp. 6)..... 122

8.1 Summary of the main findings of Exp. 1, 2 and 5..... 138
8.2 Summary of effects of cueing on irony (Exp 1-4) 143

Selbständigkeitserklärung

Hiermit erkläre ich, Stefanie Regel, geboren am 20.01.1979, daß die vorliegende Arbeit ohne unzulässige Hilfe und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt wurde, und daß die aus fremden Quellen direkt oder indirekt übernommenen Gedanken in der Arbeit als solche kenntlich gemacht worden sind.

Diese Arbeit wurde weder in der gegenwärtigen noch in einer veränderten Fassung einer anderen Fakultät einer wissenschaftlichen Hochschule zum Zwecke einer Promotion vorgelegt oder veröffentlicht.

Stefanie Regel

Leipzig, den 25.09.2008

MPI Series in Human Cognitive and Brain Sciences:

1 Anja Hahne
Charakteristika syntaktischer und semantischer Prozesse bei der auditiv Sprachverarbeitung: Evidenz aus ereigniskorrelierten Potentialstudien

2 Ricarda Schubotz
Erinnern kurzer Zeitdauern: Behaviorale und neurophysiologische Korrelate einer Arbeitsgedächtnisfunktion

3 Volker Bosch
Das Halten von Information im Arbeitsgedächtnis: Dissoziationen langsamer corticaler Potentiale

4 Jorge Jovicich
An investigation of the use of Gradient- and Spin-Echo (GRASE) imaging for functional MRI of the human brain

5 Rosemary C. Dymond
Spatial Specificity and Temporal Accuracy in Functional Magnetic Resonance Investigations

6 Stefan Zysset
Eine experimentalpsychologische Studie zu Gedächtnisabrufprozessen unter Verwendung der funktionellen Magnetresonanztomographie

7 Ulrich Hartmann
Ein mechanisches Finite-Elemente-Modell des menschlichen Kopfes

8 Bertram Opitz
Funktionelle Neuroanatomie der Verarbeitung einfacher und komplexer akustischer Reize: Integration haemodynamischer und elektrophysiologischer Maße

9 Gisela Müller-Plath
Formale Modellierung visueller Suchstrategien mit Anwendungen bei der Lokalisation von Hirnfunktionen und in der Diagnostik von Aufmerksamkeitsstörungen

10 Thomas Jacobsen
Characteristics of processing morphological structural and inherent case in language comprehension

11 Stefan Kölsch
Brain and Music
A contribution to the investigation of central auditory processing with a new electrophysiological approach

12 Stefan Frisch
Verb-Argument-Struktur, Kasus und thematische Interpretation beim Sprachverstehen

13 Markus Ullsperger
The role of retrieval inhibition in directed forgetting – an event-related brain potential analysis

14 Martin Koch
Measurement of the Self-Diffusion Tensor of Water in the Human Brain

15 Axel Hutt
Methoden zur Untersuchung der Dynamik raumzeitlicher Signale

16 Frithjof Kruggel
Detektion und Quantifizierung von Hirnaktivität mit der funktionellen Magnetresonanztomographie

17 Anja Dove
Lokalisierung an internen Kontrollprozessen beteiligter Hirngebiete mithilfe des Aufgabenwechselparadigmas und der ereigniskorrelierten funktionellen Magnetresonanztomographie

18 Karsten Steinhauer
Hirnphysiologische Korrelate prosodischer Satzverarbeitung bei gesprochener und geschriebener Sprache

19 Silke Urban
Verbinformationen im Satzverstehen

20 Katja Werheid
Implizites Sequenzlernen bei Morbus Parkinson

21 Doreen Nessler
Is it Memory or Illusion? Electrophysiological Characteristics of True and False Recognition

22 Christoph Herrmann
Die Bedeutung von 40-Hz-Oszillationen für kognitive Prozesse

23 Christian Fiebach
Working Memory and Syntax during Sentence Processing.
A neurocognitive investigation with event-related brain potentials and functional magnetic resonance imaging

24 Grit Hein
Lokalisation von Doppelaufgabendefiziten bei gesunden älteren Personen und neurologischen Patienten

25 Monica de Filippis
Die visuelle Verarbeitung unbeachteter Wörter.
Ein elektrophysiologischer Ansatz

26 Ulrich Müller
Die katecholaminerge Modulation präfrontaler kognitiver Funktionen beim Menschen

27 Kristina Uhl
Kontrollfunktion des Arbeitsgedächtnisses über interferierende Information

28 Ina Bornkessel
The Argument Dependency Model: A Neurocognitive Approach to Incremental Interpretation

29 Sonja Lattner
Neurophysiologische Untersuchungen zur auditorischen Verarbeitung von Stimminformationen

30 Christin Grünewald
Die Rolle motorischer Schemata bei der Objektrepräsentation: Untersuchungen mit funktioneller Magnetresonanztomographie

31 Annett Schirmer
Emotional Speech Perception: Electrophysiological Insights into the Processing of Emotional Prosody and Word Valence in Men and Women

32 André J. Szameitat
Die Funktionalität des lateral-präfrontalen Cortex für die Verarbeitung von Doppelaufgaben

33 Susanne Wagner
Verbales Arbeitsgedächtnis und die Verarbeitung ambiger Wörter in Wort- und Satzkontexten

34 Sophie Manthey
Hirn und Handlung: Untersuchung der Handlungsrepräsentation im ventralen prämotorischen Cortex mit Hilfe der funktionellen Magnet-Resonanz-Tomographie

35 Stefan Heim
Towards a Common Neural Network Model of Language Production and Comprehension: fMRI Evidence for the Processing of Phonological and Syntactic Information in Single Words

36 Claudia Friedrich
Prosody and spoken word recognition: Behavioral and ERP correlates

37 Ulrike Lex
Sprachlateralisierung bei Rechts- und Linkshändern mit funktioneller Magnetresonanztomographie

38 Thomas Arnold
Computergestützte Befundung klinischer Elektroenzephalogramme

39 Carsten H. Wolters
Influence of Tissue Conductivity Inhomogeneity and Anisotropy on EEG/MEG based Source Localization in the Human Brain

40 Ansgar Hantsch
Fisch oder Karpfen? Lexikale Aktivierung von Benennungsalternative bei der Objektbenennung

41 Peggy Bungert
Zentralnervöse Verarbeitung akustischer Informationen
Signalidentifikation, Signallateralisation und zeitgebundene Informationsverarbeitung bei Patienten mit erworbenen Hirnschädigungen

42 Daniel Senkowski
Neuronal correlates of selective attention: An investigation of electro-physiological brain responses in the EEG and MEG

43 Gert Wollny
Analysis of Changes in Temporal Series of Medical Images

44 Angelika Wolf
Sprachverstehen mit Cochlea-Implantat: EKP-Studien mit postlingual ertaubten erwachsenen CI-Trägern

45 Kirsten G. Volz
Brain correlates of uncertain decisions: Types and degrees of uncertainty

46 Hagen Huttner
Magnetresonanztomographische Untersuchungen über die anatomische Variabilität des Frontallappens des menschlichen Großhirns

47 Dirk Köster
Morphology and Spoken Word Comprehension: Electrophysiological Investigations of Internal Compound Structure

48 Claudia A. Hruska
Einflüsse kontextueller und prosodischer Informationen in der auditorischen Satzverarbeitung: Untersuchungen mit ereigniskorrelierten Hirnpotentialen

49 Hannes Ruge
Eine Analyse des raum-zeitlichen Musters neuronaler Aktivierung im Aufgabenwechselparadigma zur Untersuchung handlungssteuernder Prozesse

50 Ricarda I. Schubotz
Human premotor cortex: Beyond motor performance

51 Clemens von Zerssen
Bewusstes Erinnern und falsches Wiedererkennen:
Eine funktionelle MRT Studie neuroanatomischer Gedächtniskorrelate

52 Christiane Weber
Rhythm is gonna get you.
Electrophysiological markers of rhythmic processing in infants with and without risk for Specific Language Impairment (SLI)

53 Marc Schönwiesner
Functional Mapping of Basic Acoustic Parameters in the Human Central Auditory System

54 Katja Fiehler
Temporospatial characteristics of error correction

55 Britta Stolterfoht
Processing Word Order Variations and Ellipses: The Interplay of Syntax and Information Structure during Sentence Comprehension

56 Claudia Danielmeier
Neuronale Grundlagen der Interferenz zwischen Handlung und visueller Wahrnehmung

57 Margret Hund-Georgiadis
Die Organisation von Sprache und ihre Reorganisation bei ausgewählten, neurologischen Erkrankungen gemessen mit funktioneller Magnetresonanztomographie – Einflüsse von Händigkeit, Läsion, Performanz und Perfusion

58 Jutta L. Mueller
Mechanisms of auditory sentence comprehension in first and second language: An electrophysiological miniature grammar study

59 Franziska Biedermann
Auditorische Diskriminationsleistungen nach unilateralen Läsionen im Di- und Telenzephalon

60 Shirley-Ann Rüschemeyer
The Processing of Lexical Semantic and Syntactic Information in Spoken Sentences: Neuroimaging and Behavioral Studies of Native and Non-Native Speakers

61 Kerstin Leuckefeld
The Development of Argument Processing Mechanisms in German.
An Electrophysiological Investigation with School-Aged Children and Adults

62 Axel Christian Kühn
Bestimmung der Lateralisierung von Sprachprozessen unter besondere Berücksichtigung des temporalen Cortex, gemessen mit fMRT

63 Ann Pannekamp
Prosodische Informationsverarbeitung bei normalsprachlichem und deviantem Satzmaterial: Untersuchungen mit ereigniskorrelierten Hirnpotentialen

64 Jan Derrfuß
Functional specialization in the lateral frontal cortex: The role of the inferior frontal junction in cognitive control

65 Andrea Mona Philipp
The cognitive representation of tasks
Exploring the role of response modalities using the task-switching paradigm

66 Ulrike Toepel
Contrastive Topic and Focus Information in Discourse – Prosodic Realisation and Electrophysiological Brain Correlates

67 Karsten Müller
Die Anwendung von Spektral- und Waveletanalyse zur Untersuchung der Dynamik von BOLD-Zeitreihen verschiedener Hirnareale

68 Sonja A.Kotz
The role of the basal ganglia in auditory language processing: Evidence from ERP lesion studies and functional neuroimaging

69 Sonja Rossi
The role of proficiency in syntactic second language processing: Evidence from event-related brain potentials in German and Italian

70 Birte U. Forstmann
Behavioral and neural correlates of endogenous control processes in task switching

71 Silke Paulmann
Electrophysiological Evidence on the Processing of Emotional Prosody: Insights from Healthy and Patient Populations

72 Matthias L. Schroeter
Enlightening the Brain – Optical Imaging in Cognitive Neuroscience

73 Julia Reinholz
Interhemispheric interaction in object- and word-related visual areas

74 Evelyn C. Ferstl
The Functional Neuroanatomy of Text Comprehension

75 Miriam Gade
Aufgabeninhibition als Mechanismus der Konfliktreduktion zwischen Aufgabenrepräsentationen

76 Juliane Hofmann
Phonological, Morphological, and Semantic Aspects of Grammatical Gender Processing in German

77 Petra Augurzky
Attaching Relative Clauses in German – The Role of Implicit and Explicit Prosody in Sentence Processing

78 Uta Wolfensteller
Habituelle und arbiträre sensomotorische Verknüpfungen im lateralen prämotorischen Kortex des Menschen

79 Päivi Sivonen
Event-related brain activation in speech perception: From sensory to cognitive processes

80 Yun Nan
Music phrase structure perception: the neural basis, the effects of acculturation and musical training

81 Katrin Schulze
Neural Correlates of Working Memory for Verbal and Tonal Stimuli in Nonmusicians and Musicians With and Without Absolute Pitch

82 Korinna Eckstein
Interaktion von Syntax und Prosodie beim Sprachverstehen: Untersuchungen anhand ereigniskorrelierter Hirnpotentiale

83 Florian Th. Siebörger
Funktionelle Neuroanatomie des Textverstehens: Kohärenzbildung bei Witzen und anderen ungewöhnlichen Texten

84 Diana Böttger
Aktivität im Gamma-Frequenzbereich des EEG: Einfluss demographischer Faktoren und kognitiver Korrelate

85 Jörg Bahlmann
Neural correlates of the processing of linear and hierarchical artificial grammar rules: Electrophysiological and neuroimaging studies

86 Jan Zwickel
Specific Interference Effects Between Temporally Overlapping Action and Perception

87 Markus Ullsperger
Functional Neuroanatomy of Performance Monitoring: fMRI, ERP, and Patient Studies

88 Susanne Dietrich
Vom Brüllen zum Wort – MRT-Studien zur kognitiven Verarbeitung emotionaler Vokalisationen

89 Maren Schmidt-Kassow
What's Beat got to do with ist? The Influence of Meter on Syntactic Processing: ERP Evidence from Healthy and Patient populations

90 Monika Lück
Die Verarbeitung morphologisch komplexer Wörter bei Kindern im Schulalter: Neurophysiologische Korrelate der Entwicklung

91 Diana P. Szameitat
Perzeption und akustische Eigenschaften von Emotionen in menschlichem Lachen

92 Beate Sabisch
Mechanisms of auditory sentence comprehension in children with specific language impairment and children with developmental dyslexia:
A neurophysiological investigation

93 Regine Oberecker
Grammatikverarbeitung im Kindesalter: EKP-Studien zum auditorischen Satzverstehen

94 Şükrü Barış Demiral
Incremental Argument Interpretation in Turkish Sentence Comprehension

95 Henning Holle
The Comprehension of Co-Speech Iconic Gestures: Behavioral, Electrophysiological and Neuroimaging Studies

96 Marcel Braß
Das inferior frontale Kreuzungsareal und seine Rolle bei der kognitiven Kontrolle unseres Verhaltens

97 Anna S. Hasting
Syntax in a blink: Early and automatic processing of syntactic rules as revealed by event-related brain potentials

98 Sebastian Jentschke
Neural Correlates of Processing Syntax in Music and Language – Influences of Development, Musical Training and Language Impairment

99 Amelie Mahlstedt
The Acquisition of Case marking Information as a Cue to Argument Interpretation in German
An Electrophysiological Investigation with Pre-school Children

100 Nikolaus Steinbeis
Investigating the meaning of music using EEG and fMRI

101 Tilmann A. Klein
Learning from errors: Genetic evidence for a central role of dopamine in human performance monitoring

102 Franziska Maria Korb
Die funktionelle Spezialisierung des lateralen präfrontalen Cortex: Untersuchungen mittels funktioneller Magnetre sonanztomographie

103 Sonja Fleischhauer
Neuronale Verarbeitung emotionaler Prosodie und Syntax: die Rolle des verbalen Arbeitsgedächtnisses

104 Friederike Sophie Haupt
The component mapping problem: An investigation of grammatical function reanalysis in differing experimental contexts using event-related brain potentials

105 Jens Brauer
Functional development and structural maturation in the brain's neural network underlying language comprehension

106 Philipp Kanske
Exploring executive attention in emotion: ERP and fMRI evidence

107 Julia Grieser Painter
Music, meaning, and a semantic space for musical sounds

108 Daniela Sammler
The Neuroanatomical Overlap of Syntax Processing in Music and Language - Evidence from Lesion and Intracranial ERP Studies

109 Norbert Zmyj
Selective Imitation in One-Year-Olds: How a Model's Characteristics Influence Imitation

110 Thomas Fritz
Emotion investigated with music of variable valence – neurophysiology and cultural influence