Abstract

The ability to combine the meanings of individual words into complex semantic representations is a defining trait of human linguistic competence. Despite its significance, little is known about the neurocognitive mechanisms responsible for language comprehension. An important step is to establish the neural correlates of simple linguistic composition. In the present work, we studied on-line event related potentials (ERPs) and off-line behavioral responses to adjective-noun phrases in Bokmål Norwegian. We included NPs from three semantic conditions: privative adjectives ("fake doctor"), non-privative adjectives ("real doctor") and semantic anomalies ("quadrangular doctor"). We contrasted these semantic conditions, requiring composition, to three non-semantic conditions, where the adjective was replaced by either a non-word, a pseudo-word or an adverb. Looking at the critical noun ("doctor"), this contrast revealed a larger P600 in the semantic trials. This might suggest that the P600 is an ERP signature of composition.

Due to the paucity of research on how adjectival modification influences the on-line composition of phrasal meaning, we further investigated the impact of privative vs. non privative adjectives on ERP signals and behavioral responses. We found an effect of privative trials in the post-N400 time window. Lastly, we contrasted the semantically anomalous trials against the non-privative trials. This comparison did not reveal the expected N400 component, but rather a modulation of the P600 component.

The thesis will discuss these findings in light of formal theories of compositional semantics and current models of language processing.

Acknowledgments

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Contents

1 Introduction

One of the most remarkable and fundamental properties of human language is our capacity to produce and understand an unlimited number of expressions, regardless of whether or not the expression is familiar. This expressive power is reflected in the ability to assemble smaller building blocks into more complex semantic structures. This makes language combinatorial, but also compositional. Productive composition is present in even minimal phrases like adjective-noun phrases. An example is how the expression “pink banana” generates a coherent and meaningful mental representation despite its unfamiliarity to the reader. Formal semantic theories assume that the meaning of phrases like this are derived from the meaning of its constituents. The question then turns to how a speaker computes the meaning of these larger expressions.

A speaker of any language has knowledge of a finite set of basic items, namely root morphemes or words, and the collection of these basic items is called the lexicon. Due to the finiteness of the lexicon, the meaning of these basic items can be learned and stored on a case-by-case basis, but that cannot be true of larger and more complex expressions. There has to exist some set of systematic principles that speakers can make use of, when interpreting meanings, on the basis of the smaller items that make them up. This system is called compositional semantics.

Despite a large theoretical body on semantic composition, little is known about how the process is realized in the brain. In recent years, progress has been made in establishing neural correlates of composition, but no comprehensive model has pinpointed its neural correlates in brain space and time (A. E. Martin & Baggio, 2020; Pylkkänen, 2020). Conducting experiments using electroencephalography (EEG) is one way of observing language processing in real time. Researchers can with the use of EEG generate experiments where different lexico-semantic variables are manipulated. By recording and studying the electro-physiological reactions to the linguistic input, models of language in the brain can be further refined.

1.1 Research aims

The present study represents one part of a larger experiment meant to investigate minimal phrase composition of Norwegian [Det Adj N] phrases. The timing and degree of on-line language comprehension was investigated by the use of EEG and an experimental paradigm

on phrasal composition. The study is a continuation of the work of Fritz and Baggio (2020). Much research on phrasal meaning composition originates from the laboratory of Liina Pylkkänen (Bemis & Pylkkänen, 2011, 2013; Pylkkänen, Bemis, & Elorrieta, 2014; Pylkkänen, 2016, 2020), but in contrast to their work on adjective-noun phrases, we used syntactically complete phrases in this experiment. Moving forward, phrases with the syntactic structure [Det Adj N] will be referred to as minimal phrases.

This study investigates possible event-related potential (ERP) signatures of real-time meaning composition, and whether those can be distinguished from ERP responses to specific classes of adjectives (i.e., privatives), and to anomalous combinations of adjectives and nouns. The research aims are thereby twofold. Firstly we intended to replicate the result of Fritz and Baggio (2020), showing how the composition of adjective-noun phrases relative to suitable controls gives rise to a P600 effect. We do this by adopting and modifying the design used in their study, comparing adjective-noun phrases with stimuli where the adjective is replaced by either a non-word or a pseudo-word. Secondly, we investigated how adjectival semantics impacts the ERP signals, in particular the effect of privative vs. non-privative pre-nominal adjectives in Norwegian. We aimed at replicating the post-N400 effect as seen in Fritz and Baggio (2020). In order to separate the effect from N400, a classic semantic anomaly condition was included.

This research is the result of a collaborative project carried out with fellow student Martine Kibsgaard. Together we have adapted the stimuli, recruited participants and spent many hours in the Language Acquisition and Language processing Lab at NTNU, recording the data. The research aimed at isolating the neurological response to composition and to study modification at the phrasal level. Hence, conditions modifying semantic and syntactic composition were both included. This present thesis will be concerned with composition from a semantic perspective. Conditions thought to modulate syntactic aspects of composition will be presented by Kibsgaard (2021).

1.2 Overview

The following sections will present an overview of the theoretical background of this study. Chapter 2 will review parts of the literature on semantic compositionality, while keeping in mind that the goal of many language researchers is to map the relation between theoretical distinctions and actual language comprehension. In order to achieve a more complete

understanding of these relations, this thesis will focus on adjectival semantics. Both how adjectives are classified and how they function as modifiers.

Chapter 3 provides an introduction to the ERP technique. This introduction will be followed by examples of ERP components that are often encountered in language research.

Chapter 4-5 will present the study concept in more detail.

Chapter 6-7 will present the behavioral and EEG results before discussing them in light of the research aims.

2 Compositionality

The perceived tension between the infinity of language and the finiteness of the brain is partly resolved by the productive capacity of human language. Due to this productivity, all linguistic theories of semantic interpretation include some version of compositionality. How strongly, or in what cases, compositionality applies are though controversial. In some theories we see a complete homomorphism between semantics and syntax. The hypothesis is that the two systems work in tandem, the result being that the meaning of the sentence is fully determined by the meaning of the constituents and the way they are combined (Montague, 1970). Expressions that are proven well-formed by syntax are given a meaning by semantics. The syntactic rules that determine well-formedness are thereby paired with the semantics that assigned the meaning (Jacobson, 2014). Other theories open up for the idea that there may be semantic rules that do not correspond to any syntactic rule. Each syntactic process still correlates to a semantic step, but in these theories, purely semantic rules exist. Co-composition is one such example, where a semantic step can alter the meaning of a constituent in order to fit another constituent (Pustejovsky, 2012). The Simpler Syntax Hypothesis by Culicover and Jackendoff (2006) is another theory that argues for a richer compositionality. The idea is that words do contribute to the interpretation of a sentence, but that there are semantic principles that go beyond this simple mapping with syntactic structure. Ultimately, how the syntactic system of language and the compositional semantics work together is a matter of great discussion. This thesis takes its starting point in formal semantics rooting in Montague Grammar tradition (Montague, 1970, 1973).

Adjectival modification yields an interesting case for compositionality. Adjective-noun phrases serve as a minimal combinatorial process, but even simple composition like this has different neural computations depending on features of the adjective. Some adjectives have powerful effects on the interpretation of an adjective-noun phrase. A clear example is how privative adjectives like “fake” and “imaginary” significantly alter the denotational characteristics of the noun they modify. Presently there is a scarcity of research on how adjectival modification influences the composition of phrasal meaning on-line.

2.1 The principle of compositionality

When studying meaning from a formal semantics point of view, a fundamental question is how the meanings of complex expressions are composed from the meanings of their

constituents. Compositionality occupies this central position as it concerns the relation between syntax and semantics. As mentioned in the introduction, human language is able to generate an infinite number of sentences, but it is also able to establish the meaning of these infinitely many sentences. Semantics is therefore bound to establish a finitely describable engine that can generate all possible meanings (Katz & Fodor, 1963, p. 172). The idea of compositionality seems to satisfy these needs. The compositionality principle, which is often attributed to Frege, can be expressed as "The meaning of an expression is a function of the meaning of its parts and of the way they are syntactically combined" (Partee, 2008, p. 153). This idea is grounded in Frege's conjecture on saturation. He theorized that semantic composition consists in the saturation of an unsaturated meaning component (Heim & Kratzer, 1998). An unsaturated component is not complete in itself but is in need of supplementation. A verb is a prototypical unsaturated expression. Unsaturated meanings can therefore be seen as functions which take arguments, and the composition process is modeled as the application of a function to an argument. This idea is therefore often called Functional Application. However, this composition principle is very general and in need of further specification, among other things a theory of meaning.

Within, formal semantics the model-theoretic view on meaning prevails. This view emphasizes how semantic interpretation is seen as relating expressions to constituents, such as possible situations, entities, properties, truth-values etc. This is often assumed to stand in opposition to thinking of semantics in representational terms (Portner & Partee, 2008, p. 2). Nonetheless, there are linguists claiming that there is no opposition between the formal semantic view and the cognitive view (Hamm, Kamp, & Van Lambalgen, 2006).

Understanding the meaning of a sentence is often connected to its truth conditions: One needs to know what the world must be like for the sentence to be true, in order to understand its meaning. To provide truth conditions for all well-formed sentences is the job of semantics. The role of syntax is to specify the set of well-formed expressions. Syntax also has to support the compositional semantics (Partee, 2007). Syntax and semantics can therefore be seen as structures connected by a homomorphism, where compositional rules come in pairs.

2.2 Adjective semantics

2.2.1 Adjective-noun composition

A theory of semantic interpretation needs to characterize how elements in a syntactic string semantically relate to one another. In both English and Norwegian, adjective phrases have

perhaps the most varied distribution of any syntactic category (McNally & Kennedy, 2008, p. 2). Adjectives manifest a high degree of flexibility as they can serve as both primary and secondary predicates, but more importantly for this thesis also as modifiers of nominals. When determining how adjectives modify nouns we need to return to the Principle of Compositionality and Functional Application. The relationship between adjective-noun combinations is thought not to be accounted for in the same way as verbs previously was described. Heim and Kratzer (1998) show that to account the relationship between modifiers (adjectives) and the modified expressions (nouns) on Functional Application, leads to a systemic cost. This makes it more reasonable to assume another operation for modifiers, namely Predicate Modification (Heim & Kratzer, 1998, p. 65). Predicate Modification can be described in set theoretic terms as (1):

(1) "If a branching node α has as its daughters β and γ, and ⟦ β ⟧ and ⟦ γ ⟧ are both sets of individuals, then ⟦ α ⟧ = ⟦ β ⟧ ∩ ⟦ γ ⟧" (Morzycki, 2016, p. 15).

Functional Application and Predicate Modification are two standard accounts of composition, but more contemporary model-theoretic semanticists are questioning their indispensability, and multiple other accounts have been suggested (for an overview, see Leffel, 2014). Despite a number of well-grounded accounts of composition, psycholinguists are still searching for the neural correlates of this process.

Adjectives can be classified based on the inferences an adjective-noun phrase can license. The most general rule for interpreting an adjective-noun phrase is that adjectives are functions that map the semantic value of the noun that they combine with onto the semantic value of the adjective-noun phrase. Adjectives are thereby taken to be functions from properties to properties (Montague, 1970; Parsons, 1970; Kamp, 1975) . This treatment follows from the intention to generalize to the worst case, that is having a uniform assignment of semantic types to syntactic categories (Partee, 2007). Meaning postulates are then used to stipulate semantic properties that distinguish various semantic subclasses within a certain semantic type.

The relationship between an adjective and the noun it modifies vary in respect to how much influence the adjective has in the relationship. For this reason, a basic typology of different adjective-noun phrases will be presented. This classification has become more or less standard, rooting in formal semantics. The classification is stemming from the work of Parsons (1970), Montague (1970) and Kamp (1975), and was epitomized in Kamp and Partee

(1995) and Partee (1995). The classification forms a hierarchy from intersective to subsective to non-subsective, and with privative adjectives as the most extreme case of non-subsective adjectives. The hierarchy has been challenged lately, especially regarding the position of privative adjectives. A short overview of the different classes will now be given, before the focus will remain on the role of privative adjectives. A visual representation of the typology is given in Figure 2.1.

2.2.2 Adjective typology

2.2.2.1 Intersective adjectives

The simplest kind of adjective-noun relationship is a symmetric one. They are called intersective adjectives, as the noun is a member of the intersection of two sets. In (2) we have an instance of this, where both the noun and the adjective give rise to straightforward entailments:

(2) Sophie is a Danish doctor
    a. *entails*: Sophie is Danish
    b. *entails*: Sophie is a doctor.

Sentence (2) can also be represented in set theoretic terms as:

(3) [[Danish doctor]] = [[Danish]] ∩ [[doctor]].

The sentence is true if and only if both of the entailments are true. The adjective makes a contribution to the truth-conditions without regard to the properties of the noun (Morzycki, 2016, p. 16); i.e., we can replace the noun *doctor* freely with any other arbitrary noun that also characterizes Sophie and still arrive at a true sentence. It is valid to reason as in (4):

(4) Sophie is a Danish doctor
    Sophie is a swimmer
    therefore: Sophie is a Danish swimmer

2.2.2.2 Subsective adjectives

The kind of intersective interpretation just shown is not available with all kinds of adjectives. If we replace *Danish* with for instance *talented*, we get:

(5) Sophie is a talented doctor

To identify the set of talented individuals is challenging as we can only evaluate it with respect to some kind of activity. As a result, we cannot not represent it similar to sentence (3), as [[talented doctor]] ≠ [[talented]] ∩ [[doctor]]. Instead, we need to think of the denotation of the phrase as being a subset of the denotation of the noun. For example, the set of talented doctors is a subset of the set of doctors.

(6) [[talented doctors]] ⊆ [[doctors]]

The class of subsective adjectives contrast with intersective adjectives as they cannot be identified independently of the noun they modify. For example, a *large bonsai tree* is not necessarily in the subset of large things, not even in the subset of large trees. It is only large in relation to the particular noun it is modifying. Most adjectives are considered to be subsective as all intersective modification is also subsective, this due to the intersection of the two sets being a subset of both of them. Subsective is from here on out used as 'subsective, but not intersective'.

2.2.2.3 Plain non-subsective adjectives

Some adjectives do not fall into either the category of intersective or subsective adjectives. Among these:

(7) A potential/possible/likely thief.

a. [[potential thief]] ≠ [[potential]] ∩ [[thief]]
b. [[potential thief]] ⊄ [[thief]]
c. *does not entail*: * Someone is potential
d. *does not entail*: Someone is a thief

An intersective interpretation is not possible, as a *potential thie*f is not a part of the set 'potential individuals'. The individual is neither considered a part of the set of thieves. A subsective interpretation is not possible either as the set of potential thieves probably contains some thieves, but also some individuals who are innocent. This means that there may still be an intersection between the denotation of a noun modified by a non-subsective adjective and the denotation of the noun. Non-subsective adjectives like this are often analyzed as a function that applies to the meaning of the noun (Morzycki, 2016, p. 23). This is because they push the semantic content of the noun to include multiple possible worlds or truth scenarios.

2.2.2.4 Privative adjectives

The last categorization of adjectives that will be presented is privative adjectives. They are a sort of non-subsective adjectives. They are distinguished by entailments like (8):

(8) He is a fake doctor
   a. *entails*: He is **not** a doctor
   b. *does not entail*: He is a doctor

As seen in (8), these adjectives seem to negate the meaning of the noun. The set of fake doctors is neither a subset of the set of doctors, nor is a fake doctor in the set of doctors. In other words, the intersection between the two sets is empty, as (9b) reflects.

(9) He is a fake doctor
   a. [[fake doctor]] $\not\subset$ [[doctor]]
   b. [[fake doctor]] $\cap$ [[doctor]] = $\emptyset$

Privative adjectives denote a set that is disjoint from the denotation of the noun they modify. Therefore, they pose a challenge for compositionality as elements of the bare noun do not end up in the modified NP set. How the bare noun contributes to the compositional process and what operation the adjective is performing over the noun is difficult to evaluate. While the entailment pattern suggests a negation of the denotation of the noun, it would clearly be insufficient to say that a phrase like *fake doctor* denotes 'the set of things which are not doctors', as that would include both what we understand as fake doctors but also all other non-doctor entities in the world (J. Martin, 2018).

Partee (2007) has proposed a way of dealing with privatives where the fundamental idea is that they do not exist as their own category, but rather as a kind of subsective adjectives. Evidence from Polish (Nowak, 2000) have shown that an NP consisting of Adj and N only can participate in a splitting construction if the adjectives are both predicative and intersective, subsective or privative. This empirical data, showing how intersective, subsective and privative adjectives pattern together, leads to the proposal that there is no such thing as a natural class of privative adjectives (Partee, 2007). Further, she hypothesizes that the denotation of a noun should be expanded to include both fake and real versions of it. Combining a noun with what has been described as a privative adjective leads to a coerced expansion of the denotation of the noun. Once this coercion has taken place, the adjective can modify the noun in a subsective way. Without this coercion, adjectives like *real* or *authentic*, would be redundant. Modulating privatives like *fake* involves a shift in meaning (fake gun reading: looks like a gun), similar to what is observed with constitutive material adjectives (Oliver, 2014). This expanded denotation of nouns can also explain the acceptability of sentences like *Is that gun real or fake?* This sentence would be difficult to analyze if the concept of a gun entails ¬*fake gun*.

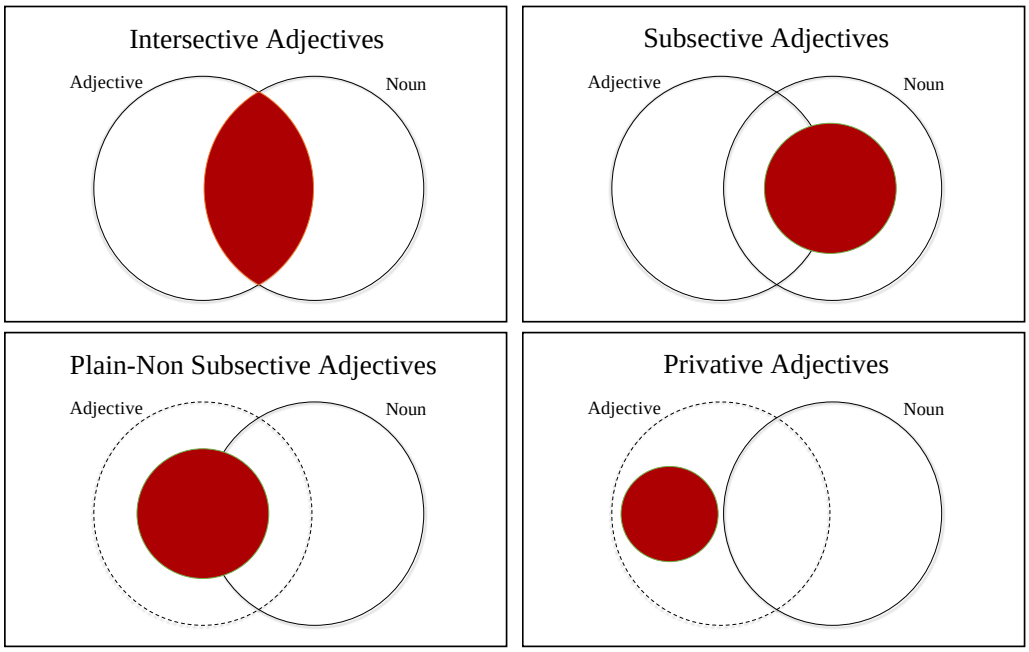

Figure 2.1 Visual representation of the different classes of adjectives. Denotation of nouns and adjectives are displayed as hollow circles. Non-subsective adjectives do not have denotations and are therefore displayed as broken circles. The red circles represents the denotation of the adjective-noun phrase. Adapted from Nayak, Kowarsky, Angeli, and Manning (2014).

2.2.3 Modification by privative adjectives

Privative adjectives force us to move beyond the literal denotation of the noun they combine with, and thus violate the principle that the head of a phrase dictates its overall meaning. Kamp and Partee (1995) has described this principle as the "Head Primacy Principle", which is the process where the noun is first interpreted in a given context before the adjective is used to adjust as needed. An example of how this works is in the adjective-noun phrases *a fast turtle* and *a slow cheetah.* Partee (2003) believes that dealing with privative adjectives includes the "Non-Vacuity Principle" outranking "The Head Primacy Principle". The "Non-Vacuity Principle" is described as "in any given context, try to interpret any predicate so that both its positive and negative extensions are non-empty" (Kamp & Partee, 1995, p. 161). Similar to Partee's (2003) negative extension, Schumacher, Brandt, and Weiland-Breckle (2018) refer to this process as a weakening of the adjective's literal meaning. They propose that the negation of properties entailed by the meaning of the head noun leads to an intermediate representation violating the law of contradiction, i.e., the demand that an item cannot be both p and not p. In some sense a *fake doctor* can be said to be a doctor and in some other sense not to be a doctor. Which particular aspect of the noun is negated, depends on the context of the utterance. Schumacher et al. (2018) concluded that the intermediate representation is followed by a process of contextual adjustment of the meaning of the noun.

Adjectives like *real* and *authentic* can also be seen as context dependent, similar to privative adjectives. Using these kinds of adjectives highlights certain properties of the noun's denotation. When uttering a *real doctor,* one needs to determine the prototypical features of a doctor. In this sense the function of "real" is not to contribute positively, but to exclude possible ways of being *not* real (Schumacher et al., 2018). The crucial difference is that they do not cause the contradiction that privative adjectives do. The use of adjectives like *real* are though not redundant as they highlight and strengthen prototypical aspects of the head noun. To summarize, privative adjectives give rise to a reconceptualization of the original denotation, while adjectives like *real* only highlight primary properties of the noun. This caused Schumacher et al. (2018) to draw the conclusion that it is expected that the negation process is more cognitively demanding than highlighting salient properties. Both adjectives do however rely on inferential reasoning and an update of the context during the compositional process.

In addition to Partee (2003), Francez and Koontz-Garboden (2015) also claim that privative adjectives do not exist as a category and that they rather should be treated as intersective. Their idea is that privative adjectives are context-dependent and that a *fake*

doctor thereby only lacks some contextually relevant property, such as a proper education. This lets us treat privative as intersective when the contextual parameters are known.

In opposition to this belief, Cinque (2014) holds that the removal of privative adjectives as its own adjective class is an idea that should be abandoned. He points out that Partee (2003) seems to be correct in that the fundamental split is between predicative and non-predicative adjectives (see also Chierchia & McConnell-Ginet, 2000). This is apparent as both intersective, subsective and privative can appear as predicates, while modal/adverbial adjectives cannot:

(10)

a. The doctor is Norwegian
b. The doctor is intelligent
c. The doctor is fake

(11) * The doctor is former

Nonetheless his theory differs from Partee (2003) in that the removal of the class of privative adjectives, in his opinion, only works for adjectives in predicate position or those who are merged as predicates in relative clauses. His example of adjectives in Italian show that pre-nominal adjectives are non-intersective while post-nominal adjectives can be either non-intersective or intersective:

(12)

a. Giorgio si è rivelato un **falso amico**
   G. turned out to be a false friend (= a non-friend, not a hypocritical friend)
b. Giorgio si è rivelato un **amico falso**
   G. turned out to be a false friend (= a hypocritical friend, not a non-friend)

(Cinque, 2014, p. 23)

In some cases, the non-intersective interpretation is not plausible, which in Italian is expressed when the adjective is in predicate position:

(13) Quel tuo amico è falso
'that friend of yours is hypothetical'
that friend of yours is a non-friend

(Cinque, 2014, p. 23)

In other cases, the subsective/intersective interpretation is not available, which in Italian coincides with cases where the adjective can neither be in predicate position nor can be used post-nominally. Cinque (2014) shows that the adjective *fake* has a truly privative meaning when in a pre-nominal position in Italian, as it then negates the denotation of the noun. When the adjective appears in a post-nominal position it has an intersective/subsective interpretation, indicating one of the possible forms that the referent of the noun can take.

By that, the conclusion is that two separate uses of words like "fake" should be posited and thereby the class of privative adjectives exists after all. Cinque (2014, p. 24) describes privative adjectives as "non-intersective, non subsective, non-predicative".

3 EEG research in linguistics

The present thesis reports on an experiment on the semantics of adjective-noun combinations using EEG. In what follows, I will therefore introduce the EEG technique and relevant dependent measures (event-related potentials) to the extent that they are useful for understanding the methodology of the present study.

3.1 Overview of the Event-Related Potential Technique

One of the most widely used methods to study cognitive processes in real time is EEG. This neurophysiological technique was the first direct and noninvasive measurement of human brain activity (Woodman, 2010). Ever since Berger (1929; cited in Luck, 2014) discovered that the electrical activity of the brain can be measured at the human scalp, it has been assumed that these fluctuations reflect neural activity, including mental processes. In most cases, these neural responses (ERPs) are generated by a large number of postsynaptic potentials (Woodman, 2010). Postsynaptic potentials represent the changes in potential that arise when neurotransmitters are released from one neuron and then bind to the membrane of another. This process alters the flow of ions across the cell membrane (Luck, 2014). Thus, the activity recorded with EEG represents the summation of postsynaptic potential present in the dendrites and the body of the neuron. A postsynaptic potential from a single neuron creates a miniscule electrical dipole, which means that an ERP can only be recorded when thousands of neurons, which are similarly oriented with respect to the scalp, are active simultaneously in a given region. The electrical potential travels close to the speed of light and the voltages measured at the scalp thereby reflects activity at that particular instant (Kappenman & Luck, 2011, p. 6).

An EEG channel consists of the three electrodes combined: active, reference and ground. The potential for current to pass from the active electrode to the ground electrode is recorded. However, electrical noise generated from the amplifiers is present in the electrical circuits and will inevitably be mixed up in the recording. As a result, a reference electrode is used to create a differential amplifier (Luck, 2014, p. 151). The output is equivalent to the electrical potential between the active and reference electrodes, resulting in some of the noise being cancelled out.

The ERPs generated are averaged across multiple time-locked trials in order to remove activity that is unrelated to the stimulus (Luck, 2014). The result is waveforms representing

the commonalities of small amplitude voltage fluctuations. The series of positive and negative peaks are represented in terms of latency and amplitude. When comparing two differing waveforms, the ERP effects are what sets them apart. ERP effects are described by the scalp distribution and the amplitude differences of the two waves (Otten & Rugg, 2005, p. 7). A difference in scalp distribution implies that different neural and cognitive processes are associated with the two waves. When the ERP effect is only differing in amplitude, it is taken to be a quantitative difference between the two waves. That is, the experimental manipulations are thought to have engaged the same neural activity, but to differing degrees.

The ERP waveforms detected at the scalp typically reflect multiple internal underlying components. Although there is no universally accepted definition of what constitutes an ERP component, it can be useful to think of it as a part of the ERP waveform representing certain neurocognitive processes (Kappenman & Luck, 2011, p. 4). These neurocognitive processes show up reliably as modulations of the ERP wave, either of polarity or at specific temporal latencies from the events of interest. A component may occur at different times and under different conditions. That is, an ERP component is a source of a systematic and reliable variability in the ERP. ERP components are often defined by a combination of polarity, latency and scalp distribution, and this is evident in their naming scheme. An ERP component is most commonly named with an N or a P, indicating if it is positive- or negative-going, and a number indicating either its position in the waveform or its latency. Importantly, the ERP components are not the same thing as the peaks, as peaks are somewhat arbitrary (Kappenman & Luck, 2011, p. 4). A peak is only the local voltage maxima and does thereby not reflect a specific brain process. One reason for peaks and components to not co-occur is that the neural activation connected to each distinct mental process lasts for tens or hundreds of milliseconds (Kappenman & Luck, 2011, p. 10). This means that the ERP signature of one process overlaps with the subsequent process.

ERP components can be classified as exogenous and endogenous. Components peaking within the first 100 milliseconds are named exogenous or ‘sensory’ as they depend substantially on physical parameters of the stimulus. ERPs generated at a later stage reflects how subjects evaluate stimulus, and by that how information is processed. These components are named ‘cognitive’ or endogenous (Gaillard, 1988; Sur & Sinha, 2009). Most language researchers have restricted their attention towards endogenous ERP components as they can be elicited by linguistic stimuli (Coulson, 2007, p. 405).

3.2 Making inferences from ERPs

Within cognitive neuroscience, ERPs are commonly used to assess the brain's sensitivity to various experimental manipulations (Luck, 2014). Determining what stage or stages are influenced (or not influenced) can in turn constrain theories of various cognitive and behavioral phenomena (Kutas & Dale, 1997). There is an immense amount of research attempting to associate particular features of ERP waveforms (components) with distinct cognitive processes (Otten & Rugg, 2005). The following section will present the methodological strengths of ERP.

The most acknowledged virtue of the ERP technique is its ability to track subtle differences in the rapidly changing electrical fields, at multiple locations at the scalp with millisecond resolution. By taking measurements prior to the stimulus and extending the ending past the response, it results in a continuous measurement of the whole process. This enables the possibility to make inferences based on the state of the brain prior to the onset of stimulus. It also provides information on the brain activity after the response, reflecting processes that determine how the brain will operate in upcoming trials (Luck, 2014, p. 25). This continuous temporal information shows how a given experimental manipulation influences several different processes. In studies of language comprehension, ERPs can be used for assessing processing of words at the time the word is presented, instead of relying on a response made afterwards. In addition to information on the time course of linguistic computation, EEG data can provide us with knowledge on the nature of the neural responses of interest. That is whether the responses are fast or slow, phasic or tonic, etc.

Many researchers have attempted to understand how the different fields on the scalp function, both in terms of neuronal populations and cognitive processes (Otten & Rugg, 2005). In other words, by decomposing an ERP waveform into the underlying components, researchers hope to establish an understanding of how cognitive or neural processes differ across conditions. Waveforms recorded at the scalp represent a mixture of many components. The voltage at a given electrode site is the combined sum of all the underlying components. This means that decomposing an ERP wave into the individual underlying components is a very complicated process. Luck (2014, p. 29) refers to it as the superposition problem as there are multiple components that are superimposed onto the same waveform. This is one of the most challenging aspects of ERP research. Despite the lack of an infallible way to recover underlying components, there are multiple techniques to help identify specific ERP components.

3.3 Known ERP components

As mentioned, the idea behind an ERP component is that it represents underlying neural and cognitive processes. ERP waveforms recorded at the scalp are a result of a mixture of components. This means that the voltage peaks do not represent the underlying neurological activity. To learn about the underlying conditions, a possible measure is to subtract the voltages from each timepoint in one ERP waveform to the corresponding times of another waveform. Subtracting difference waves, attempts to eliminate overlapping ERP components and thus isolate components that differ. To focus the experimental design so that the conditions differ minimally is also a strategy commonly used to isolate single components (Kappenman & Luck, 2011, p. 21).

In electrophysiological research on language comprehension, the two language sensitive ERP components N400 and P600 take center stage. Despite a tremendous number of ERP studies conducted in recent decades, their functional interpretation is still in question. Lack of agreement is followed by large theoretical debates on the nature of language comprehension. An account of the discovery and the ensuing theoretical hypotheses of the components will be given below.

3.3.1 N400

The first report of N400 came with Kutas and Hillyard (1980), and it has since become the best-studied language component. Their experimental research consisted of a modified oddball paradigm, having participants reading congruent and incongruent sentences. The experiment was expected to elicit a P300 response when sentences were semantically incongruent, but a large negative deflection was observed instead. This observed negative wave, largest over the centro-parietal electrode sites, with a slight right-hemisphere bias and a peak at 400 ms after stimulus onset, was labeled the N400 response (Kutas & Hillyard, 1980). The measured difference between the N400 amplitudes of stimuli in two different experimental conditions is called the N400 effect.

This result may lead to the invalid impression that N400 is the neural reflection of a linguistic anomaly detector. Today the consensus view is that all potentially meaningful items elicit N400 activity (Kutas & Federmeier, 2009; Kutas & Federmeier, 2011). This has led to a vast amount of research manipulating the component's amplitude, in an endeavor to figure out how language processing unfolds over time and what kind of information is engaged at specific time points by the processing system.

Even though N400 can be elicited by any meaningful stimuli, two experimental paradigms called the semantic-priming paradigm and the semantic-anomaly paradigm are often used to look at N400 effects. Within the semantic-priming paradigm, a related or unrelated word is presented ahead of a word target (such as 'moon-sun' or 'car-sun') (Lau, Phillips, & Poeppel, 2008). The N400 has generally been smaller when words are primed. The semantic-anomaly paradigm involves the presentation of a congruous or incongruous word embedded in the sentence, most often in the final position (such as 'the sun is shining/singing') Incongruent words show a much larger negativity than congruent words (Kutas & Hillyard, 1980).

N400 has been a useful measure for studies of language due to the number of factors proven to affect the amplitude of the elicited N400 response. Predictability, repetition, word-level priming and supportive context information are all thought to ease the processing effort relative to the baseline of N400 (N400 amplitude to stimuli presented in isolation) (Lau et al., 2008; Kutas & Federmeier, 2009).

The immense interest in the N400 component has led to multiple functional theories attempting to map it to particular cognitive operations. Two major competing functional interpretations are that it either reflects a lexical retrieval process, or that it reflects a semantic integration process (Baggio & Hagoort, 2011; Cosentino, Baggio, Kontinen, & Werning, 2017). In the lexical view it is believed that the amplitude of the N400 component is modified by the effort it takes to access information in the semantic memory. Thinking back to the semantic-anomaly paradigm, the difference between anomalous and predictable endings are explained by this theory as resulting from predictable words being easier to access from memory (Lau et al., 2008). The integration view holds that the amplitude of the N400 component is modulated by the effort to integrate the lexically retrieved information of the present word into the meaning information in the preceding context (Hagoort, Hald, Bastiaansen, & Petersson, 2004). Research on incongruence can be explained by this account as due to the extended effort it takes to process an implausible continuation in a way that fits the preceding context. Resolving the functional interpretation of the N400 effect has not reached full agreement, much due to contextual factors easing lexical access also could facilitate semantic integration (Lau et al., 2008).

Later developments have led Baggio and Hagoort (2011) to propose that the N400 reflects multiple processes. They argue that the distinction between lexical and combinatorial processes is a theoretical one and that processing is not a unidirectional procedure. They view the processing of words as a cyclic interaction of lexical and combinatorial processes. The

N400 component then reflects this cycle of the connected operations of both lexical activation and integration ('unification') (Nieuwland et al., 2020).

3.3.2 P600

A second ERP effect that has been related to language processing is a later positivity referred to as P600. This response has initially and most commonly been linked to the cost of syntactic processing, such as syntactic integration and repair or reanalysis of syntactic structure (Osterhout & Holcomb, 1992; Hagoort, Brown, & Groothusen, 1993; Hagoort & Brown, 1994b). The effect is broadly distributed, beginning approximately 500 ms after the occurrence of a syntactic violation (Coulson, King, & Kutas, 1998). One of the investigations using ERP to look at sensitivity to well-formedness was conducted by Hagoort et al. (1993). Their findings showed how subject-verb agreement violations in Dutch elicited similar effects as P600 (e.g., "Het verwende kind *gooien het speelgood op de grond/ "The naughty child *throwing the toy on the floor"). Due to these findings, it was argued that syntactic processing is distinct from semantic processing, as was seen in connection with the N400 effect. Studies have shown that the P600 effect is seen with a number of different syntactic anomalies. A study by Hagoort and Brown (1994a) showed how this also applied to syntactic violations in otherwise meaningless sentences (e.g., "the boiled watering-can smokes/*smoke the telephone in the cat"). This reinforced the conclusion that this component reflected linguistic structure and not meaning.

The neat mapping between linguistic domains and language related ERP-components has been doubted by linguists after the discovery of semantically induced P600 effects (Kim & Osterhout, 2005; Bornkessel-Schlesewsky & Schlesewsky, 2008). The abandonment of the idea that all semantic processing occur around N400 and that all the syntactic processing is reflected by P600, is one of the major empirical shifts in the field (Brouwer, Crocker, Venhuizen, & Hoeks, 2017; Fritz & Baggio, 2020). One of the most influential works was carried out by Kim and Osterhout (2005). In their work it was revealed that certain types of syntactically correct, but semantically anomalous sentences, did not elicit a N400 effect, but rather produced a P600 effect. They demonstrated that sentences like "The hearty meal was devouring the kids" produced the P600 effect and they hypothesized this effect as being dependent on the "semantic attraction" of the thematic roles. In the example, the "*meal*" is not an appropriate Agent for the verb "*devour*", but there is a semantically attractive alternative thematic role assignment as "*meal*" is an appropriate Theme. In sentences with low semantic attraction, an N400 effect was seen instead. Seeing as the inversion of the theta roles led to a

P600 effect, this component could be tied to a conflict between the output of the two streams of meaning and grammar.

Following the finding of a P600 effect to violations of thematic constraints, a number of possible explanations have been put forward in order to account for the occurrence of the semantic P600. The effects have been linked to both the integration of semantic meaning (Brouwer et al., 2017) and to the representation of the interface where semantic and syntactic information are combined (Bornkessel-Schlesewsky & Schlesewsky, 2008). Both approaches share the assumption that the on-line composition of meaning is not primarily determined by syntactic representations. In support of the latter idea, Kuperberg (2007) proposed that language comprehension consists of two parallel processes. First, a semantic-memory based process which computes the semantic features and relationships among the semantic components. Second, a combinatorial process which is sensitive to morpho-syntactic constraints and of semantic-thematic relationships. When there is contradicting output from the two processes, the extended analysis needed to resolve the inconsistency is reflected in the P600 component.

Propositional content may also be of importance regarding the P600 component. Schumacher (2013) shows how the metonymy in cases like (12a) is reflected as an enhanced processing cost compared to (12b).

(12)

a. The ham sandwich at table 2 wants to pay.
b. The ham sandwich is delicious.

Sentence (12a) only makes sense if the string “the ham sandwich” is interpreted as referring to a person associated with it, such as “the ham sandwich eater”. An account of the P600 should therefore include an explanation for reference transfers like this. Enriched composition shows a late positivity that could reflect the modification and updating of discourse representation structures (Schumacher, 2011).

The latest findings cast serious doubt on the traditional interpretation of P600 as a component reflecting syntactic integration and repair. In a broader sense, the occurrence of semantic P600 calls into question the dominance of combinatory syntactic processing.

4 The present study

The sections below will present the design of this study in more detail. The first section will focus on what is currently known about the brain signatures of meaning composition, based on MEG (magnetoencephalography) and EEG studies. The second section will present a few suggestions on the neural signature of privative adjectives. Together the sections make a connection between the theoretical background and the aim of this thesis.

4.1 The minimal phrase paradigm in language research

Within the field of cognitive neuroscience, an essential goal is to characterize the computations responsible for constructing complex meanings (Pylkkänen, 2016, p. 621). Complex meanings have in this thesis been described as the result of semantic composition. Despite the substantial amount of research conducted on semantic processing, there is currently a paucity of research targeting the composition of two simple elements. Pylkkänen and colleagues aimed at isolating compositional operations in their studies, contrasting brain activity when two consecutive stimuli could be composed to a phrase (eg., 'red boat') with brain activity where such combinations was either discouraged (e.g., 'cup, boat') or not possible (e.g., 'xkq boat') (Bemis & Pylkkänen, 2011, 2013; Pylkkänen et al., 2014). They reported across several studies that the left anterior temporal lobe (LATL) showed increased engagement in combinatorial context in the time window ~200-250 msec after the noun's onset. The authors concluded that these results are in agreement with the syntax-first accounts of language processing. Syntax-first models posit that the building of basic syntactic structure may precede semantic processes (Friederici, 2002). In addition to the early LATL effect, the compositional conditions elicited activity in the ventromedial prefrontal cortex (vmPFC) around 400 msec post noun onset (Bemis & Pylkkänen, 2011, 2013).

Neufeld et al. (2016) conducted an ERP study using the same paradigm and stimuli from Bemis and Pylkkänen (2011). Their findings supported the earlier MEG data, as they also found an early signature of composition (~180-250 msec) when comparing adjective-noun phrases with a letter string condition. This negative waveform was also present in the 300-400 msec interval and Neufeld et al. (2016) indicated that it could be the classic N400 effect. As shown in section 3.3.1, the functional interpretation of the N400 component is still debated. A study by Fritz and Baggio (2020) argued against the idea of N400 reflecting meaning composition. They are of the opinion that the different accounts of the N400, that is

integration, retrieval or unification, all reflect a top-down context-sensitive unification of word meaning. They do not believe that N400 reflects bottom-up syntax driven composition. Their research points towards the P600 being one component that correlates to meaning composition. A comparison between [Det Adj N] phrases with a real adjective relative to a non-word or a pseudo-word revealed a larger P600 in the semantic trials. This result culminated in the proposal that the P600 reflects either semantic composition or syntactic and semantic composition.

Pylkkänen (2016, p. 621) pointed out the need for more research on minimal composition, which is what the current study makes a contribution towards. The study follows the design of Fritz and Baggio (2020) with trials consisting of [Det Adj N] phrases, but with a different set of stimuli and conditions. ERP averages were time-locked to the noun and the pre-nominal adjective was manipulated. A total of seven conditions were constructed, where six are analysed in this thesis. The three experimental conditions include privative adjectives, non-privative adjectives and semantically anomalous adjectives. Three conditions replacing the adjective with an unpronounceable string (non-word), a pseudo-word and a submodifier (details below) functions as baselines. We set out to further test the hypothesis that the P600s amplitude is modulated by semantic composition. By contrasting trials containing real non-anomalous adjectives against trials where the noun is preceded by pseudo-words or non-words, we would presumably replicate the results of Fritz and Baggio (2020).

The non-semantic conditions in Fritz and Baggio (2020) can be criticised for not being suitable as baselines, as participants might stop paying attention due to no compositional task. The present study wants to address that by including a condition with the syntactic structure [Det Adv N]. Our prediction, based on the empirical results of Fritz and Baggio (2020), is that the contrast between semantic (privative, non-privative and semantic anomalous) and non-semantic (non-word, pseudo-word and submodifier) conditions modulate the amplitude of the P600 component. The experimental design differs from the work of Bemis and Pylkkänen (2011) as a word list was not included. Omitting the word list was due to the high occurrence of noun-noun compounds in Norwegian. An N-N list could potentially lead to semantic composition, which would make them unsuitable as control conditions.

4.2 Adjectival modification

The previous section shows how preceding research on the neural bases of meaning composition in minimal phrases primarily have used adjective-noun combinations. Adjectival modification can significantly impact noun meaning. In the case of privative adjectives, we have seen that the adjective determines the denotations of the noun entirely. Previous research on the neural bases of meaning composition has also revealed P600 effects in connection with privative adjectives and nouns. Schumacher et al. (2018) reported that privative [Adj N] phrases like (e.g., "fake diamond") elicited P600-like effects compared to their negative [Adj N] phrase counterparts (e.g., "damaged diamond"). Schumacher et al. (2018) proposed that these effects could reflect the processing costs of privative adjectives. The Late Positivity seen when extending the interpretation of an entity, could reflect the repair mechanism of structures violating the notion that not (p and not p) (Schumacher et al., 2018). This relates to the point made by Partee (2003), that "Is that gun real or fake" is both well-formed and interpretable, but at the same time the sentence "A fake gun is not a gun" stands to be true. Privative [Adj N] combinations could by that involve a mechanism that repair the noun meaning and reconfigure the discourse model, much like was proposed in the case of word metonymy.

Fritz and Baggio (2020) identified a different neural correlate for privative adjectives. Similar to the conclusion of Schumacher et al. (2018), they initiated their research with the assumption that privative adjectives prompt additional processing costs compared to non-privative adjectives. Their results indicated that it was not a P600 effect, but rather a post-N400 effect that follows the comparison of privative and non-privative trials. They propose two ways of interpreting this effect. First, they suggest that the effect could represent modulations of a negative post-N400 component. This could be seen in compliance with other research on referential processing, also showing a negative component. This interpretation was their initial choice but as the scalp distribution differs from other referential ERP effects, i.e., they had a centroparietal distribution compared to referential ERP effects normally being frontally or anteriorly distributed, they are holding back on making more assertive claims. The second interpretation presented is that the post-N400 effect actually could be an instance of P600 effects. This view entails privative adjectives evoking a smaller response than non-privative adjectives. Both latency and distribution of their effect supports this hypothesis, but their behavioral data does not.

The present study wishes to replicate the effects of privative adjectives seen in Fritz and Baggio (2020). Using formal linguistic theories to guide the experimental design, enables us

to determine which linguistic phenomena should be grouped together in a condition. In this case we tested whether the theoretical difference between privative and non-privative adjectives are reflected in different ERP effects. In light of the empirical data presented, we predict that this comparison will modulate the time window following the N400, but earlier than the P600. By including the condition with a semantically anomalous adjective-noun combination, we wished to further separate the effect of privative adjectives from the N400 component. We predict that the semantically anomalous condition will modulate the N400 component when compared to non-privative adjectives.

5 Methods

5.1 Design and aims of the present study

This thesis made use of EEG to collect data on minimal phrase composition, specifically adjective-noun phrases. Four different conditions of adjective-noun phrases were tested, privative, non-privative, semantic anomaly and syntactic anomaly. Three phrases including non-word, pseudo-word and a submodifier were included as baselines for comparison. This chapter describes and explains the methodology of the experiment conducted – stimuli, participants, procedure, data acquisition and data analysis.

As mentioned in the introduction of this thesis, the recruitment of participants and the data collection were done in close collaboration with fellow student Martine Kibsgaard.

5.2 Participants

Participants were recruited at and around NTNU Trondheim by flyers. Participants received a voucher with the value of 150 NOK as compensation for their participation. 30 right-handed participants were included in the final data analysis (20 female and 10 male; mean age 25,0 years, range [19, 52] years, SD= 7,1). All participants had normal or corrected-to-normal vision and had no self-reported history of neurological disorders or trauma. All participants were native speakers of Norwegian and had Bokmål as their native written language. The participants reported that they grew up in a monolingual environment with Norwegian as their first language of acquisition. Three additional volunteers were tested and then later excluded due to low accuracy in at least one condition (below 60%). Data from one additional volunteer was excluded due to excessive EEG artifacts, i.e., fewer than 15 trials were left in one or more experimental conditions. Prior to the experiment, participants gave their written consent to partake in the study. By signing the consent form, participants also declared that they were not taking any medication that could affect the EEG recording (Appendix D). The study was approved by the *Norsk senter for forskningsdata* (NSD; project nr. 965339) and was conducted in compliance with NSD regulations.

5.3 Stimuli

The experiment made use of stimuli created for a former experiment by Fritz and Baggio (2020). The stimuli was then reworked to fit the current experiment. Native Norwegian speakers checked the stimuli for naturalness and grammaticality. Three pilot tests were

conducted ahead of the experiment in order to prevent mistakes and unforeseen effects. The feedback following the pilot test led us to change some ambiguous words and phrases.

5.3.1 Conditions

A total of 100 phrases in Norwegian (Bokmål) with the syntactic form [Det Adj N] were included in the experiment. These 100 phrases formed the four experimental conditions, including privative adjective, non-privative adjective, semantic anomaly and syntactic anomaly. In addition, the stimuli consisted of 25 phrases with the syntactic form [Det Adv N], 25 phrases using a non-word instead of the adjective and 25 phrases using a pseudo-word instead of the adjective. This makes a total of 175 phrases constructed as 25 groups of 7 where each group had the same N and each group included all the experimental conditions. The phrases were then organized into 7 experimental blocks where each block had equal or almost equal number of trials from each condition. Each block contained exactly one of all of the 25 target nouns and the adjectives were drawn equally from all 7 conditions. The phrases were randomized within the blocks so that the same condition would not show up twice in a row. The blocks were counterbalanced by grouping them into 4 different groups, which were further organized into 4 lists using a 2x2 Latin square design. An equal number of participants was assigned to each version created by the Latin square design. Counter-balancing the lists prevents variables such as insecurity in the beginning or tiredness towards the end of the experiment, from having an effect on the results. A within subject design was used. In this type of design each participant is exposed to every trial in the experiment. Having only 30 participants included in the final data analysis; this type of design gave a boost to the statistical power of the results.

The experiment includes a total of 7 conditions. In order to look at the effect of *semantic* composition, two conditions were included to function as baselines. In one condition the noun was preceded by an unpronounceable string of consonants (i.e., non-word), which was meant to block any semantic or syntactic composition of the prenominal stimulus and noun. A second condition contained a pseudo-word which resembled a Norwegian adjective in that it followed the rules of Norwegian phonotactics and morphology. The pseudo-word was marked morphologically with the correct gender, in agreement with the noun and the determiner. With the pseudo-word condition, syntactic composition may occur, but not in the non-word condition. The difference between the two baselines lets us disentwine the possible differences between syntactic and semantic composition. For each adjective used in the

stimuli, a non-word and a pseudo-word were created with the same word length to match it. The non-words and pseudo-words were each used once in the stimuli set.

The phrases with the syntactic form [Det Adv N] were included as an additional condition that is assumed not to involve syntactic and semantic composition. Participants might stop paying attention with the non-word and pseudo-word conditions as they know there is nothing to compose. The adverb functions as a meaningful word, but it is still not possible to compose it with the noun to make a meaningful and grammatically correct phrase.

There was a total of four experimental conditions. Two conditions were concerned with the notion of privativity, i.e., one condition with privative adjectives and one condition with non-privative adjectives. The third condition included a semantically anomalous adjective in combination with the noun and the last condition had an adjective-noun phrase paired with a syntactically anomalous determiner. Table 5.1 shows an example set of stimuli in each experimental condition together with their English translations. The full set of stimuli is given in Appendix B.

Det.	**Adjective**	**Noun**	**Composition**	**Condition**
en	tvbmpl	student	Syn– Sem–	Letter string
a	[nonword]	student		
en	vurlig	student	Syn+ Sem–	Pseudo-word
a	[pseudoword]	student		
en	tydeligvis	student	Syn? Sem?	Submodifier
an	apparently	student		
en	ekte	student	Syn+ Sem+	Non-privative
a	real	student	[Adj N] ∩ [N] ≠ Ø	
en	trekantet	student	Syn+ Sem?	Anomalous semantic
a	triangular	student	[Adj N] ∩ [N] ≠ Ø	
en	imaginær	student	Syn+ Sem+	Privative
an	imaginary	student	[Adj N] ∩ [N] = Ø	
et	indisk	student	Syn? Sem+	Anomalous syntactic
an	Indian	student	[Adj N] ∩ [N] ≠ Ø	

Table 5.1 Experimental design and examples of stimuli in all 7 conditions.

5.3.2 Adjectives

The number of privative and non-privative adjectives in Norwegian are limited and the adjectives were therefore re-used multiple times in the stimuli set. The attributive adjectives used in the experimental stimuli were: 5 non-privative adjectives (*virkelig* real, *ekte* genuine, *eksisterende* existing, *ordentlig* proper, *autentisk* authentic), 4 privative adjectives (*falsk* fake, *fiktiv* fictive, *imaginær* imaginary, *oppdiktet* made-up), 5 intersective adjectives for the semantic anomaly (*oval* oval, *sirkulær* circular, *oransje* orange, *trekantet* triangular, *kvadratisk* square) and 5 intersective adjectives for the syntactic anomaly (*australsk* Australian, *nederlandsk* Dutch, *grøndlandsk* Greenlandic, *indisk* Indian, *gresk* Greek). Each single adjective was repeated between 5 and 7 times in the experiment. To achieve a well-controlled stimulus set, it was attempted to match adjectives on phoneme numbers, see Table 5.2. An attempt was also made to match the adjectives on frequency, but the scarcity of privative and non-privative adjectives made this unachievable (Table 5.3).

In the syntactic anomaly condition, the noun was combined with a syntactically incorrect determiner. The nationality adjectives were chosen for this condition specifically because they have a zero (null) morpheme for gender marking and the anomaly is therefore only apparent at the noun. Regarding the adjectival modification in the semantic anomaly, we included a sortal mismatch. The adjectives denoted either color or shape attributes. These properties of the adjective cannot apply to the referent noun due to ontology and our world knowledge, i.e., a student is not the sort of thing that can be triangular.

Length	*Submodifier*	*Non-Privative*	*Privative*	*Semantic anomaly*	*Syntactic anomaly*
Mean	8.2	8.4	7.0	7.6	8.2
SD	2.17	2.88	1.83	2.30	2.59

Table 5.2 Mean and standard deviation for length on adjectives

Frequency	*Submodifier*	*Non-Privative*	*Privative*	*Semantic anomaly*	*Syntactic anomaly*
Mean	9444.0	43980.8	5549.5	1192.4	10067.8
SD	10757.89	56168.05	8277.26	1252.86	10869.62

Table 5.3 Mean and standard deviation for frequency on adjectives. Taken from Guevara (2010).

5.3.3 Critical words

Across all 7 conditions, the same lexical item, N, was used as the critical item. Nouns were chosen on the basis of being applicable for adjective-noun combinations with privative and non-privative adjectives. The nouns were either describing persons (e.g., customer), occupations (e.g., teacher) or relationships (e.g., marriage). Nouns were also chosen on the basis of them being masculine or neutral. Nouns with a feminine grammatical gender were excluded due to some Norwegian dialects replacing them with the masculine article (Busterud, Lohndal, Rodina, & Westergaard, 2019). Nouns were thereby accompanied with either the male ("en") or the neuter ("et") determiner. The frequency of critical words was assessed using the NoWaC (written Norwegan Web as Corpus). This is a large web based corpus containing ~700 million words reflecting contemporary Norwegian language (Guevara, 2010). The nouns had a mean lemma frequency per million entries at 83,77 (SD = 90,97).

None of the critical words or words in the preceding sentence exceeded the length of twelve characters. This means that all words could be read without eye movements (Mean length critical words: 6,6 characters).

5.3.4 Questions

The behavioral task assessed whether participants processed the distinction between syntactic anomaly, semantic anomaly and privative adjectives. After each NP, a question was presented to the participants. The questions differed some in wording, but the propositional content was always either "Is it actually a [N]?" or "Is it an unreal [N]?". The question was meant to encourage semantic composition of the noun and adjective; answering correctly and rapidly, depended on the composition of the intended meaning of the phrase. A question for the non-semantic phrases (non-word, pseudo-word and submodifier) was given to assure that the participants were paying attention to these trials as well, i.e., "Is it a [N]?".

5.3.5 Filler phrases

In addition to the 175 experimental phrases, 42 fillers were included, spread out evenly throughout the blocks. The structure of the fillers matched the experimental phrases and had the syntactic form [Det Adj N]. Similarity in phrase structure was implemented, to make sure that there were no obvious differences between the experimental phrases and the fillers.

19 of the fillers made use of the experimental adjectives but replaced the nouns, 10 of them were semantic violations and 9 were syntactic violations. The remaining 23 fillers contained both adjectives and nouns that are not seen in the experimental conditions, 12 fillers were on semantic violations and 11 fillers concerned syntactic violations. We chose to include both nouns representing professions (e.g., *pilot*) and nouns representing objects (e.g., *mobil*). The non-experimental adjectives described either nationality (e.g., *amerikansk*), shape (e.g., *rund*) or color (e.g., *grønn*). Fillers were followed by a question similar to the experimental phrases.

5.4 Procedure

Preceding the experiment, participants read through an A4 paper with instructions and answered seven training questions (Appendix E). Minimal instructions were given for the sake of reliability. When finishing the training, participants were given the solution combined with an explanation on a separate paper. Participants were also told that there would be a final questionnaire following the EEG experiment. The intention of this was to motivate participants to keep focus throughout the experiment. Following the training completion, participants were equipped with the elastic cap and electrodes for the EEG experiments (Figure 5.1)

Participants were seated in a dimly lit, sound-attenuated booth approximately 90 cm away from an LCD screen. Stimuli were presented visually by using Presentation software against a dark grey background. The stimuli were displayed in lower case letters, using a white 30-point size Arial Font. Each trial was initiated by a white crosshair fixation shown at the center of the screen for 500 msec, and then followed by a word-by-word presentation of a [Det Adj/Adv N] phrase. Each single word was presented for 400 msec and was followed by a 400 msec interval of an inter-word blank screen. Following the stimuli were another fixation cross, shown for 500 msec, before the question appeared.

The participants were instructed to respond to the questions by pressing on F or J on a standard QWERTY keyboard for ‘Yes’ and ‘No’. As button press responses give rise to motor potentials lateralized to the side of the brain opposite to the responding hand, the pairing of keys was randomized (Garnsey, 1993). The pairing of keys to responses was also counterbalanced across participants. As soon as the participant had given an answer, the experiment continued. If no response was given, the experiment continued automatically after a time limit of 4 sec.

Participants were asked to read each phrase silently and carefully. We encouraged them to respond quickly and accurately to the questions and they were told that there would be a limited time to answer. There were, however, given no instructions on *how* to answer the questions. Participants were asked to relax and move as little as possible during the experiment. In particular we stressed this when it came to head and shoulder movements. The participants were also asked to try to avoid eye blinking when the stimuli were being presented.

Between each experimental block (consisting of 29 or 30 trials each), the participants were given the opportunity to take a break and continue with the experiment when they were ready. A brief practice session of 14 trials, two from each condition, not including any of the experimental stimuli, preceded the experimental session. The experiment took on average 31 minutes, including breaks, to complete (SD=4,69).

Following the EEG experiment, participants were asked to fill in a final questionnaire. The questionnaire was, as mentioned, only used to keep participants motivated throughout the EEG experiment and was thereby not analyzed further.

5.5 COVID-19

The experiment was conducted during the fall semester of 2020. It co-occurred with the global pandemic caused by the coronavirus COVID-19. As a result, NTNU's Department of Language and Literature introduced suitable measures for infection control at the Lab. All participants were given information on the potential risk of partaking and a directive to cancel in case they had any symptoms of covid-19. To reduce the risk of infection, researchers and participants kept a 1 m distance, except when the electrodes were attached. Researchers wore gloves and masks when attaching the electrodes and the participants also wore a mask. The participants mask was taken off during the EEG recording in order to avoid unnecessary muscle tension. In case of a virus outbreak, everyone entering the EEG lab had to sign in electronically for contact tracing, all in compliance with official NTNU guidelines.

5.6 Data acquisition

Participants were fitted with an elastic electrode cap (actiCAP system by Brain Products GMbH). The EEG was recorded from 32 active electrodes (Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, TP9, CP5, CP1, CP2, CP6, TP10, P7, P3, Pz, P4, P8, PO9, O1, Oz, O2, PO10). The electrodes were placed according to the location and label of

the 10/20 system (Jasper, 1958), (Table 5.1). The on-line recordings were referenced to a left mastoid channel, and recordings were re-referenced to averaged mastoids, using signal from the TP10 channel, in the final data. TP10 was placed on the right mastoid.

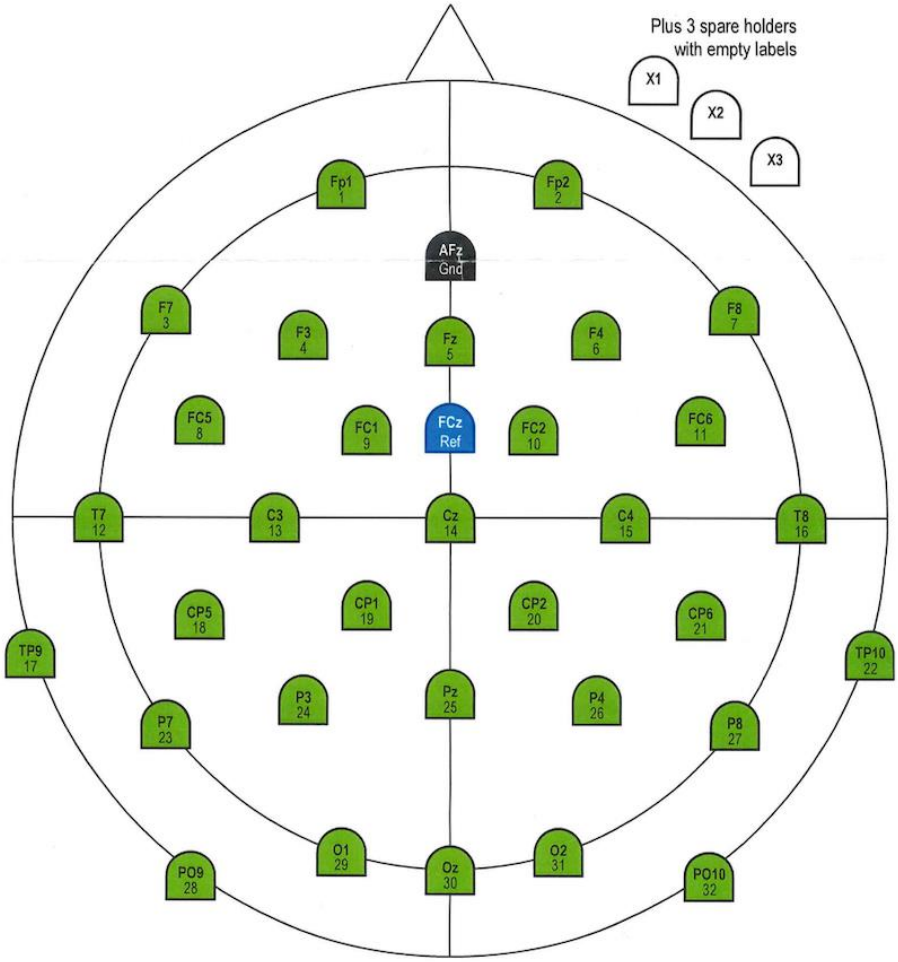

Figure 5.1 Electrode layout of the Easycap 32 Channel Standard EEG Cap. Reference was placed at the left mastoid.

EEG data were sampled at 1000 Hz, making use of a 1000 Hz high cutoff filter and a 10s time constant. Electrode impedance was kept below 1 kOhm across all channels throughout the experiment.

5.7 Data Analysis

5.7.1 Behavioral responses

Response times were measured from the onset of the critical word until subjects pressed yes/no key. Data on response accuracy and response time was analyzed separately by fitting linear mixed effects models in RStudio. This type of analysis controls for the variability

between items and participants. Only correct responses were included in the analysis of response times. For the analysis reported in this thesis, only the semantic conditions, privative, non-privative and semantic anomaly are included. The mean response accuracies and response times will though also be reported for the two non-semantic conditions: non-word and pseudo-word.

5.7.2 Event-related potentials

Fieldtrip, a Matlab software toolbox, was used for analyzing the EEG data (Oostenveld, Fries, Maris, & Schoffelen, 2011). EEG segments time locked to the critical noun were extracted from each trial in the pre-processing stage. These epochs have a starting point at 200 msec before stimulus onset and an 800 msec post-stimulus interval. The 200 msec pre-stimulus interval was established as a baseline against which the amplitude was computed. For each participant, the waveform in this time window was averaged across conditions to result in a 0 μV pre-stimulus mean wave. This baseline correction results in an average waveform in the -200-0 time-window which is used to correct the pre-stimulus voltage for each trial. Luck (2014) points out how noise in the baseline leads to noise in the measurements. In order to avoid this, a large time span was used for the baseline, as shorter time spans are more sensitive to voltage fluctuations.

Artifact rejection in the extracted segments was based on two FieldTrip functions. Firstly, all trials where amplitude values exceed a threshold of ± 150 μV from the baseline were detected and rejected. Secondly, trials containing eye blinking and/or eye movement artifacts were rejected based on raw data from the channels Fp1 and Fp2; the Z-transformed values from these channels were preprocessed with a band pass filter of 1-15 Hz. Based on the rejection criteria described, on average 22.9 trials were kept in each condition per participant for further EEG analysis. Following artifact rejection, a low-pass filter of 30-Hz was applied to the cleaned segments. This was done in order to filter out muscle artifacts.

For the statistical analyses, a cluster-based approach described by Maris and Oostenveld (2007) was used. In order to find channels and time points in which conditions differed, ERPs were compared by a t-test for each sample (a pair of time point and channel). Pairs where the t-values corresponded to a p-value smaller than 0.05 were clustered with adjacent samples for which $p<0.05$, if any. This statistical analysis was used to derive spatiotemporally connected clusters of electrode-time samples. A minimum of 2 neighboring time points and 2 neighboring channels were a prerequisite for clusters. Two time-intervals were used as input for the test: a pre-stimulus baseline [-200, 0] msec, and a post-stimulus interval [0, 800] msec,

where 0 msec was the onset of the critical noun. For each cluster-level, t-values were calculated as the sum of sample level t-values. Cluster level p-values were estimated by the use of Monte Carlo simulations: firstly, ERP averages from each specific participant in each condition were gathered in a single set. This set was further randomly divided into two equally sized subsets; a dependent-samples t-test was then used to compare the means of the two subsets. This whole procedure was repeated 1000 times. P-values were then estimated as the proportion of random partitions (x/1000) that resulted in a larger t-statistics than the actual t-value (Maris & Oostenveld, 2007, p. 179). A consequence of the Monte Carlo simulation is that when running the algorithm one can obtain slightly different p-values while the T_{sum} and S values remain the same. The latter therefore provides a more dependable measure of the "size" of an ERP effect. This approach addresses the multi comparisons problem as it requires individual samples to cluster together spatially and temporally.

6 Results

The results presented in the following sections are based on data from 30 participants, who were each presented with 25 phrases in each condition. In each condition some trials were rejected from EEG processing due to the artifact rejection, as described in the methods chapter. However, the mean number of usable trials are still high, as at least 88% of trials could be used in each condition. Table 6.1 shows that in every condition a mean of at least 22 trials out of 25 were not rejected.

The following sections will first present the behavioral results of the comprehension questions, before presenting the results from the ERP analysis. It should be noted that the behavioral analysis was done in collaboration with PhD candidate Lia Calinescu, and the ERP analysis was done in collaboration with professor Giosuè Baggio.

Condition	Mean	SD
Non-word	24.10	2.11
Pseudo-word	23.41	1.76
Privative	23.35	1.88
Non-Privative	23.45	2.01
Semantic anomaly	22.93	2.17

Table 6.1 Mean and standard deviation of usable trials within each condition

6.1 Behavioral responses

Behavioral data were collected from the comprehension questions presented after each trial. The descriptive results are presented in Figure 6.1, Figure 6.2 and Table 6.1. These figures and table show that accuracies were high in all conditions (above 90%). This indicates that participants composed phrasal meanings as intended. We also see that there were no significant differences between the three experimental conditions in terms of response times. Additionally, we see that the interquartile range for the experimental conditions were between 1000 and 2000 milliseconds.

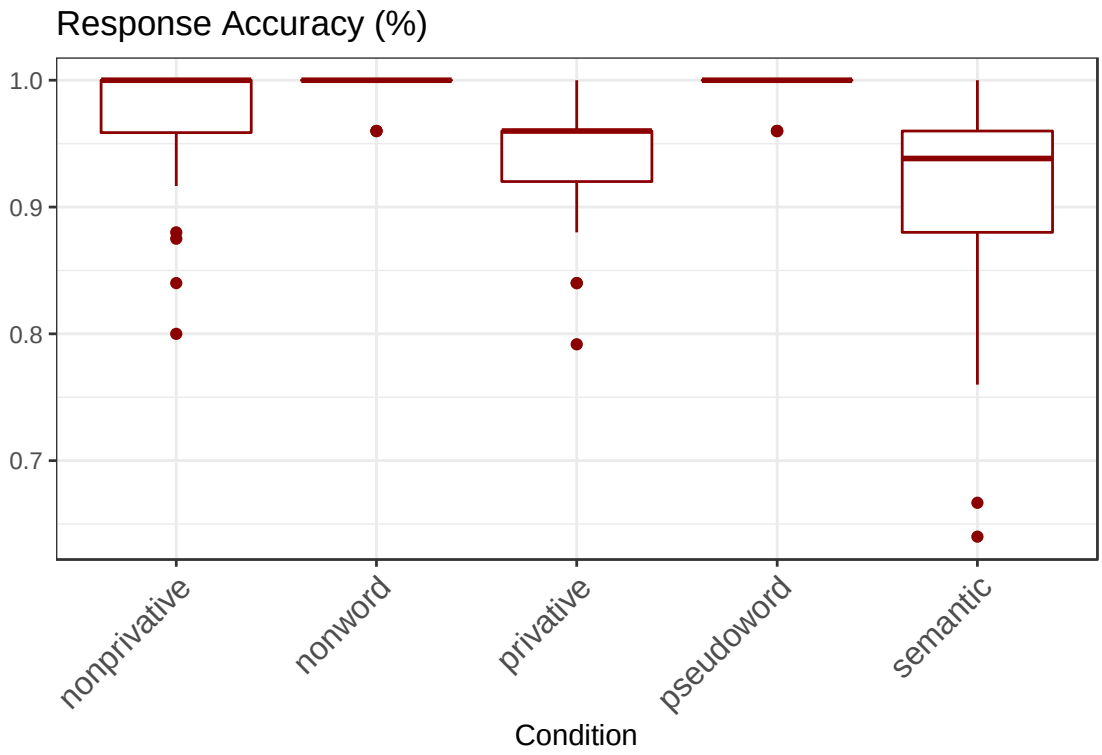

Figure 6.1 Response accuracies (% correct) for responses to the question.

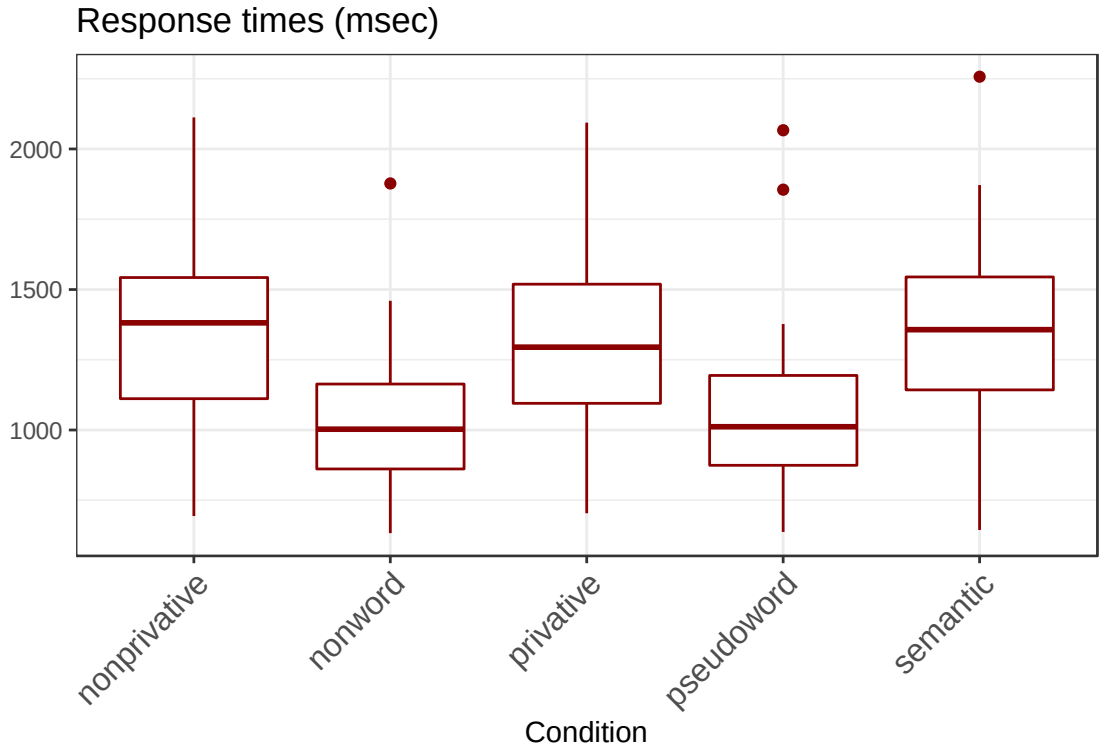

Figure 6.2 Response times (msec) for correct responses to the question.

	Response accuracies		Response times	
Condition	Mean	SD	Mean	SD
Non-privative	96.36	18.74	1362.78	612.89
Privative	93.85	24.04	1342.38	569.23
Semantic anomaly	90.15	29.82	1355.33	587.33
Non-word	99.6	6.32	1040.35	445.2
Pseudo-word	99.6	6.32	1058.9	587.33

Table 6.2 Descriptive statistics of response accuracy and response time data

A linear mixed effect model analysis was conducted where the response accuracy was set as a binomial dependent variable (correct or incorrect). The privative and the semantic anomaly conditions were then compared against the non-privative condition revealing a significant difference in both comparisons. The statistics in Table 6.3 show an effect of privative adjectives, with more accurate responses in the non-privative condition compared to privative adjectives. The p-value of the semantic anomaly condition also shows a significant effect, with accuracies being lower in this condition.

Condition	*β*	SE	z	p
Intercept	3.45	0.23	14.8	<.0001
Privative	-0.56	0.25	-2.30	0.022
Semantic anomaly	-1.09	0.23	-4.75	<.0001

Table 6.3 Response accuracy data for the question from the logistic mixed model. The intercept is the predicted log odds of a correct response (=1) in the non-privative condition. Slope estimates are the predicted change in log odds for each condition compared.

Regarding response times (RTs), a linear mixed effects regression analysis was carried out where log-transformed response times were entered as a dependent variable. There was no significant effect in the two comparisons made, privative vs. non-privative and semantic anomaly vs. non-privative. Participants had equally fast response times in these conditions. The results are reported in Table 6.3.

Condition	*β*	SE	DF	t	p
Intercept	7.16	0.06	52	117.39	<.0001
Privative	0.15	0.05	24	0.33	0.74
Semantic anomaly	0.004	0.005	24	0.08	0.93

Table 6.3. Response time data for the question from the linear mixed model. The intercept is the log odds of RTs in the non-privative condition. Slope estimates are the predicted change in log odds for each condition compared.

6.2 Event-related potentials

The results of the analysis of the ERP data are described below. Brain potentials evoked by the critical noun were compared in the conditions privative, non-privative, semantic anomaly and the baselines (non-word, pseudo-word and submodifier). This created four comparisons where we aimed at seeing the effect of composition, the effect of privative adjectives and the effect of a semantic anomaly. The inspection of ERP waveforms revealed an N100 component and a P200 component across all conditions, and more importantly a P600 effect for composition and a post-N400 effect of privative adjectives. These P600 and post-N400 effects are described below. The comparison made with the semantic anomaly condition showed an effect similar to the effect of composition.

6.2.1 Effect of composition

The first step when processing the ERP data was to analyze the comparison between the two semantic conditions (privative and non-privative), and the two non-semantic conditions (non-words and pseudo-words). The two datasets were compared by using non-parametric cluster-based permutation statistics (See Methods). A single positive cluster was found at 400-800 msec post noun onset (Figure 6.4, bottom-left panel). The cluster reached its maximum size at ~600 msec, which is around the peak of the ERP wave (Figure 6.3, left panel and Figure 6.4, top-left panel). The cluster-level statistics yield a p-value of 0.7. The effect has a centro-parietal scalp distribution (Figure 6.3, topographies). The spatial and temporal profiles of our results suggest that this is a P600 effect. Table 6.4 presents the sum of the t-values of the clustered sample.

Further, we added the semantic anomaly condition to the privative and non-privative conditions, making a dataset representing composition. The submodifier violation condition was added to the non-word and pseudo-words conditions, creating a non-composition dataset.

These two datasets compared showed the same P600 effect, but this time it was significant (Table 6.4 and Figure 6.4) This means that we can reject the null hypothesis of no difference between conditions.

Comparison	T_{sum}	p	S	Fig.
Privative and non-privative vs. non-word and pseudo-word	2388,3	0,070	890	6.3
Privative, non-privative and semantic anomaly vs. non-word, pseudo-word and submodifier	3579,9	0,028	1131	6.4
Privative vs. non-privative	-783,6397	0,188	294	6.6
Semantic anomaly vs. non-words and pseudo-words	4451,2	0,022	1468	6.7

Table 6.4 Summary of results of non-parametric cluster-based statistics on ERP data from the onset of the critical noun.

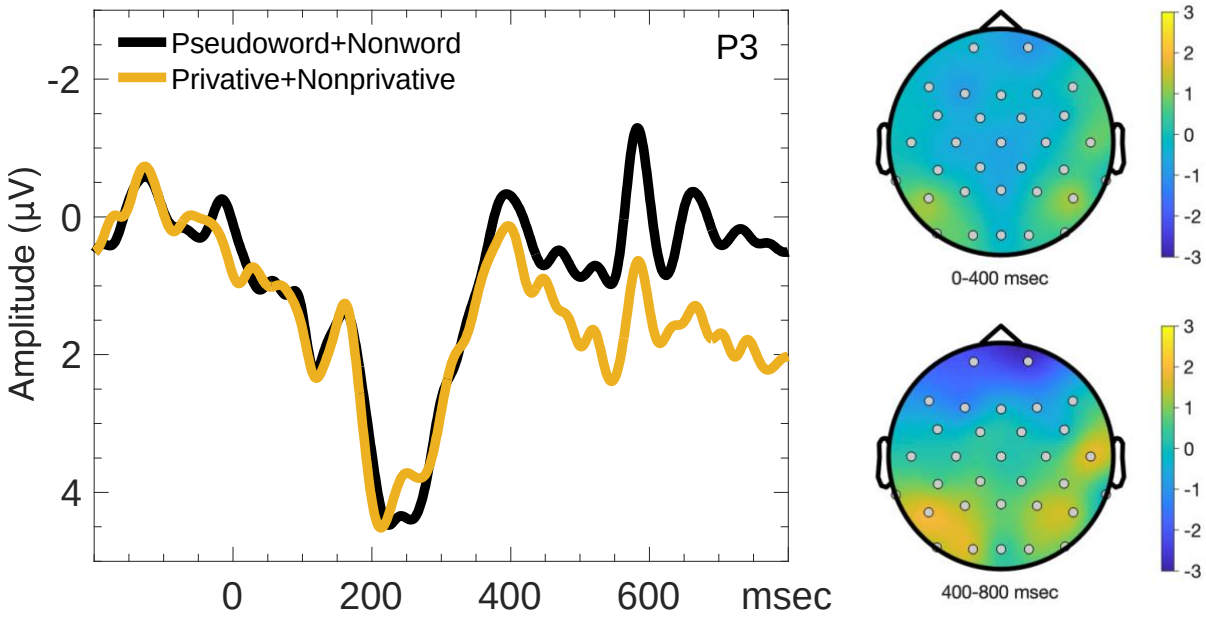

Figure 6.3 ERP results of the comparison between semantic (privative + non-privative) and non-semantic (non-word + pseudo-word) trials. Grand average of ERP waveforms (left) and topographies (right).

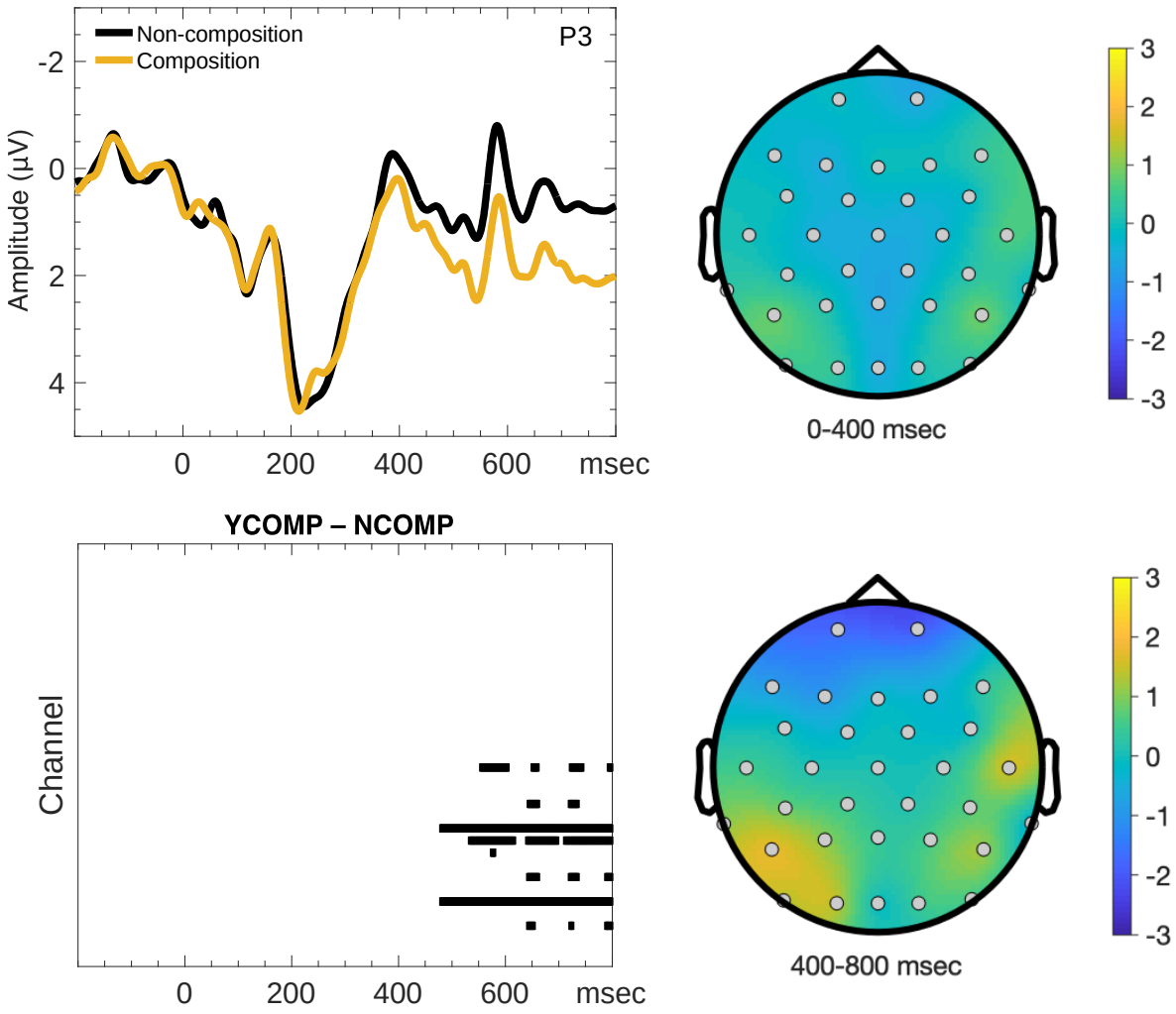

Figure 6.4 ERP results of the comparison between semantic (privative + non-privative + semantic anomaly) and non-semantic (non-word + pseudo-word + submodifier) trials. Grand average of ERP waveforms (top left) and topographies (right). Raster plot of sample-level t-tests in composition comparison bottom left. Each black tick indicates a significant difference (sample-level α=0.05) between conditions for a given sample pair. Labels: YCOMP, yes composition; NCOMP, no composition.

6.2.2 Effect of privative adjectives

The second step of the ERP data analysis looked at the possibility that ERP responses are modulated differently depending on whether the noun is preceded by a privative or non-privative adjective. Figure 6.5 displays the grand average ERPs for 9 electrodes, 3 are frontal, 3 are central and 3 are parietal. All ERPs are time locked to the visual word presentation of the critical noun. These panels show that a post-N400 ERP is modulated at the noun. The effect is larger, that is more negative, after privative adjectives compared to non-privative adjectives. This effect is largest over parietal channels. The averaged ERPs coincides with the

peak of the raw effect, both showing the largest negative in the time interval post-N400 (Figure 6.6, top left panel). Figure 6.5 also shows how the latency of the ERP response falls outside the known N400 component. This effect is strongest at the parietal channels (Figure 6.6, right panels). The cluster statistics in the bottom left panel of Figure 6.6 identifies a negative cluster reaching its peak at ~600 msec after the onset of the noun. This shows that the clearest difference between the two conditions occur in this time range. The cluster is small in size and has a p-value above the 0.05 threshold (Table 6.4).

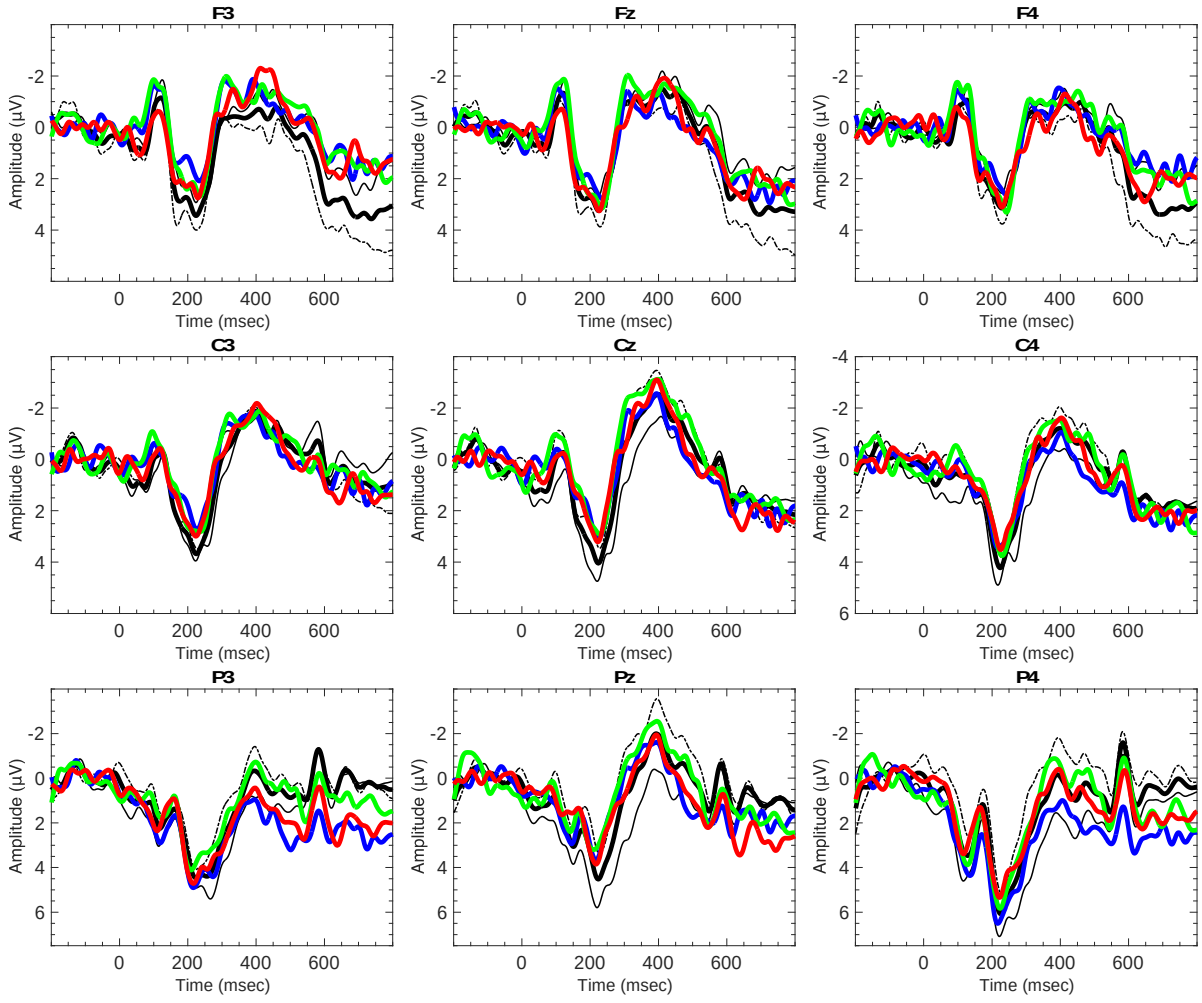

Figure 6.5 Grand average (N=30) ERP waveforms of the semantic anomaly, privative, non-privative and baselines (non-word + pseudo-word) trials.

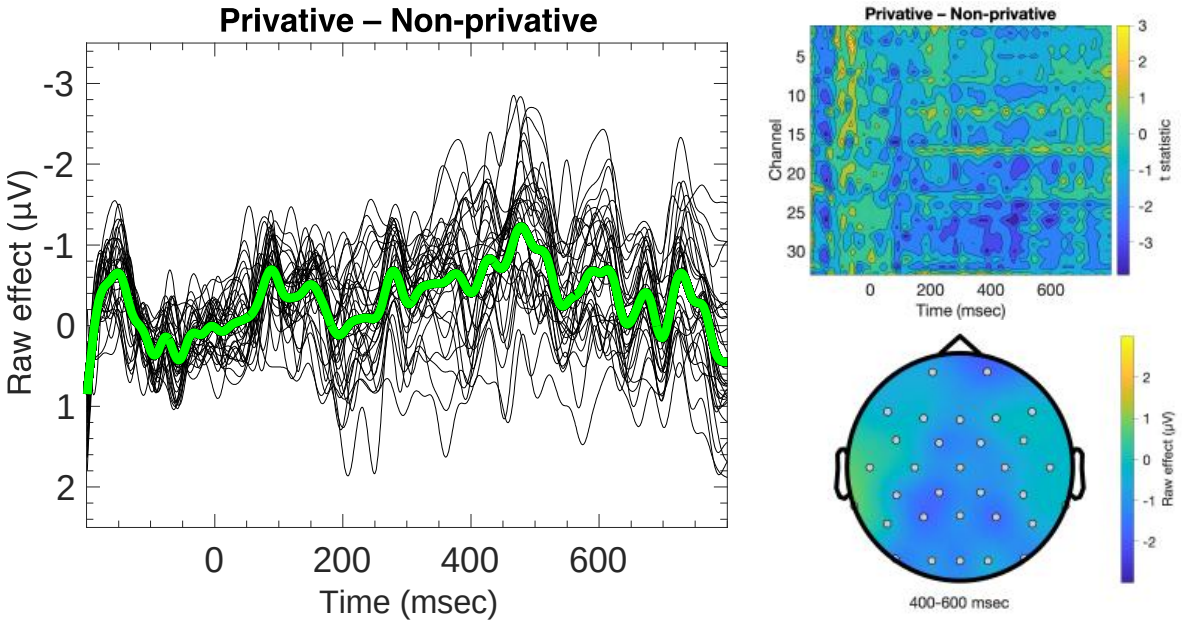

Figure 6.6 Results of ERP statistics of privative adjectives compared to non-privatives. ERP contour plot and topography of the comparison on the right. The left plot shows raw ERP effects (privative minus non-privative) across channels: each line is an ERP difference waveform from one channel. The colored line is the grand-average. These graphs show the effect of privativity, on ERP responses at the noun.

6.2.3 Effect of semantic anomaly

The final comparison made was between the semantic anomaly condition and the non-word and pseudo-word conditions combined. This contrast showed a positivity occurring in the same time frame as the (P600) effect with composition vs. non-composition. A cluster is present at 400-800 msec after noun onset, peaking at approximately ~600 msec (Figure 6.7, left panels). The effect has a parietal scalp distribution (Figure 6.7, right panels).

There was no difference between the semantic anomaly condition and any of the other conditions, i.e., no clusters were found.

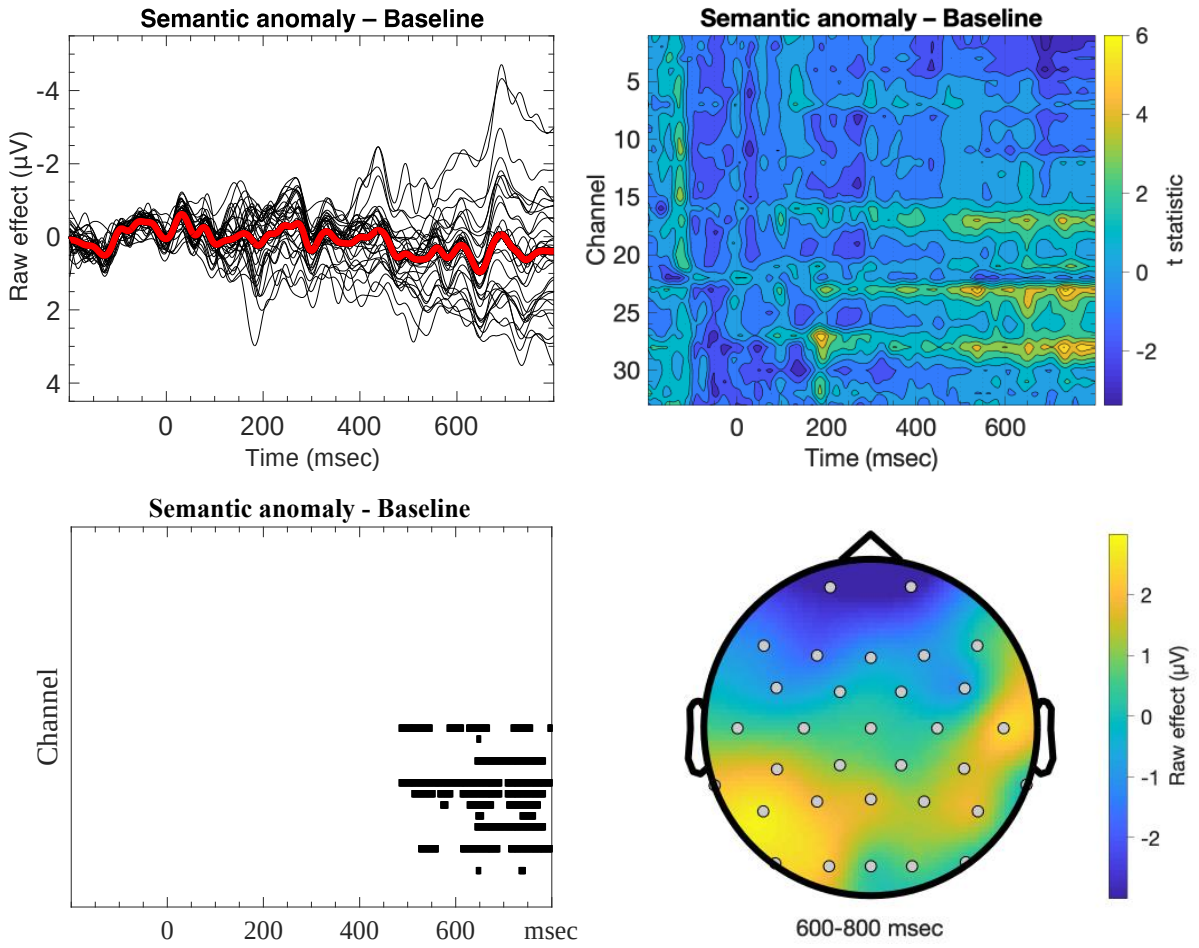

Figure 6.7 Results of ERP statistics of semantic anomaly trials compared to baseline trials (non-word and pseudo-word). ERP contour plot and topography of the comparison on the right. The top-left plot shows raw ERP effects (semantic anomaly minus non-word and pseudo-word) across channels: each line is an ERP difference waveform from one channel. The colored line is the grand-average. The bottom-left panel is a raster plot of sample-level t-tests: each black tick indicates that the ERP difference between conditions is significant for a given sample pair.

7 Discussion

The current study has investigated the on-line processing of minimal phrases ([Det Adj N]). We pursued a dual goal to firstly establish which ERP components are modulated by semantic composition in minimal phrase contexts, and to secondly assess how adjectival modification impacts the neural processing of the modified noun. We manipulated the adjective preceding the noun in order to determine which ERP components relate to the semantic composition of phrases (semantic vs. non-semantic trials), and which components relate to the computation of the denotation of the noun phrase as a whole (privative vs. non-privative trials). The two composition comparisons revealed a larger P600 component in the semantic trials, which will be discussed in more detail in section 7.1. The contrast between privative and non-privative adjectives revealed a post-N400 ERP difference, which will be discussed in section 7.2. We also wanted to establish a hypothesized difference between our results and the known N400 component, thus we included a comparison with a semantic anomaly vs. privative and non-privative trials. Despite our initial beliefs, the comparison did not reveal a modulation of the N400 component, but rather the P600 component. Down below in section 7.3, a few potential accounts for this effect will be discussed.

The behavioral data show high accuracies across the semantic conditions, which implies that the participants composed the phrasal meanings as intended. Altogether, behavioral results are only partly consistent with the ERP data. Both privative trials and semantic anomaly trials appear more difficult compared to the non-privative as they both have a lower accuracy and they both drive an ERP effect. However, there was not a significant result on RTs, as participants answered equally fast in all three conditions. Due to the divergence in behavioral results, no emphasis will be placed on the relation between ERP effects and behavior results. Further supporting this decision is the fact that it cannot be excluded that phrasal meanings composed on-line may have been further elaborated off-line as a preparation for the behavioral response to each question.

7.1 Effects of phrasal meaning composition: P600 modulations

Composition effects were assessed in two comparisons, which both showed a larger P600 in phrases where the noun was preceded by a real adjective. The first comparison on privative and non-privative adjectives vs. non-words and pseudo-words did not reveal a significant result, which may be due to the relatively small sample size. Qualitatively we replicated the

result of Fritz and Baggio (2020), which postulated that the P600 reflects either semantic composition or semantic *and* syntactic composition.

To further support this hypothesis, we did another comparison including the three semantic conditions, privative adjectives, non-privative adjectives and semantic anomaly, and the three non-semantic conditions, non-words, pseudo-words and submodifiers. The semantic anomaly condition was included, as it is grammatically well-formed and thereby possible to compose the meaning of the phrase. The submodifier condition was included such that the non-semantic conditions also included a condition with a real word preceding the noun. As this comparison also revealed a modulation of the P600 component in the semantic conditions compared to the non-semantic conditions, this can be taken as further evidence for the P600 effect reflecting composition. The effect seen in our data coincides with proposals relating the P600 to operations at the interface of syntax and semantics (Kuperberg, 2007; Bornkessel-Schlesewsky & Schlesewsky, 2008).

Our results do not support the claim by Neufeld et al. (2016) that phrasal composition is reflected by the N400 component. There was no modulation of the N400 component in neither of our comparisons. Our findings are neither in line with the results of the MEG studies by Bemis and Pylkkänen (2011, 2013), which suggest that compositional processing occur around the time of 400 msec.

7.2 Effects of privative adjectives: larger N400 or smaller P600?

Our prediction that privative adjectives incurs additional processing costs relative to non-privative adjectives was based on formal semantic theory and empirical evidence (Partee, 2003; Fritz & Baggio, 2020). Our assumption was confirmed as nouns following a privative adjective resulted in a larger post-N400 effect than nouns following a non-privative adjective. Given that the effect of composition and privativity in our experiment took place in the same time window, our results indicate that the denotational aspects of meaning are processed around the same time as composition happens. This is in line with formal semantic models saying that what we are composing are actually denotations (Heim & Kratzer, 1998). The effect of privative adjectives resulted in a small cluster, and a consequence of the weak statistics and p-value is that the upcoming discussion can only serve as an indication of effects. The results are qualitatively similar to Fritz and Baggio (2020).

There are at least two possible interpretations to explain the post-N400 effect. The first view is that the post-N400 effect reported here could be a modulation of a *negative* post

N400-component. If this is the case, there would be a larger effect with privative trials. This view is accordant with previous research, reporting modulations of *negative* components to stimuli involving referentially ambiguous nouns, e.g. "the girl" in a two girl context, or to words that trigger (re)computation at the level of the referential or denotational structure (Nieuwland, Otten, & Van Berkum, 2007; Baggio, Van Lambalgen, & Hagoort, 2008). However, even though the latency of our effect fits this view, our scalp distribution does not. Previous research on referentially ambiguous nouns has mainly presented EEG data with a frontally or anteriorly distributed effect, while our EEG data has a more centroparietal distribution. Nonetheless, our behavioral data is in support of this account, as it shows how privative trials are followed by more errors, and they could thereby be concluded as more difficult than the non-privative trials.

These negative ERP effects may be explained by recent neurolinguistic models positing that interpretive processing follows the stage where lexical meanings are activated, both commencing around N400 (Baggio, 2018). Interpretive processing entails the computation of denotations for referring expressions, like nouns and noun phrases (Fritz & Baggio, 2020). Privative adjectives might need additional computation at this stage as they require a negation of the individual being referred to, in order to make it a non-member of the set denoted by the noun. The intersection between the denotation of the noun and the noun phrase is empty, which might be more cognitively challenging. This explanation fits well with the results of Schumacher et al. (2018), who suggests that privatives lead to a processing cost in the post-N400 time window.

Partee (2007) has presented the hypothesis that privative adjectives involve coercion of the noun. In the case of "a fake doctor" (*en falsk lege*), the noun "doctor" (*lege*) should be expanded to encompass both imaginary and non-imaginary doctors. Multiple earlier ERP studies have found similar post-N400 negativities in response to various kinds of coercion, corroborating that coercion give rise to processing costs (Baggio, Choma, Van Lambalgen, & Hagoort, 2010; Kuperberg, Choi, Cohn, Paczynski, & Jackendoff, 2010). Direct comparisons made between semantic anomalies and complement coercions has shown evidence for a functional dissociation between the processing of the two constructions (Baggio et al., 2010).

An alternative explanation to the increased processing costs of privative adjectives is the account of conceptual blending by Coulson and Fauconnier (1999). Their theory is located within the field of cognitive semantics, and it proposes that privative adjectives, like that in "a fake doctor", require the establishment of cognitive mappings between different "spaces". In the case of "a fake doctor" there is a blending of the medical community space (e.g., formal

education) and the individual space (e.g., the person is only acting like they have a formal education). In both models, coercion and conceptual blending, privative adjectives stand as an instance eliciting additional processing at the semantic or conceptual level.

Alternatively, the second view of the post-N400 effects seen in our data is that they are instances of the P600 effect. Hence, the privatives would evoke a smaller P600 than non-privatives. This view is supported by both the latency and distribution of the effect of privative adjectives, but not by the behavioral data gathered. This view would mean that when the critical noun is followed by a non-privative adjective, a larger P600 effect is triggered. A possible explanation for this seemingly non-intuitive response is that non-privative adjectives do not act like a normal modifier, as they do not add or alter information about the modified expression. Non-privative adjectives are simply less informative compared to privative adjectives and sometimes they might even be redundant. Uttering "a real doctor" (*en ekte lege)* in the absence of context, has the same propositional content as just "a doctor".

Following this view, two different approaches to the P600 effect can be mapped out. The P600 could reflect the conflict between meaning and form, or it could reflect pragmatic processing. The idea that language comprehension stems from two parallel processes, the combinatorial process and the semantic-memory based process, as proposed by Kuperberg (2007), are in line with the approach pointing at a conflict between meaning and form. In the case of "a real doctor", the meaning is simply "a doctor", but it includes the syntactic presence of the optional adjective. Kuperberg (2007) further theorizes that the conflict between the two different representations, which are the output from the two distinct streams, leads to a continued combinatorial computation. The proceeding computation is then reflected in the P600 effect. The second potentially explanatory view of the P600 effect is that it reflects the detection of under-informative elements (Bambini, Bertini, Schaeken, Stella, & Di Russo, 2016). Our experimental phrases were presented without any context and the adjective "real" does thereby not contribute to the phrase meaning. The adjective can be said to be phonetically present, but semantically superfluous. The P600 could therefore reflect processing costs at the semantic and pragmatic level.

7.3 Effects of semantic anomaly: no N400, but a P600 modulation

We designed our experiment and stimuli under the assumption that the semantic anomaly condition would elicit an N400 effect compared to the non-privative condition. Our results did however show no difference between the semantic anomaly condition and the other

experimental conditions. When comparing the semantic anomaly condition to the baselines, we saw a posterior positivity similar to the composition effect.

Our null results for semantic anomalous phrases warrant a discussion as they seemingly contradict the large body of work describing on-line ERP effects of anomaly manipulations (Kutas & Federmeier, 2011). However, it is important to emphasize that most of the previous work, that has produced reliable N400 effects, has been done on sentences or discourses. This study should thereby not be seen as a failed replication of the well-known N400 effect, as there has not yet been much research on semantic anomalous phrases.

One of few studies within the minimal phrase paradigm was carried out by Lau, Namyst, Fogel, and Delgado (2016). They asserted that the N400 undoubtedly is not primarily a response to semantic anomalous meanings. They investigated the effect of contextual predictability (runny nose vs. dainty nose) and semantic congruity (yellow bag vs. innocent bag). Their results demonstrated a small N400 effect of congruity and a much more robust N400 effect of predictability. The lack of a strong N400 effect could perhaps be explained by the lack of sufficiently rich semantic context to engage the processes modulated by the N400, such as lexical semantic preactivation and context-driven integration. However, their results show that both the level of incongruity and predictability may play a role. More semantically deviant or less probable stimuli than what was used in our study may therefore elicit the N400 effect, also in minimal phrase context.

The study of Molinaro, Carreiras, and Duñabeitia (2012) also look at noun-adjective pairs, but their stimuli included a sentential context. They compared neutral Spanish noun-adjective pairs (lonely monster, *monstruo solitario*) to pairs with anomalous adjectives (geographic monster, *monstruo geográfico*), which elicited an increased N400 effect. They propose that the increased activity in the N400 time interval is a result of the impossibility to semantically compose the noun-adjective pair. If Molinaro et al. (2012) inferences are correct, then the lack of an N400 effect in our experiment can be due to a process allowing our participants to compose the minimal phrase. Two possible explanations for this might be metaphoric combination and coercion. The use of color and shape adjectives may have led to some sort of extreme metaphoric combination, e.g., participants thinking that “an orange teacher” (*en oransje lærer*) is a teacher with a bad tan. Nevertheless, ERP research on metaphors have revealed amplitude manipulations in the N400 time frame compared to literal sentences, which makes this seems unlikely (Coulson & Van Petten, 2007; Lai, Curran, & Menn, 2009). Coercion could be another explanation. Our stimuli used nouns denoting persons, occupations and relationships; the nominal expression could have been coerced from

the human denotation to a fictional or abstract or imaginary representation. The phrase "A triangular student" (*En trekantet student*) could be proceeded by transforming the human-denoting entity to something more visual like a cartoon image or a statue. However, as the comparison showed no post-N400 effects, it seems unlikely that these results would be generated by coercion (Baggio et al., 2010; Kuperberg et al., 2010).

Comparing the semantic anomaly condition with the baselines revealed a modulation in the P600 time frame. This effect was similar to the ones seen in the composition comparison. This finding could also support the hypothesis that the phrases were not sufficiently semantically deviant, and that we as a result of that see a modulation of a component responsible for composition. Our results may be interpreted in light of the 'good enough' approach to language comprehension, introduced by Ferreira, Bailey, and Ferraro (2002). They postulate that language processing can result in partial and sometimes even incomplete semantic representations, but that these meanings are 'good enough' for the purpose of comprehension. Given the task demand and the time limit in the experiment, this theory could serve an explanatory role for why participants might have attempted to compose the semantically anomalous phrases: this additional composition effort may have produced the observed P600.

7.4 Further research

In this study we chose to use a within-subject design in order to possibly get a significant result despite the number of participants (thirty). Subsequently we successfully replicated Fritz and Baggio (2020) by eliciting a P600 effect for composition and a post-N400 effect of privativity. The effect of privativity was in spite of this only qualitatively similar. We can therefore only take these results as indications of the effect privative adjectives have. A feasible explanation for the weak statistics is that we included only 22.9 trials on average in each condition from each participant in the final analysis. Due to the experiment including seven conditions, we decided when planning the study design, that increasing the number of trials would make the experiment too lengthy and habituation effects could thereby occur, e.g., a decrease in signal strength due to participants being exposed to a substantial amount of stimuli. A larger sample is needed to achieve a higher degree of certainty that the observed effects are statistically significant. A follow up study with fewer conditions and an increased number of trials within each condition would therefore be beneficial.

Next, the discrepancy between the results of this study and the study of Fritz and Baggio (2020) on the one hand and the studies by Bemis and Pylkkänen (2011, 2013) and Neufeld et al. (2016) on the other, deserve additional attention. Resolving these inconsistencies are needed to further establish which neurological components are responsible for phrasal composition. This calls for studies addressing composition using multiple neurophysiology or imaging methods.

Research on composition and adjectival modification has predominantly been carried out with sentential stimuli. The lack of comparable research on minimal phrases has thereby been apparent throughout this thesis. The results presented here should therefore be seen as preliminary to further MEG and EEG research. Especially, our data showing that privative adjectives modulate the time window post-N400, represents a complicated question in need of more research. This thesis has reflected on multiple cognitive processes that might have generated such an effect, but we remain agnostic to how they actually should be interpreted. Uncovering the neural correlates of referential processing and form-meaning integration are important inquiries to further refine cognitive models of language. Additionally, the fact that we did not see an N400 effect in the semantic anomaly condition shows that an important area of future research is to pinpoint what conditions modulate the N400 component in phrases, as opposed to sentences or discourse.

Lastly, this study analyzed only the ERP effects at the noun. Possible differences apparent at the adjective is as a result not accounted for. Another approach would therefore be to make use of the adjective as the critical word and see if semantic differences are apparent at earlier stages in the minimal phrase context.

8 Conclusion

This study investigated the neural correlates to composition and privativity in adjective-noun phrases in a minimal context. Our results show that phrasal composition occurs in the time window post-N400, possibly by modulations of the P600 component. This study is thereby additional data undermining the previous notion that the P600 reflects strictly syntactic or grammatical processing. The ERP effects of adjective-noun composition suggest that the P600 component might reflect syntactic and semantic composition.

Privative adjectives were investigated by measuring their influence on the ERPs at the noun. As seen in the literature presented, there is a disagreement on the nature of privative adjectives. This thesis remains agnostic to whether they constitute a natural word class, but our results show that denotation has an effect on word composition. With the use of cluster-based statistics, we have qualitatively shown how privative adjectives modulate a post-N400 ERP effect at the noun. The interpretation of this result has led to two different proposals accounting for the effects seen. First, the post-N400 effects could be a modulation of a negative component and thereby be associated with studies pointing towards a link between referential processing and negative components. Second, the effects might be a result of a modulation of the P600 component. Thus, non-privative adjectives would evoke a larger P600 than privative adjectives, perhaps due to a conflict between form and meaning, or the detection of pragmatic issues. In spite of multiple possible interpretations, our results show that the denotational aspect of meaning, here represented with privative adjectives, is taken into account in the same time frame as compositional processes occur.

Our study did not elicit any effects of semantic anomaly in a minimal phrase condition. We did however see a modulation of the ERP in the P600 time frame when comparing the condition to the baselines. The similarity to the effect of composition suggests that participants attempted to compose the semantic anomalous phrases. These observed ERP effects might be an indication that the phrases were not sufficiently deviant and therefore possible to compose for the purpose of communication.

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Appendices

Appendix A: Relevance for the teaching profession
Appendix B: Stimuli
Appendix C: Background information form
Appendix D: Consent form
Appendix E: Instructions to participants

Appendix A Relevance for the teaching profession

The process of writing this thesis has benefited my academic development in several ways. Indeed, working with a large project has been beneficial from a more general perspective, as it has challenged my organizational skills and my ability to persevere despite facing obstacles. Planning and structuring an experimental research project is challenging and can in many ways be compared to planning teaching lessons. There is in both cases a great need for staying focused, efficient and to constantly evaluate your work.

Despite immense individual efforts, running a complicated EEG experiment is not something one does in solitude. Enhancing my communication and cooperation skills by being part of a professional team has been a valuable experience that is unquestionably relevant for me becoming a part of the teaching profession.

Furthermore, by completing a substantial writing project, I have improved my language competence. The extensive textual production has allowed me to work with aspects like textual coherence, semantics and syntax. The enhancement of my language skills will make me even more capable to help future students to become independent academic writers. The thesis' need for thorough research and use of sources in a critical and verifiable manner is also something that will be actively facilitated in my classroom.

Probably one of the most important realizations I have made throughout this thesis has been how challenging it is to acquire new knowledge. In the beginning I knew nothing about the EEG method and how the brain reacted to language stimulus. Neither did I have any statistical training. Not only have I learnt a significant amount about my topic, but I now also know so much more about *learning* as an exercise. The field of neurolinguistics has been complicated and challenging, and only through continued reading, discussing and writing have I become more educated within this field. As a teacher I will attempt to teach my students the tools they need when facing challenges in educating themselves. Overall, my experience will serve as a backdrop, making sure that I have the necessary understanding and are able to support students in an ongoing learning process.

Appendix B Stimuli

	Det	Adjective	Noun	Condition	Question	Answ.
1	en	qxflnhjpzs	lege	Letter string	Er det snakk om en lege?	Yes
2	en	rlpz	pasient	Letter string	Er det snakk om en pasient?	Yes
3	en	tvbmpl	student	Letter string	Er det snakk om en fisker?	No
4	en	xqprngk	konge	Letter string	Er det snakk om et lag?	No
5	en	scglqmpkn	idrettsmann	Letter string	Er det snakk om en snekker?	No
6	en	qpsljg	investor	Letter string	Er det snakk om en prins?	No
7	en	slkjtmvql	kunde	Letter string	Er det snakk om en kunde?	Yes
8	en	tqlskclfbqlf	kunstner	Letter string	Er det snakk om en kunstner?	Yes
9	en	thrlpvn	lærer	Letter string	Er det snakk om en politiker?	No
10	en	cfhrmpkqxr	forfatter	Letter string	Er det snakk om en forfatter?	Yes
11	et	tpcfmjlzwrb	medlem	Letter string	Er det snakk om en skuespiller?	No
12	en	qcfnjrmtpvx	president	Letter string	Er det snakk om en danser?	No
13	en	mdcflpxjzk	musiker	Letter string	Er det snakk om en pilot?	No
14	et	htrp	parti	Letter string	Er det snakk om et parti?	Yes
15	en	kvgnj	eier	Letter string	Er det snakk om en eier?	Yes
16	et	cpgqm	band	Letter string	Er det snakk om en regjering?	No
17	en	txjknq	forsker	Letter string	Er det snakk om en forsker?	Yes
18	en	nbqvlp	sjef	Letter string	Er det snakk om en sjef?	Yes
19	en	fmgqlcgq	ordfører	Letter string	Er det snakk om en ordfører?	Yes
20	et	jgmqlxz	korps	Letter string	Er det snakk om en svømmer?	No
21	en	bcqdpkm	professor	Letter string	Er det snakk om en professor?	Yes
22	en	hvpqsldkwq	maler	Letter string	Er det snakk om en elev?	No
23	en	sglncfwpq	sanger	Letter string	Er det snakk om en sanger?	Yes
24	et	xdpkjsqm	ekteskap	Letter string	Er det snakk om et ekteskap?	Yes
25	en	grlpmdqr	forhandler	Letter string	Er det snakk om en psykolog?	No
26	en	klåkkerlig	lege	Pseudo-word	Er det snakk om en lege?	Yes
27	en	råsk	pasient	Pseudo-word	Er det snakk om en kaptein?	No
28	en	vurlig	student	Pseudo-word	Er det snakk om en organisasjon?	No
29	en	trådisk	konge	Pseudo-word	Er det snakk om en konge?	Yes
30	en	råstkende	idrettsmann	Pseudo-word	Er det snakk om en sykepleier?	No
31	en	bræst	investor	Pseudo-word	Er det snakk om en investor?	Yes
32	en	stråndlig	kunde	Pseudo-word	Er det snakk om en pilot?	No
33	en	stalråmmende	kunstner	Pseudo-word	Er det snakk om en kunstner?	Yes
34	en	våsklig	lærer	Pseudo-word	Er det snakk om en lærer?	Yes
35	en	frøstitten	forfatter	Pseudo-word	Er det snakk om en alpinist?	No
36	et	leståmmende	medlem	Pseudo-word	Er det snakk om en forbryter?	No
37	en	slikåmmende	president	Pseudo-word	Er det snakk om en elektriker?	No
38	en	trostenlig	musiker	Pseudo-word	Er det snakk om en musiker?	Yes
39	et	nirt	parti	Pseudo-word	Er det snakk om et parti?	Yes
40	en	garsk	eier	Pseudo-word	Er det snakk om en politiker?	No
41	et	stirt	band	Pseudo-word	Er det snakk om et band?	Yes
42	en	kullig	forsker	Pseudo-word	Er det snakk om en forsker?	Yes
43	en	nårisk	sjef	Pseudo-word	Er det snakk om et orkester?	No
44	en	fråstisk	ordfører	Pseudo-word	Er det snakk om et postbud?	No
45	et	skømmelt	korps	Pseudo-word	Er det snakk om et korps?	Yes
46	en	tikelig	professor	Pseudo-word	Er det snakk om en prins?	No
47	en	resimmende	maler	Pseudo-word	Er det snakk om en forbryter?	No
48	en	strøkklig	sanger	Pseudo-word	Er det snakk om en sanger?	Yes
49	et	størvitt	ekteskap	Pseudo-word	Er det snakk om en identitet?	No

50	en	grustisk	forhandler	Pseudo-word	Er det snakk om en forhandler?	Yes
51	en	ekte	lege	Non-privative	Er det faktisk en lege?	Yes
52	en	virkelig	pasient	Non-privative	Er det faktisk en pasient?	Yes
53	en	ekte	student	Non-privative	Er det faktisk en student?	Yes
54	en	ekte	konge	Non-privative	Er det faktisk en konge?	Yes
55	en	autentisk	idrettsmann	Non-privative	Er det snakk om en uekte idrettsmann?	No
56	en	eksisterende	investor	Non-privative	Er det en uekte investor?	No
57	en	virkelig	kunde	Non-privative	Er det snakk om en uekte kunde?	No
58	en	virkelig	kunstner	Non-privative	Er det faktisk kunstner?	Yes
59	en	ordentlig	lærer	Non-privative	Er det en uekte lærer?	No
60	en	ekte	forfatter	Non-privative	Er det faktisk en forfatter?	Yes
61	et	eksisterende	medlem	Non-privative	Er det snakk om et uekte medlem?	No
62	en	ordentlig	president	Non-privative	Er det en uekte president?	No
63	en	virkelig	musiker	Non-privative	Er det en uekte musiker?	No
64	et	eksisterende	parti	Non-privative	Er det snakk om et uekte parti?	No
65	en	eksisterende	eier	Non-privative	Er det faktisk en eier?	Yes
66	et	autentisk	band	Non-privative	Er det faktisk et band?	Yes
67	en	ordentlig	forsker	Non-privative	Er det faktisk en forsker?	Yes
68	en	autentisk	sjef	Non-privative	Er det en uekte sjef?	No
69	en	ordentlig	ordfører	Non-privative	Er det snakk om en uekte ordfører?	No
70	et	eksisterende	korps	Non-privative	Er det faktisk et korps?	Yes
71	en	ekte	professor	Non-privative	Er det faktisk en professor?	Yes
72	en	autentisk	maler	Non-privative	Er det en uekte maler?	No
73	en	ordentlig	sanger	Non-privative	Er det en uekte sanger?	No
74	et	autentisk	ekteskap	Non-privative	Er det faktisk et ekteskap?	Yes
75	en	virkelig	forhandler	Non-privative	Er det en uekte forhandler?	No
76	en	kvadratisk	lege	Anomalous semantic	Er det snakk om en uekte lege?	Yes
77	en	kvadratisk	pasient	Anomalous semantic	Er det en mulig pasient?	No
78	en	trekantet	student	Anomalous semantic	Er det en mulig student?	No
79	en	oval	konge	Anomalous semantic	Er det en mulig konge?	No
80	en	oval	idrettsmann	Anomalous semantic	Er det snakk om en uekte idrettsmann?	Yes
81	en	oransje	investor	Anomalous semantic	Er det en mulig investor?	No
82	en	sirkulær	kunde	Anomalous semantic	Er det en uekte kunde?	Yes
83	en	oval	kunstner	Anomalous semantic	Er det snakk om en uekte kunstner?	Yes
84	en	oransje	lærer	Anomalous semantic	Er det en mulig lærer?	No
85	en	oval	forfatter	Anomalous semantic	Er det en uekte forfatter?	Yes
86	et	oransje	medlem	Anomalous semantic	Er det et uekte medlem?	Yes
87	en	kvadratisk	president	Anomalous semantic	Er det en mulig president?	No
88	en	sirkulær	musiker	Anomalous semantic	Er det en mulig musiker?	No
89	et	trekantet	parti	Anomalous semantic	Er det snakk om et uekte parti?	Yes
90	en	oransje	eier	Anomalous semantic	Er det en mulig eier?	No
91	et	trekantet	band	Anomalous semantic	Er det et uekte band?	Yes
92	en	kvadratisk	forsker	Anomalous semantic	Er det snakk om en uekte forsker?	Yes
93	en	sirkulær	sjef	Anomalous semantic	Er det en uekte sjef?	Yes
94	en	kvadratisk	ordfører	Anomalous semantic	Er det en uekte ordfører?	Yes
95	et	sirkulært	korps	Anomalous semantic	Er det et mulig korps?	No
96	en	trekantet	professor	Anomalous semantic	Er det en mulig professor?	No
97	en	oval	maler	Anomalous semantic	Er det en mulig maler?	No
98	en	trekantet	sanger	Anomalous semantic	Er det en uekte sanger?	Yes
99	et	oransje	ekteskap	Anomalous semantic	Er det et mulig ekteskap?	No
100	en	sirkulær	forhandler	Anomalous semantic	Er det en mulig forhandler?	No
101	en	falsk	lege	Privative	Er det en uekte lege?	Yes
102	en	imaginær	pasient	Privative	Er det en uekte pasient?	Yes

103	en	imaginær	student	Privative	Er det snakk om en uekte student?	Yes
104	en	fiktiv	konge	Privative	Er det en uekte konge?	Yes
105	en	falsk	idrettsmann	Privative	Er det faktisk en idrettsmann?	No
106	en	fiktiv	investor	Privative	Er det snakk om en uekte investor?	Yes
107	en	imaginær	kunde	Privative	Er det faktisk en kunde?	No
108	en	imaginær	kunstner	Privative	Er det faktisk en kunstner?	No
109	en	falsk	lærer	Privative	Er det en uekte lærer?	Yes
110	en	imaginær	forfatter	Privative	Er det faktisk en forfatter?	No
111	et	oppdiktet	medlem	Privative	Er det faktisk et medlem?	No
112	en	fiktiv	president	Privative	Er det en uekte president?	Yes
113	en	fiktiv	musiker	Privative	Er det snakk om en uekte musiker?	Yes
114	et	oppdiktet	parti	Privative	Er det faktisk et parti?	No
115	en	fiktiv	eier	Privative	Er det snakk om en uekte eier?	Yes
116	et	oppdiktet	band	Privative	Er det faktisk et band?	No
117	en	falsk	forsker	Privative	Er det faktisk en forsker?	No
118	en	oppdiktet	sjef	Privative	Er det faktisk en sjef?	No
119	en	falsk	ordfører	Privative	Er det snakk om en uekte ordfører?	Yes
120	et	imaginært	korps	Privative	Er det et uekte korps?	Yes
121	en	imaginær	professor	Privative	Er det en uekte professor?	Yes
122	en	oppdiktet	maler	Privative	Er det faktisk en maler?	No
123	en	oppdiktet	sanger	Privative	Er det faktisk en sanger?	No
124	et	falskt	ekteskap	Privative	Er det et uekte ekteskap?	Yes
125	en	fiktiv	forhandler	Privative	Er det faktisk en forhandler?	No
126	et	australsk	lege	Anomalous syntactic	Er det snakk om en uekte lege?	No
127	et	nederlandsk	pasient	Anomalous syntactic	Er det en uekte pasient?	No
128	et	indisk	student	Anomalous syntactic	Er det en mulig student?	Yes
129	et	nederlandsk	konge	Anomalous syntactic	Er det snakk om en uekte konge?	No
130	et	nederlandsk	idrettsmann	Anomalous syntactic	Er det en uekte idrettsmann?	No
131	et	grønlandsk	investor	Anomalous syntactic	Er det en mulig investor?	Yes
132	et	indisk	kunde	Anomalous syntactic	Er det faktisk en kunde?	Yes
133	et	indisk	kunstner	Anomalous syntactic	Er det snakk om en uekte kunstner?	No
134	et	gresk	lærer	Anomalous syntactic	Er det en mulig lærer?	Yes
135	et	gresk	forfatter	Anomalous syntactic	Er det faktisk en forfatter?	Yes
136	en	grønlandsk	medlem	Anomalous syntactic	Er det et mulig medlem?	Yes
137	et	indisk	president	Anomalous syntactic	Er det en uekte president?	No
138	et	gresk	musiker	Anomalous syntactic	Er det faktisk en musiker?	Yes
139	en	nederlandsk	parti	Anomalous syntactic	Er det et mulig parti?	Yes
140	et	grønlandsk	eier	Anomalous syntactic	Er det snakk om en uekte eier?	No
141	en	australsk	band	Anomalous syntactic	Er det snakk om et uekte band?	No
142	et	grønlandsk	forsker	Anomalous syntactic	Er det snakk om en uekte forsker?	No
143	et	australsk	sjef	Anomalous syntactic	Er det en mulig sjef?	Yes
144	et	gresk	ordfører	Anomalous syntactic	Er det faktisk en ordfører?	Yes
145	en	gresk	korps	Anomalous syntactic	Er det et uekte korps?	No
146	et	indisk	professor	Anomalous syntactic	Er det faktisk en professor?	Yes
147	et	australsk	maler	Anomalous syntactic	Er det en uekte maler?	No
148	et	grønlandsk	sanger	Anomalous syntactic	Er det faktisk en sanger?	Yes
149	en	australsk	ekteskap	Anomalous syntactic	Er det et uekte ekteskap?	No
150	et	nederlandsk	forhandler	Anomalous syntactic	Er det en mulig forhandler?	Yes
151	en	cirka	lege	Adverb	Er det snakk om en elev?	No
152	en	aldeles	pasient	Adverb	Er det snakk om en pasient?	Yes
153	en	tydeligvis	student	Adverb	Er det snakk om en student?	Yes
154	en	uheldigvis	konge	Adverb	Er det snakk om en konge?	Yes
155	en	vekselvis	idrettsmann	Adverb	Er det snakk om en mekaniker?	No

156	en	uheldigvis	investor	Adverb	Er det snakk om en investor?	Yes
157	en	aldeles	kunde	Adverb	Er det snakk om en kunde?	Yes
158	en	cirka	kunstner	Adverb	Er det snakk om en forbryter?	No
159	en	tydeligvis	lærer	Adverb	Er det snakk om en lærer?	Yes
160	en	vekselvis	forfatter	Adverb	Er det snakk om en kaptein?	No
161	et	vekselvis	medlem	Adverb	Er det snakk om en psykolog?	No
162	en	aldeles	president	Adverb	Er det snakk om en alpinist?	No
163	en	cirka	musiker	Adverb	Er det snakk om en musiker?	Yes
164	et	tydeligvis	parti	Adverb	Er det snakk om et orkester?	No
165	en	uheldigvis	eier	Adverb	Er det snakk om en eier?	Yes
166	et	cirka	band	Adverb	Er det snakk om en prins?	No
167	en	tydeligvis	forsker	Adverb	Er det snakk om en forsker?	Yes
168	en	aldeles	sjef	Adverb	Er det snakk om en elev?	No
169	en	uheldigvis	ordfører	Adverb	Er det snakk om en ordfører?	Yes
170	et	vekselvis	korps	Adverb	Er det snakk om en sanger?	No
171	en	cirka	professor	Adverb	Er det snakk om en danser?	No
172	en	tydeligvis	maler	Adverb	Er det snakk om en maler?	Yes
173	en	aldeles	sanger	Adverb	Er det snakk om en regjering?	No
174	et	uheldigvis	ekteskap	Adverb	Er det snakk om et ekteskap?	Yes
175	en	vekselvis	forhandler	Adverb	Er det snakk om en forhandler?	Yes

Appendix C Background information form

NTNU
Institutt for språk og litteratur

Prosessering av syntaktisk og semantisk komposisjon ved lesing: Et ERP-prosjekt
Helseopplysninger

Deltakernummer: _____

Fyll ut denne spørreundersøkelsen med informasjon om deg selv. Ved å fylle ut dette arket gir du oss tillatelse til å bruke dataen din i forskningsprosjektet.

Biologisk kjønn: M / K

Alder: _____

Hvor mange år har du gått på skole?

_____

Hvilket fagområde har/tar du utdanning i?

_____

Hvilken hånd skriver du med? Høyre Venstre Begge

Bruker du briller eller kontaktlinser? Ja Nei

Hvis ja, er synet ditt normalt når du bruker dem? Ja Nei

Har du noen andre problemer med synet? Ja Nei

Er norsk ditt eneste morsmål? Ja Nei

Hvilket skriftspråk bruker du? Bokmål Nynorsk

Hvilken dialekt snakker du?

_____

Hva er morsmålet til foreldrene dine?

_____

Er det noen andre språk som har vært fremtredende under oppveksten din?

_____

Har du en medisinsk, psykiatrisk eller nevrologisk lidelse (inkludert dysleksi, autisme)? Ja Nei

Forstår du at du kan trekke deg fra prosjektet når som helst dersom du ønsker det? Ja Nei

Appendix D Consent form

NTNU
Institutt for språk og litteratur

Prosessering av syntaktisk og semantisk komposisjon ved lesing: Et ERP-prosjekt
Samtykkeskjema

Deltakernummer: _____

Fyll ut denne spørreundersøkelsen med informasjon om deg selv. Ved å fylle ut dette arket gir du oss tillatelse til å bruke dataen din i forskningsprosjektet.

Navn: _____

Telefon: _____

Har du lest informasjonsskrivet til denne studien? Ja Nei

Har du stilt eventuelle spørsmål du mener er nødvendige? Ja Nei

Har du fått tilfredsstillende svar på eventuelle spørsmål? Ja Nei

Har du forstått at du kan forlate eksperimentet når du vil? Ja Nei

Jeg bekrefter at jeg ikke har forkjølelsessymptomer eller andre symptomer på koronavirus, og at jeg ikke har fått påvist covid-19. Ja Nei

Jeg samtykker til at navn og telefonnummer lagres midlertidig, og i henhold til NSDs personvernregler, for å bidra til eventuell smittesporing. Ja Nei

Samtykker du til å delta i denne studien? Ja Nei

Dato: _____

Deltakers signatur: _____

Forskers signatur: _____

Appendix E Instructions to participants

Instruksjoner for eksperimentet:

I dette eksperimentet skal du lese setninger som vises ord for ord på en dataskjerm. Les alle 3 ordene nøye, men ikke høyt. Det er viktig at du følger med på betydningen av setningene, dette er fordi du vil bli stilt et spørsmål om hva du har lest etter hver setning. Du må svare på hvert spørsmål så fort og riktig som mulig. Du har begrenset tid til å svare på hvert spørsmål.

Etter endt eksperiment kommer du til å få et kort spørreskjema omhandlende det du har lest. Det er derfor viktig at du leser alle ordene som dukker opp på skjermen.

Hvis svaret ditt er JA trykker du på F-knappen, hvis NEI trykker du på J-knappen.

Eksempelsetninger

1. **En veldig sykkel**
    a. Er det snakk om en båt? (Nei): Setningen er ikke grammatisk korrekt, men den handler om en sykkel, ikke en båt.
2. **En uansett astronaut**
    a. Er det snakk om en astronaut? (Ja): Setningen handler om en astronaut
3. **Et rektangulært innebandylag**
    a. Er det et uekte innebandylag? (Ja): Hverken mennesker eller lag bestående av mennesker kan ha geometriske former. De kan derfor ikke være rektangulære.
4. **En lilla baker**
    a. Er det en mulig baker? (Nei): Et menneske kan ikke være naturlig farget lilla.
5. **Et svensk tannlege**
    a. Er det en mulig tannlege? (Ja): Fordi en tannlege kan være svensk.
6. **Et irsk bussjåfør**
    a. Er det en uekte bussjåfør? (Nei): Fordi en bussjåfør kan være irsk.
7. **Et tzxn hjul**
    a. Er det snakk om en baker? (Nei): Denne setningen inneholder ikke noe om en baker.
8. **En schgbshj telefon**
    a. Er det snakk om en telefon? (Ja): Selv om setningen ikke er helt forståelig, så handler den fortsatt om en telefon.
9. **En uforfalsket seng**
    a. Er det en uekte seng? (Nei): En seng som ikke er forfalsket er ikke uekte.
10. **En reell pizza**
    a. Er det faktisk en pizza? (Ja): Dette er en pizza.
11. **En innbilt flaske**
    a. Er det en uekte flaske? (Ja): Om flasken er innbilt så finnes den ikke og derfor er den uekte.
12. **En oppfunnet katt**
    a. Er det faktisk en katt? (Nei): Om katten er oppfunnet så finnes den ikke og det er derfor ikke en katt.
13. **En urgorsk himmel**
    a. Er det snakk om en himmel? (Ja): Denne setningen handler om en slags himmel.
14. **En næiven vennegjeng**
    a. Er det snakk om en fotball? (Nei): En vennegjeng er ikke en fotball**.**

Trening

1. **En ganske prest**
    a. Er det snakk om en prest?
2. **En sekskantet enke**
    a. Er det en mulig enke?
3. **En finsk selskap**
    a. Er det faktisk et selskap?
4. **En ksjeol flaske**
    a. Er det snakk om en flaske?
5. **En legitim kartong**
    a. Er det en uekte kartong?
6. **En fantasert kjæreste**
    a. Er det faktisk en kjæreste?
7. **En udunnel megler**
    a. Er det snakk om en megler?

Fasit

1. **En ganske prest**
    a. Er det snakk om en prest? Ja: Det handler om en prest.
2. **En sekskantet enke**
    a. Er det en mulig enke? Nei: En enke, som er et menneske, kan ikke være sekskantet.
3. **En finsk selskap**
    a. Er det faktisk et selskap? Ja: Et selskap kan være finsk.
4. **En ksjeol flaske**
    a. Er det snakk om en flaske? Ja: Setningen handler om en flaske.
5. **En legitim kartong**
    a. Er det en uekte kartong? Nei: En legitim kartong er en ekte kartong, og er derfor ikke uekte.
6. **En fantasert kjæreste.**
    a. Er det faktisk en kjæreste? Nei: En fantasert kjæreste eksisterer ikke og er derfor ikke en ekte kjæreste.
7. **En udunnel megler.**
    a. Er det snakk om en megler? Ja: Denne setningen handler om en megler.