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# The Processing of Grammar Violations in Minimal Phrase Structures

An ERP Study

Master's thesis in Language Studies with Teacher Education

Supervisor: Professor Giosuè Baggio

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Faculty of Humanities  
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## Abstract

There is still a gap in our knowledge about how the brain composes form and meaning in language, but we do know that the ability to compose individual syntactic units into complex utterances is uniquely human. Manipulating syntactic units in simple phrases may help us understand composition in language more clearly. This study is concerned with how syntactic modulation impact composition of minimal phrases. Adjective-noun phrases are investigated using EEG. We studied online event related potentials (ERPs) and offline behavioural responses for 30 Norwegian Bokmål language users using compositional phrases such as “en autentisk maler” (“an authentic painter”) and “en falsk lærer” (“a fake teacher”), and grammar violation phrases such as “en australsk band” (“a Australian band”) and “en cirka professor” (“a circa professor”). This study focuses on one composition comparison composed of three semantic conditions, and two grammar violations: a submodifier violation in a [Det Adv N] construction where the adverb requires an adjective to create meaning, and an agreement violation with the [Det Adj N] construction where the determiner does not follow the inflection of the noun.

The ERPs were derived from the critical noun. A P600 effect were found for both the composition comparisons and the grammar violation comparisons against the baselines. Unexpectedly, we found the P600 effect to be processed similarly for all the conditions mentioned. The results in compositional phrases with and without grammar violations indicate that the P600 might reflect the interplay between syntax and semantics. Additionally, the P600 effect in the submodifier violation condition indicates that participants processed the adverb as a word in which the noun could derive meaning, whether this was derived successfully or not.



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# 1. Introduction

There is still a gap in our knowledge about which neural functions are used to compose form and meaning. We do know that the ability to compose individual syntactic items into complex utterances is something uniquely human. The field of psycholinguistics studies the mental representations and processes in human language, often by examining sentence parsing (Warren, 2016, p. 4-5). Generally, syntax allows the language user to bind single-word information into a unified interpretation of utterances with multiple words (Hagoort, 2003). However, syntax alone is not enough to create meaning. Thus, the semantic meaning of the units in a phrase is composed with syntax to create the meaning of an utterance (Partee, 2007). To understand the neuro-cognitive mechanisms behind language comprehension, we need to investigate how the brain composes form and meaning in relation to each other. In order to express the attributes of a noun, we need to add the appropriate determiner and an adjective describing our intended meaning, as in “en flink doktor” (“a good doctor”). The adjective is used to modify the noun, but not to change its core meaning. A weak syntactic violation, as in “et flink doktor” (“an good doctor”), is not grammatically correct, but the brain is still able to compose the meaning of the utterance by reanalysing the agreement between the determiner and the noun. A stronger syntactic violation such as “en aldeles doktor” (“a completely doctor”) is not grammatically correct and does not provide any coherent meaning due to the syntactic constraints on adverbs. Thus, the language system is not able to compose a coherent meaning. The relation between form and meaning is not yet uniformly agreed upon.

The present study is concerned with how syntactic modulations affect composition. This is examined through two different grammar violations and three composition conditions in minimal phrase structures. The thesis investigates adjective-noun phrase compositions using electroencephalography (EEG). A determiner is included in the minimal phrases. The experiment is conducted by looking at event related potential (ERP) components traditionally related to syntax: the P600 effect and the left anterior negativity (LAN) effect. The thesis represents one part of a continuation of the study by Fritz and Baggio (2020) on meaning composition in a minimal phrasal context. They studied adjective-noun phrases, with focus on the intentional and denotational semantics of the modifying adjective. Their results revealed a larger P600 effect for the noun in composition trials compared to non-composition baselines. This thesis attempts to replicate the P600 in the former study’s composition trials and compares that composition effect to an effect elicited by grammar violations.

The refinement of stimuli, recruitment of participants and the completion of the experiment for this thesis was a joint effort with my fellow student Camilla Hafstad. The current study addresses the data gathered from the grammar violations and composition contrasts, while the results from the semantic anomalies and the privative and non-privative conditions are reported in the master's thesis of Camilla Hafstad (2021). In this thesis I aim to:

(i) Replicate the P600 effect reported in Fritz & Baggio (2020), found for composition of privatives and non-privatives in adjective-noun phrases. In this thesis, privatives, non-privatives and semantic anomalies are merged into one condition labelled composition conditions, and compared against the non-compositional baselines pseudo-word, non-word and submodifier violation.

(ii) Elicit a P600 effect in the grammar violation conditions. The grammar violations consist of a submodifier violation and an agreement violation condition. Additionally, I expect a LAN-P600 effect for the agreement violation condition due to the morphosyntactic error in the determiner.

We conducted an EEG experiment in Bokmål Norwegian where participants were visually presented the adjective-noun phrases followed by a yes/no-question in relation to each phrase. The experiment consisted of seven conditions. The noun was held constant while the preceding adjectives were manipulated. The experiment consisted of two grammar violations: the submodifier violation which requires an adjective to be present between the adverb and the noun, and an agreement violation which consists of an ungrammatical determiner. The grammatical violations explored in the thesis are different from each other and should therefore differ in their results. The composition condition consists of adjectives expected to cost more when processed. If the P600 is elicited by the composition condition, the data would point towards the P600 encompassing more or other mechanisms than syntax. The full set of stimuli can be found in Appendix A. In light of the aims above, I wish to acquire knowledge about the processing of grammatical constructions in language, and whether the neural mechanisms used to elicit the P600 effect is purely syntactical or includes semantic elements.

## **1.1 Overview**

Chapter 2 describes the composition of syntax and semantics and how they are strongly correlated. The chapter reviews adjectives as modifiers and their semantic role. Section 2.3 and 2.4 presents how the syntax of the Norwegian noun phrase is composed, and how determiners and adjectives are inflected by the noun. Chapter 3 provides an introduction to the EEG technique, and the ERP components P600 and LAN. Section 3.1 reviews the syntactic and semantic observations eliciting the P600 effect, while section 3.2 reviews observations of the LAN effect and presents a critical review regarding its early nature. My account of the ERP effects is very selective and touches upon the surface of the theories and foundations in the field. However, they serve to support my predictions concerning the P600 and LAN effect. Chapter 5 presents the methods used to conduct the EEG experiment, with description of the stimuli, the recruitment of participants and the gathering of the ERP and behavioural data. Chapter 6 presents the results, while chapter 7 discusses the results compared to my aims, with special focus on the grammar violations compared to the composition conditions. Chapter 8 concludes the thesis.



## 2. Compositionality and the role of syntax

Many linguistic theories assume that language is compositional. Compositionality concerns the process of structuring different units together to create meaning. Humans are able to communicate meaning through impressively complex linguistic structures. However, to create a coherent utterance these units need to follow certain morphosyntactic rules. In the perspective of formal semantics, the principle of compositionality is the idea that the “meaning of an expression is a function of the meanings of its parts and of the way they are syntactically combined” (Partee, 2007, p. 147). According to Partee (2007), the meaning of units and their syntactic structure are what influences the meaning of a phrase (labelled compositional semantics). The task of syntax in a language is to specify the set of well-formed expressions of said language and do this in a way that supports the compositional semantics. Thus, the relationship between semantics and syntax can be described as compositional.

From a language processing perspective, syntax allows the user to bind single-word information into a unified interpretation of utterances consisting of multiple words (Hagoort, 2003). Syntax alone does not fulfil the requirements for comprehending an utterance, so syntax and semantics are dependent on each other to compose a valid sentence. For each syntactic category (e.g., a noun phrase (NP)), there must be a uniform semantic type, meaning that syntactic and semantic rules come in pairs (Partee, 2007). The semantic meaning from each of the units combine into a structure of meaning, based on rules from the syntax. One view of the interpretation of sentences is that “semantic integration can be influenced by syntactic analysis” (Hagoort, 2003, p. S18), illustrating how syntax might be processed first. A syntax first-model can be used to describe how if the word category information can be derived earlier than semantic information, the information available will be used immediately for further processing. This way syntax sometimes needs to be revised, if it turns out that the semantic information is incompatible with the word category-based structure assigned (Hagoort, 2003, p. S21). Another view maintains that the lexical-semantic and contextual information can contribute to the syntactic analysis of an utterance, illustrating how syntax and semantics interplay during interpretation of sentences (Hagoort, 2003). This alternative view of the syntax first-model claims that different information levels (lexical, phonological, pragmatic) are processed in parallel with the syntactic structure and influence the process as soon as the relevant pieces of information are available. This type of view is referred to as the immediacy-model (Hagoort, 2003, p. S21-S22)

## 2.1 Psycholinguistic research on syntax

Psycholinguistics can be defined as the study of mental representations and processes, and much of the studies in the field has dealt with word recognition and sentence parsing (Warren, 2016). Parsing strategies are referred to as “the syntactic structural analysis of the input string of words” (Warren, 2016, p. 158), meaning that during reading, language users have grammatical preferences for how the structure of a sentence is built. In a psycholinguistic study, sentences can be manipulated to violate the preferred structure. This gives the researcher a better understanding of the processes form and meaning during language comprehension. Garden path sentences are sentences which biases the language user into assuming an interpretation that turns out to be incorrect, and they typically involve a misleading syntactic analysis (Warren, 2016). An example of this is the removal of explicit syntactic markers as seen in “the horse raced past the barn fell” (Bever, 1970). When manipulating structure, the researcher deceives the participant with the expectations that one linguistic unit will appear and examines their reaction when the expectations are not met. This adds to a level of ambiguity which is central for studying language comprehension.

Friederici et al. (1996) conducted an event related potential (ERP) experiment proposing a two-stage model of language parsing. In the first stage, structure-driven parsing assigns the initial structure to the input of words on the basis of major word category information. The researchers claim that this is reflected in ERP studies by an early anterior negative amplitude peaking at around 200 ms (an ELAN effect), an effect prominent in word category errors (Friederici et al., 1996). In the second stage of their model thematic role assignment takes place, and reanalysis and repair of the initial input is needed to resolve any possible ambiguities or violated structures. During the thematic role assignment, syntactic and semantic analyses are mapped onto each other. If initial analysis and thematic roles do not map, reanalysis becomes necessary. If there is an ambiguity, the language user does not dismiss the nonpreferred structure altogether but keeps both structures active while setting a preference for one of them (Friederici, 1995, p. 278; Friederici et al., 1996, p. 1221).

The garden path effect reflects the operation of the first stage of the model proposed by Friederici et al. (1996), while the recovery from the garden path reflects the second stage of the model. The second stage of the model “seems to be associated with a late positive ERP component with a centroparietal distribution observed in relation with the processing of [...] syntactic and morphosyntactic violations” (Friederici et al., 2016, p. 1222). This late component is called the P600 component. In addition, the researchers observed that the

component was also found for processing structures requiring reanalysis or repair. As a further argument for this 2-stage processing model, the researchers reported cases of an early anterior negativity (ELAN) only in the syntactic violation condition, while the late positivity was reported in both anomaly conditions (syntactic category violation and syntactic category ambiguity) of their experiment. Friederici (2002) later divided the two-phase model into a three-phase model in an auditory experiment, proposing that phase 1 (100-300 ms) is the time window where initial syntactic structure is formed on the basis of word category information. Phase 2 (300-500 ms) is where the lexical-semantic and morphosyntactic processes take place, aiming for thematic assignment. In phase 3 (500-1000 ms), initial structure and thematic assignment are integrated. Friederici (2002, p. 79) argues that although the syntactic phrase structure is autonomous and precedes semantic processes in the early time-window, these processes interact in the late time window. A multi-phase view is compatible with the syntax first-model if one assumes late interaction takes place.

## **2.2 Adjectival modification**

Modification is a broad term in linguistics, and linguists tend to use the term in a loose, intuitive way. On a very general level, modification means to alter the values of some of the parameters of a word, but not enough to change the core semantic properties of the word (Castroviejo & Gehrke, 2014). Modification can also mean to add attributes or parts that are not necessary for the modified item to be what it is. Modifiers cannot change the type of their modifiee, i.e., a modifier combines with another expression to produce a result with the same semantic type (Castroviejo & Gehrke, 2014). In the experiment done in this thesis, we used modifiers as the manipulated variable in our stimuli. A relatively big class of modifiers are adjectives. Adjectives are modifiers used to further characterise a noun or a NP. They are a common word class in many languages, and their semantic role is to change or refine information given by the noun. This thesis focuses on the grammar aspects of language processing. However, it is still necessary to discuss adjectives' semantic role to fully understand the role of adjectives in relation to the nouns in the adjective-noun phrases.

Within formal semantics, adjectives are commonly classified into at least three interpretations: intersective, subsective, and (non-intersective) nonsubsective. Intersective adjectives are the most common adjective-noun relationship. They have a symmetric relationship, meaning that if Floyd is a Canadian surgeon, then Floyd is *Canadian* and a *surgeon* (Morzycki, 2016, p. 14). Neither of the adjectives are dependent on each other to

describe the noun. Subsective adjectives are subsets of the meaning of the noun. This means that if Floyd is a skilful surgeon, *skilful surgeons* are only part of the set of *surgeons*. As for non-subsective adjectives, these adjectives contain both members of the adjective-noun phrase and non-members of the phrase. The non-subsective set of alleged murders contains both actual murderers and innocent people (Morzycki, 2016, p. 23).

In the case of privative adjectives such as false or fake, the meaning of the noun is negated. Privative adjectives fully determine the denotation of the head noun (Fritz & Baggio, 2020, p. 3). Partee (2007) claims that due to the nature of privatives, one constraint cannot be imposed on the class as a whole. Privatives have a particularly powerful effect on the interpretation of the noun by expressing the opposite of the intended meaning of the noun, e.g., in *fake painter* the fake painter is not a painter. The nouns must shift their meaning when faced with incompatible information for the words prior to itself (Partee, 2007). Empirical evidence from Polish has led Partee (2007) to propose a new way of classifying adjectives. She suggests reanalysing the privative adjectives as inside the subsective-category, as *nonsubsective*. Nonsubsective adjectives may be either non-privative adjectives where the meaning is redundant, or privatives where the meaning negates the original properties of the noun. Cinque (2014, p. 24) supports this view of privatives, and categorises privatives as non-intersective, nonsubsective and nonpredicative. This definition explains how the privative adjective truly reverses the semantic meaning of the noun in a pre-nominal position.

### **2.3 The conjugation of determiners and adjectives in Norwegian NPs**

Norwegian nouns are conjugated with a suffix in definiteness and number (*en bil - bilen*). This is different from English, where the determiner *a/the* describes definiteness (*a car - the car*). The Norwegian suffix that is added to nouns is labelled a “definiteness-suffix” (Enger & Kristoffersen, 2000, p. 64) as illustrated in the example “*en lege – legen*”. Here, *-en* is added as a suffix to *lege* to represent a single definite noun. There are three grammatical genders carried by the noun in Norwegian: masculine, feminine and neutral gendered nouns. Thus, “*et lege*” with a neutral determiner and a masculine noun is an ungrammatical utterance, while “*en lege*” carries the appropriate masculine determiner for the masculine noun and is therefore a grammatical utterance.

Enger & Kristoffersen (2000) propose that grammatical gender is not a grammatical category conjugating nouns, but rather a category the noun carries within itself. It is the noun which decides the determiner and suffix, not vice versa. As such, grammatical gender



conjugates adjectives, since they have different forms of grammatical gender depending on the noun they modify, as exemplified in (1):

- (1a) **En** lite**n** mann  
(masculine noun)  
*A little man*
- (1b) **Et** lite\_ hus  
(neutral noun)  
*A little house*

In (1a), a definite masculine noun requires a conjugated adjective with the suffix *-n*, in contrast to the neutral noun in (1b) which drops the suffix entirely for the adjective. At first glance, the distribution of gender among nouns may seem random and hard for learners of Norwegian to learn, but there are generalisations as to which word belongs to which gender. The Norwegian word *vin* (wine) is always masculine, even when talking about *hvitvin* (white wine) or *rødvin* (red wine) (Enger & Kristoffersen, 2000, p. 72). As demonstrated in (1a) and (1b), the determiner follows the noun. Therefore, “en lege” is correct and “et lege” is wrong. The noun agrees predicatively with pronouns as well (“*han* er **en** lærer” and “*de* er lærere”).

Most Norwegian adjectives are conjugated by agreement, since the adjective follows the form/gender of the noun. They have an asymmetric relationship, since the noun dominates the form of the adjective. Adjectives are conjugated by number, gender and definiteness. If the noun is definite plural, then the adjective follows this. Not all adjectives can be conjugated, however, and as a general rule an adjective ending with a non-stressed *-a* cannot be conjugated. Example: *bra* (good) cannot be conjugated as *\*brae* in plural form. In a NP, it is characteristic for the adjective to have agreement with the head of the phrase, as seen in (2):

- (2a) **Ei** fin\_ bok  
(feminine, nondefinite, singular)  
*A nice book*
- (2b) **Et** fin**t** hus  
(neutral, nondefinite, singular)  
*A nice house*

- (2c) Fine hus  
(neutral, nondefinite, plural)  
*Nice houses*

In the examples in (2), the adjective agrees with the gender of the noun. This is illustrated with the different suffixes, *-t* for a neutral nondefinite singular noun and *-e* for neutral, nondefinite plural. So does the determiner, changing from *ei* in *ei bok* (feminine) to *et* in *et hus* (neutral). In summary, the determiner *en/ei/et* combines with the head of the phrase and specifies number and definiteness. The adjective modifies the noun and is therefore conjugated accordingly. As a rule, in both English and Norwegian, the determiner goes first, then the adjective.

## 2.4 The structure of the Norwegian NP

This section will look more closely at the syntactic structure of the noun phrase in Norwegian. Vassenden (2005) describes the Norwegian noun phrase with the following pattern:

[DET + DESCR] + [N] + [GEN/POSS + ADV + CLAUSE]

(Vassenden, 1993, p. 46)

The determiner can consist of definiteness, quantity, and case. For example, *den mannen* (that man) gives us information about definite singular count. A phrase does not necessarily consist of all the levels presented above, as not every sentence will contain items, such as genitive case following the noun. Pragmatic or stylistic rules determine which part of the NP pattern to activate when creating phrases (Vassenden, 1993).

Following the determiner is a descriptor. This is usually an adjective. Trustwell (2009) writes that when using multiple adjectives to modify a noun, the subsecutive classes dominate the intersective classes. An example of this is “big wooden bridge” where the subsecutive adjective *big* precedes the intersective adjective *wooden* (Trustwell, 2009, p. 527). In English, adjectives only allow pre-nominal positioning for idiomatic readings. In addition, adverbs can modify adjectives in the descriptor-position. In an adjective phrase (AP), the adjective is the core while a pattern is created around it, i.e., the adjective can stand by itself, but an adverb and degree-marker cannot. According to Vassenden (2005), when breaking down the example above further, the pattern for the syntactic entity of adjectives can be defined as such:

[ [ADV + DEGREE] + [ADJ] ]

(Vassenden, 1993, p. 56)

The adverb modifies the adjective. An intensifier strengthens the content in degree and amount, as in “*helt utrolig vakker*” (Vassenden, 1993, p. 56). The adverb and intensifier combine into a core, with the adverb *utrolig* as a subordinate to the intensifier *helt*. Again, the speaker may or may not make use of every part of the syntactic entity when using natural language. In the current thesis, the pattern [ DET + [ (ADV) [ADJ] ] + N ] was used, as in [en<sub>[DET]</sub> Ø<sub>[ADV]</sub> oppdiktet<sub>[ADJ]</sub> maler<sub>[NOUN]</sub>] or in the submodifier violation condition, [en<sub>[DET]</sub> tydeligvis<sub>[ADV]</sub> Ø<sub>[ADJ]</sub> maler<sub>[NOUN]</sub>]. The adverb functions as a submodifier, modifying the adjective which in turn modifies the noun. The role of the determiner, adverb and adjective relative to the noun are illustrated below in the phrase “*et trekantet brev*” (“a triangular letter”):

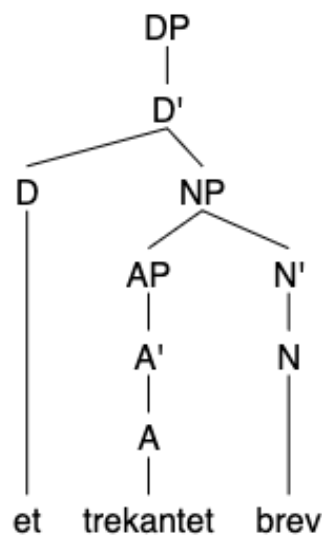


Figure 1: DP illustrating the syntactic roles for the determiner, adjective and noun. The adjective modifies the noun.

Figure 1 contains only an adjective and no submodifier. The adjective is positioned as the head of its own phrase, and as a specifier to the noun acting as the head for the NP projection. This is grammatically correct, as the adjective modifies the noun. In Figure 2 (1), the adverb has the determiner in its specifier position on the NP-level. However, the adverb *nesten* (“almost”) works as an intensifier and is therefore also in a specifier position on the AP-level, acting as a submodifier for the projected adjective. The adjective functions as the head of the AP projection, so the adverb needs the adjective in order to work as a submodifier. Removing the

adjective from the phrase would leave the adverb in a specifier position without a head to modify, thus rendering the phrase ungrammatical, as seen in Figure 2 (2) below.

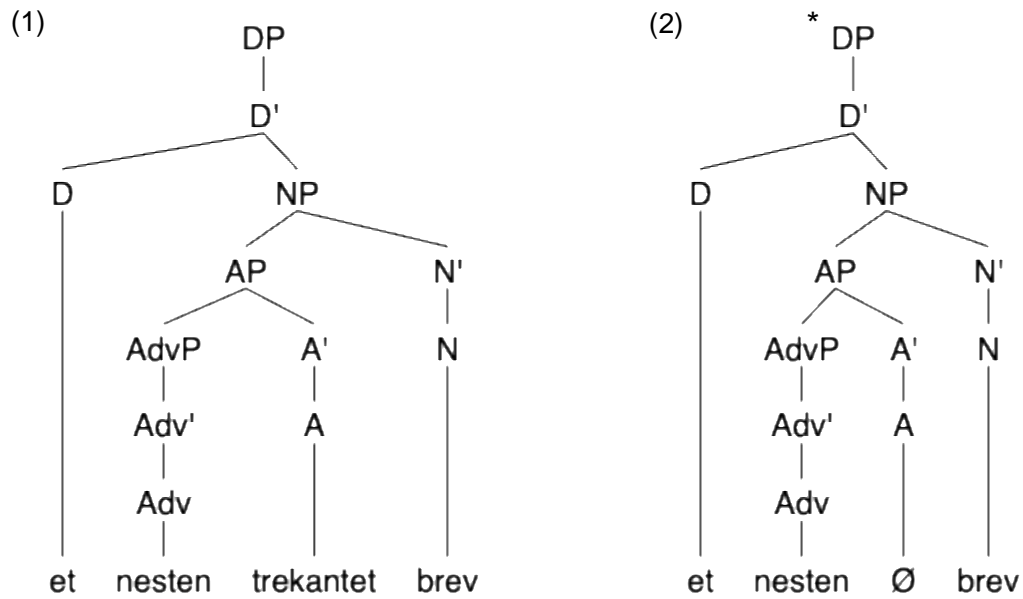


Figure 2: DP illustrating the syntactic roles for the determiner, adverb, adjective and noun. The adverb acts as a submodifier, modifying the adjective which in turn modifies the noun. On the right, the adjective is removed from the syntax tree, leaving the submodifier in a specifier position where it modifies nothing. This makes the phrase ungrammatical.

### **3. EEG effects in psycholinguistics**

The human mind is immensely complex. We are able to communicate with a seemingly open-ended system of communication unlike any other species. We can hypothesize about the past, express our thoughts about the present, and plan for the future. It is even possible for humans to talk about abstract concepts that do not correspond to anything perceivable by the senses, and we are able to do this in collaboration with others. Many psycholinguistic questions about the human brain and language remained speculative until science became refined enough. Now we are able to investigate what happens in the human mind in response to specific stimuli, without physically accessing the brain.

EEG is a non-invasive method to study how the brain works when processing language. The technique electroencephalography (EEG) gives the researcher the opportunity to study time-locked reactions to stimuli by placing a plastic cap with electrodes attached onto a subject's head. EEG measures postsynaptic potentials, meaning the currents that pass from one neuron to another (Luck, 2014, p. 37). EEG captures a mix of many different neural sources of activity, making it difficult to measure highly specific neural processes in its raw form (Luck, 2014). However, embedded within the EEG are neural responses associated with specific sensory, cognitive, and motor events. It is possible to extract such responses from the EEG by means of simple averaging techniques or more sophisticated techniques such as time-frequency analyses (Luck, 2014, p. 4). The technique is used to derive event related potentials (ERPs), which in turn can be used to make inferences about online comprehension (Garnsey, 1993). Online processing can be defined as "processing as it happens" (Warren, 2016, p. 162), in contrast to offline tasks measuring the consequences of processing. As Garnsey (1993) writes, while ERPs record language comprehension as it unfolds, there does not need to be an external event triggering a response. Sometimes the absence of expected stimuli can also provoke a response. This gives the researcher numerous possibilities to monitor how language unfolds (or does *not* unfold) in real time.

#### **3.1 The P600 effect: Syntactic and semantic implications**

The P600 effect is a positive amplitude derived from an ERP at around 600 ms after onset of a critical word (sometimes measured at 500-1000 ms). Early research has often connected the P600 to syntactic processing. In later research, the P600 has been debated to include semantic properties, such as thematic role assignment. The fundamental effects of the P600 are still a

matter of debate today. The P600 effect usually starts at around 500 ms after the onset of the critical word and lasts for at least 500 ms. In addition, research often report a left anterior negativity (LAN), observed in combination with the P600 (Hagoort, 2003; Friederici & Meyer, 2004).

### 3.1.1 Syntactic observations of the P600

The P600 effect has traditionally been linked to syntactic and morphological anomalies. The P600 effect is assumed to be a result of violation of syntactic constraints, as well as an effect of seemingly well-formed sentences that vary in complexity or syntactic ambiguity once a syntactic error has been detected in a multi-stage parsing model (Hagoort, 2003; Kutas, van Petten & Kluender, 2006, p. 693). Other proposals for the function of the P600 effect is the inability to assign preferred structure to input, linguistic parsing difficulty (Kutas et al., 2006), as well as detection of morphosyntactic errors (Morris & Holcomb, 2005). As an example, if the syntactic requirement of number-agreement between the subject of a sentence and its finite verb is violated, a positive shift is triggered by the word that renders the sentence ungrammatical. In an early study, Osterhout and Holcomb (1992) reported a P600 effect after onset of critical words that were incompatible with the expected syntactic structure in garden path sentences, e.g., “the broker persuaded *to* sell the stock was sent to jail.”, indicating that the P600 effect is sensitive to ambiguities in sentence structures as well. Hagoort (2003) proposes that the P600 effect is independent from possible semantic factors, because sentences in which the usual semantic constraint has been removed the effect still occurs. An example of a sentence that elicited the P600 effect with removed semantic constraints can be seen in (3).

(3a) The boiled watering-can *smokes* the telephone in the cat.

(3b) \*The boiled watering-can *smoke* the telephone in the cat.

(Hagoort, 2003, p. S21)

Despite the fact that the type of sentences in (3) convey no plausible semantic meaning (a boiled watering-can does not have the ability to smoke a telephone in a cat in the real world), the ERP effect of the syntactic violation shows that the language system in our brain is able to parse the sentence into its syntactic constituents. The P600 effect has been reported for a broad range of syntactic violations in many languages for both visual and auditory input, such as violations in phrase-structure, subcategorization, and violations in gender, case and number

(Hagoort, 2003, p. S21). In addition, Friederici et al. (1996) reported that the P600 was observed in different syntactic anomalies, including violation of obligatory structures and syntactic preferences requiring syntactic reanalysis or repair. Several data point towards the late positivity as not taken to reflect sensitivity to syntactic *errors* alone (Kutas et al., 2006, p. 692).

The debate around whether the P600 effect is a result of syntax-specific processes or rather reflects interaction between syntax and semantics is far from resolved. More recent studies have linked the P600 to processes outside the uniquely syntactic scope, such as the combination of syntactic and semantic information (Kuperberg, 2007). In an attempt to specify the syntactic processing in the P600 effect, artificial grammar learning (AGL) has been used in linguistic experiments. AGL is used as an “uncontaminated” space consisting of a formal grammar without associated semantic or world knowledge. AGL experiments are used to see whether the P600 effect can be elicited by surface structure familiarity after exposure or by underlying (syntactic) structure resembling natural language (Silva et al., 2017, p. 152). According to Silva et al. (2017), violations of semantic-free grammar did elicit a typical P600 effect, strengthening the idea that syntax processing alone is enough to generate a typical P600 response. AGL captures the aspects of structural processing shared with natural language processing, so the argument that P600 to some degree relates to syntax independent of meaning is a plausible approach. The findings by Silva et al. (2017) supports the findings from Hagoort (2003) in relation to a P600 effect in the absence of semantic constraints.

### **3.1.2 Syntax-semantic observations of the P600 effect**

The current thesis represents a continuation of the study done by Fritz and Baggio (2020). They ran an experiment on meaning composition in minimal phrasal contexts, looking at intensional and denotational semantics through adjective-noun combinations. Their study was conducted in Norwegian Bokmål, with four semantic conditions. The noun was held constant as the critical word in which the ERP readings were analysed, while the adjective was manipulated. They included two non-semantic conditions to link the semantic composition to known ERP components, such as the N400 effect (a negative amplitude around the 400 ms mark after onset of the critical word) and the P600 effect (Fritz & Baggio, 2020). These two conditions were a non-word of unpronounceable units designed to block semantic and syntactic composition of the adjective-noun phrase, and a pseudo-word resembling normal Norwegian adjectives in phonetics, agreement and gender, but without semantic meaning. Syntactic composition was

assumed to occur in the pseudo-word condition, not in the non-word, while semantic composition was designed to only occur in real adjectives. This allowed them to distinguish between possible semantic and syntactic effects during composition. They assumed that the contrast between semantic and non-semantic conditions would trigger a P600 component, held to either reflect top-down contextual semantic or pragmatic constraints on syntactic analysis, or bottom-up, syntax driven meaning composition.

What they found regarding the P600 was a larger effect in phrases where the noun was preceded by a real adjective relative to the non-word and pseudo-word. Whether or not pseudo-words involve syntactic composition is a debated topic, but on the assumption that they do, Fritz and Baggio (2020) suggests the possibility that the P600 may reflect semantic composition. Their results were consistent with the hypothesis that syntax-driven meaning composition modulated the amplitude of the P600, with proposals relating the P600 to operations at the syntax-semantics interface (Fritz & Baggio, 2020, p. 15). The privatives evoked a smaller P600 than the non-privatives. Nouns elicited a N400 effect in both modal and temporal intentionality. Additionally, they reported a post-N400 effect, possibly indexing “(re-)activation of semantic features [...] of the adjective, relevant for interpretation of the noun and for composition of the phrasal meaning” (Fritz & Baggio, 2020, p. 15).

A view on the post-N400 effects of denotation is that it may be an instance of the P600 effect. One possible account of the possibly-P600 effect of the privatives and non-privatives is that non-privatives are redundant, thus less informative than privative adjectives. As mentioned earlier, a modifier’s role is to provide additional information to the modified element, whereas a true doctor just means a doctor (Fritz & Baggio, 2020, p. 16). Pursuing this, the view on the P600 effect follows two accounts: (1) the P600 reflects conflict between meaning and form, *or* (2) the P600 reflects pragmatic processing (e.g., detection of uninformative elements in the input, or other processes required for interpretation). In this study, the authors also suggest that the P600 may be shifting away from the idea that the P600 reflects strictly syntactic and grammatical processing.

The view that the P600 effect does not reflect only syntactic processing is becoming more evident. Bambini et al. (2016) examined the role of context in the metaphor comprehension process. Understanding metaphors is a result of pragmatic inference exploiting world knowledge, the context, and the lexical meaning of the expression. When lexical access is facilitated by providing enough supporting context, words are easily integrated, but a final interpretation is more costly than the literal case. Here, the P600 might reflect a step in the pragmatic inferential process when the speaker arrives at an interpretation of the intended



meaning of the utterance (Bambini et al., 2016). Other researchers, such as Kim and Sikos (2011) have also suggested that the P600 is a semantic effect in the sense that syntactic cues (word order, patterns, rules) vary in their ability to resist or surrender to conflict from a semantic analysis, such as theta role-assignment. In their research which is a continuation of Kim and Osterhout (2005), semantic cues can sometimes drive interpretative commitments, even when there exists opposition from unambiguous syntactic cues. This phenomenon has been observed to happen especially in verb-argument combinations, eliciting an apparently semantic P600, such as in “The hearty *meal* was **devouring**...” (Kim & Osterhout, 2005, p. 208). The semantic attraction in this case is the *meal* in the Agent-position which is preferred in the Theme-position due to strong linear constraints in English. The syntactic cues are correct, but the semantic attraction opposes and overwhelms syntactic cues, causing the sentence to appear ill-formed (Kim & Sikos, 2011).

Kuperberg (2007) takes the claim that syntactic cues are dominated by semantic attraction between arguments further. She proposes that the P600 demonstrates semantic-thematic constraints (such as animacy) in addition to morphosyntactic cues. Natural language comprehension proceeds in two neural processing streams: (1) a semantic-memory based stream and (2) a combinatorial stream (Kuperberg, 2007, p. 24). The combinatorial stream consists of semantic-thematic constraints and morphosyntactic rules. Conflicts between morphosyntactic rules and semantic-thematic constraints in the combinatorial stream will elicit a P600 effect. Thus, the P600 effect can be argued to not be constrained only by syntax. The argument is illustrated by an experiment performed by Kuperberg et al. (2003) where they created sentences that violated the semantic-thematic relationship between critical verbs and their preceding inanimate subject NP arguments. The sentence “Every morning at breakfast *the eggs* would **eat**...” (Kuperberg et al., 2003, p. 118) is a semantic-thematic violation in nature, with no syntactic violation or ambiguity. However, the expected N400 was not observed and a robust P600 effect could be observed instead. Sentences could be repaired by ignoring the syntax and changing the thematic roles of the critical verb’s arguments, as for example “Every morning at breakfast the eggs would be eaten...” (Kuperberg, 2007, p. 28). Thus, the claim is that the conflict between the two streams proposed by Kuperberg (2007) lead to a continued combinatorial processing, and this continued processing is reflected in a P600. These two streams are dynamic and can be modulated by judgement tasks or context (Kuperberg, 2007).

### 3.2 The LAN effect

Another ERP effect often connected to syntactic violation-studies is the left anterior negativity (LAN). The LAN shows a frontal maximum amplitude, sometimes larger on the left hemisphere than the right, even though the distribution is bilateral in several cases (Hagoort, 2003). In psycholinguistic research, the conditions that elicit this effect are seemingly related to syntactic processing. The LAN effect is still widely debated. The effect is reported to be different from the N400 effect, with a more frontal maximum and sometimes a more left lateral distribution, even if it may show a negative amplitude in the same range as the N400 (300-500 ms). Sometimes the LAN is reported earlier, at 100-300 ms (labelled ELAN). Studies point to a LAN effect in response to word category violation constraints, word order or morphological violations (Hagoort, 2003; Friederici, 1995; Morris & Holcomb, 2005)

Friederici et al. (1996) found an early left anterior negativity (ELAN) in their syntactic category-violation conditions, which was reported to be absent in the syntactic category-ambiguity condition. The syntactic category-violation consisted of NPs where past participles created a violation of the required syntactic category in the phrase. They did two experiments: one with auditory stimuli and one with visual stimuli. For the word-by-word visual presentation in the experiment, the ELAN was found in the syntactic category-violation, while a late positivity (a P600 effect) was found for both violation and ambiguity.

In another research with Friederici & Meyer (2004), they attributed the ELAN effect to violations of word category, while they argued that the LAN reflected morphosyntactic processing. The earlier ERP studies done on syntactic processing observed a correlation between the LAN (between 100-500 ms) and a following P600 component. They propose that phrase structure violations such as word category violations appear to elicit the LAN-P600 pattern. The LAN amplitude and latency varies as a function of how fast word category information becomes available to the participant, as word category information is crucial for local phrase structure-building. If the word category or morphosyntactic information is in the prefix of the incoming word, information becomes available earlier in the stimuli than if the information is in the suffix. Early information results in effects being present early, such as ELAN in the 120-200 ms window post word onset, and a later effect as LAN if the information is in the suffix (Friederici & Meyer, 2004).

As mentioned, LAN is proposed to reflect structural or morphosyntactic conditions with a left lateralization. In contrast, the P600 effect has been described not exclusively in errors, but also in association with a wide range of different syntactic anomalies such as ambiguous

or complex structure requiring reanalysis or repair. The ELAN is reflecting a first pass-parsing, while LAN is taken to reflect syntactic processing when structural and thematic relation is assigned. Friederici & Meyer (2004) sought to find data on this using a German paradigm with a phrase structure violation. The verb they used required two arguments, and the structure differed only in the presence or absence of a complementizer introducing a complement clause, such as seen in the phrase structure violation example in (4).

(4a) Correct: Er meinte *dass* Lisa **Ärger** verursacht.  
(He mentioned *that* Lisa **trouble** causes.)

(4b) Incorrect: \*Er meinte *auch* Lisa **Ärger** verursacht.  
(He mentioned *also* Lisa **trouble** causes.)

(Friederici & Meyer, 2004, p. 73)

The critical word is marked in bold. In this example, the German matrix clause and complement clause require different phrase structures. German requires a subject-object-verb order after the introduction of a complementizer like (4a), and subject-verb-object in matrix clauses such as (4b). Therefore, (4b) is ungrammatical due to a phrase structure violation. The phrase structure violation in this example gave rise to an anterior negativity peaking between 380-450 ms in the ERP recordings, corresponding with the time window LAN appears in, followed by a P600 effect. The results indicate that the different spatial distribution of the LAN compared to a N400 effect reported shows separate stages for detecting and processing grammatical violations during sentence processing (Friederici & Meyer, 2004, p. 76).

Traditionally, the LAN has been considered to include both the very early ELAN effect at 100-300 ms and the LAN at 300-500 ms. However, the ELAN effect has in later research been criticized to be an irrelevant contextually driven artefact (Steinhauer & Drury, 2012). Steinhauer and Drury (2012) conducted a compiled research review examining the empirical and methodological issues regarding research expressing that the ELAN is a syntactic violation-effect. This includes the research done by Friederici and colleagues. The authors argue that the 3 phase-model Friederici and colleagues suggest, including the consideration that ELAN occurs as a result of word class syntactic violation, has not been examined critically enough. Most reading experiments investigating word category information-violation did not observe an ELAN effect, only anterior negatives post 300 ms (Steinhauer & Drury, 2012). The defending argument for the ELAN proposes that the ELAN effects were absent due to no

outright violations of word category information. Steinhauer and Drury (2012, p. 138) do not agree with this claim, as those experiments did not use sentences completely ruling out grammatical continuation. They state that there are methodological and empirical issues in research including the ELAN as a LAN effect. The empirical issues concern research not differentiating between auditory and visual experiments. The methodological issues raised questions on how context-manipulation may give rise to context effects on target word ERPs, independent of the phrase structure that is investigated. Stimuli-symmetry and condition-counterbalancing is important to avoid variables influencing ERP effect. Thus, there is not an unambiguous way to differ between the “early LAN” (ELAN in the 100-300 ms range) as a phenomenon linked to syntactic processing or to irrelevant contextually driven artefacts. For visual experiments using reading in order to avoid context manipulation, the LAN-like effects in the 300-500 ms range have been the more prevalent pattern (Steinhauer & Drury, 2012).

## 4. Returning to the study at hand

This section will present the design of the current study in more detail. First, I will present what is currently known about syntactic modulation on composition from formal linguistic theories and EEG studies. Second, I will present the predictions of the study in light of this knowledge. Thus, this section is a link between the theory presented and the aims of the thesis.

In Norwegian [Det Adj N] constructions, the noun inflects the determiner and the adjective in terms of gender, definiteness and number. The adjectives modify the noun, but do not change the core meaning of the noun. However, privative and non-privative adjectives provide problems for the traditional categorization of adjectives. These modifiers either negate the semantic meaning of the noun or provide no additional information to the notion of the noun. As such, the processing of phrases containing these adjectives are expected to be higher than for intersective adjectives. EEG studies report a positive amplitude in the 500-800 ms window assumed to be the P600 component for these types of phrases. This is the case for stimuli without any syntactic ambiguous structure as well, as in the case of Kim and Osterhout (2005). The semantic implications reported in Fritz and Baggio (2020) suggest that the P600 do encompass semantic constraints, in addition to syntactic violation and ambiguity.

However, research also observes a P600 effect as for syntactic ambiguous or violated phrases. Silvia et al. (2017) reported the P600 effect for sentences without any semantic constraints, indicating that syntax also trigger the effect. This is the originally reported reason for the effect, as claimed in Hagoort (2003) and Friederici et al. (1996). The P600 effect reported is often paired with a LAN effect in the 100-500 ms window, depending on the type of violation: word category violation is reported as an ELAN effect in the 100-300 ms window, while morphosyntactic violations are often reported as a LAN effect in the 300-500 ms window. The implications of this effect in pair with the P600 might suggest that syntax is processed prior to semantics in composition, as in the 3-phase model of Friederici (2002).

The present study examines how syntactic modulation on adjective-noun phrases impact composition. Adjective-noun phrases are presented to the participants followed by a yes/no question. The phrases are structured as [Det Adj N], with the exception of the submodifier violation condition with the [Det Adv N] structure. One compound of three composition conditions (privative, non-privative and semantic anomaly) is compared against baselines with non-compositional conditions (pseudo-word, non-word and submodifier violation). Two grammar violation are examined: a submodifier violation and an agreement violation. The effects of the grammar violations are compared to the baselines pseudo-word and non-word. In

light of the former studies presented, I predict a P600 effect for the two grammar violation comparisons in the experiment. If the participants attempt to process meaning in the submodifier violation, I predict a P600 effect there. On the other hand, if participants dismiss the meaning of the noun when presented with a submodifier without a modified adjective, then no effect of composition will be elicited the same manner as the baselines. The theory presented above leads me to expect a P600 effect when participants attempt to compose meaning in a phrase with an agreement violation, since the morphosyntactic violation still gives room to compose meaning from the noun, in contrast to the submodifier violation where composition should not take place. A LAN effect is expected for the agreement violation condition due to the morphosyntactic error in the determiner. Due to the construction of the minimal phrases, the compositional ERP effects elicited are expected to be at the noun, where the processing of the phrase takes place. The behavioural data is expected to reflect the processing of the baselines by providing better accuracy and reaction times than for the other experimental conditions.

## 5. Methods

The following chapter describes the methodology in the experiment: the stimuli, participants, procedure and data acquisition. The experiment made use of EEG. Four different experimental conditions of adjective-noun compounds were tested. They consisted of a privative, non-privative, semantic anomaly and agreement violation. Three baselines were included for comparison: the non-word, pseudo-word and submodifier violation condition. The syntactic anomaly in the determiner is referred to as agreement violation, while the adverb without a modified adjective is referred to as submodifier violation.

As mentioned in the introduction of this thesis, the construction of the stimuli, recruitment of participants, and data collection were done in close collaboration with my fellow student Camilla Hafstad.

### 5.1 Stimuli and conditions

The stimuli were based on a former experiment by Fritz & Baggio (2020) and reworked by us to fit the current experiment. 175 phrases were created in Norwegian Bokmål with the syntactic form [Det Adj N], with the exception of the submodifier violation condition with the syntactic form [Det Adv N]. The phrases formed the seven conditions non-word, pseudo-word, privative, non-privative, semantic anomaly, agreement violation and submodifier violation. The experiment had 42 fillers, bringing the stimuli to a total of 217 items.

The stimuli included 25 nouns grouped into 25 different noun groups of 7 trials. Each noun group included one trial for every condition, and the noun was held constant. The manipulated variable was the adjectives in the trials. 24 modifiers were used in the experiment: 19 adjectives and 5 adverbs. Adjectives were either non-privative (“virkelig”, “ekte”, *real*), privative (“imaginær”, “falsk”, *imaginary, fake*), intersective and semantically anomalous (“en kvadratisk lege”, *a square doctor*), intersective and grammatically incorrect (“et australsk lege”, *a Australian doctor*), pseudo-words or non-words. The conditions are labelled after the manipulated adjective. The non-word condition (a random string of words that cannot be processed into a lexical word) and a pseudo-word condition (a pronounceable word with the expected conjugation but not a Norwegian adjective or adverb) were included in the seven conditions as baseline conditions, together with the submodifier violation condition. The non-word condition was meant to block any syntactic or semantic composition of the phrase. The pseudo-word may trigger composition, as it was marked morphologically correct in agreement

with the noun, but there is no semantic information to process. The baselines let us unravel the possible differences between syntactic and semantic composition. In the seventh condition, a prenominal adverb in a NP without an adjective to modify was used, thus labelled the submodifier violation condition. The submodifier must modify an adjective to be processed semantically and syntactically, so we placed the adverb in a position without an adjective where composition of the minimal phrase would fail. Adding the submodifier violation condition as a baseline gave us a baseline condition in which the stimulus preceding the critical noun was a real, but where composition at the noun position still failed.

The minimal phrases were checked by native Norwegian speakers for naturalness and grammaticality. Before starting the experiment, we completed three pilot tests to double check for mistakes that could affect the results. Taking the pilot-feedback into consideration, we changed ambiguous words and phrases, and located occasional misspellings in the experiment. In this master thesis, the results for the grammar violation conditions (submodifier and agreement violation) and composition conditions (privative, non-privative adjectives and semantic anomaly) are reported. The privative, non-privative and semantic anomaly condition results are reported in the thesis of Camilla Hafstad (2021). Table 1 shows an example of the seven conditions with their English translations.



Det.	Adjective	Noun	Syntax	Semantic	Condition	Question
en	hvpqsldkwq	maler	Syn-	Sem-	non-word	Er det snakk om en elev?
<i>a</i>		<i>painter</i>				<i>Is it about a student?</i>
en	resimmende	maler	Syn+	Sem-	pseudo-word	Er det snakk om en forbryter?
<i>a</i>		<i>painter</i>				<i>Is it about a criminal?</i>
en	autentisk	maler	Syn+	Sem+	Non-privative	Er det en uekte maler?
<i>an</i>	<i>authentic</i>	<i>painter</i>				<i>Is it a fake painter?</i>
en	oval	maler	Syn+	Sem-	Anomalous semantic	Er det en mulig maler?
<i>an</i>	<i>oval</i>	<i>painter</i>				<i>Is it a possible painter?</i>
en	oppdiktet	maler	Syn+	Sem+	Privative	Er det faktisk en maler?
<i>a</i>	<i>fictitious</i>	<i>painter</i>				<i>Is it actually a painter?</i>
et	australsk	maler	Syn-	Sem+	Agreement violation	Er det en uekte maler?
<i>a</i>	<i>Australian</i>	<i>painter</i>				<i>Is it a fake painter?</i>
en	tydeligvis	maler			Submodifier violation	Er det snakk om en maler?
<i>an</i>	<i>apparently</i>	<i>painter</i>				<i>Is it about a painter?</i>

Table 1: Example of the stimuli in all conditions. The full set of stimuli can be found in Appendix A.

### 5.1.1 Adjectives

24 adjectives were used in the stimuli. The length of the adjectives ranged from 4 to 12 letters. Mean and standard deviation for the adjectives in each condition is found in Table 2. The adjectives used were intersective (semantic anomalies, agreement violation), subsective (non-privatives) or nonsubsective (privatives). Each non-word and pseudo-word were only repeated once and were matched in length with the real adjectives. For the other conditions, we used 5 different adjectives and repeated them approximately 5 times for each condition, with the exception of the privative condition with only 4 different adjectives. The privative adjectives were therefore used 6 times each, except for *imaginær* (“imaginary”) which was used 7 times. For the semantic anomaly condition, adjectives referring to shapes and colors were used. For the agreement violation condition, adjectives referring to nationalities were used in addition to a grammatically incorrect determiner.

The frequency of nouns, adjectives and adverbs were assessed with the NoWaC corpus (Norwegian Web As Corpus), a large written Norwegian Bokmål corpus consisting of approximately 700 million tokens. The corpus is built by processing Norwegian Bokmål use

on the web by gathering documents from commercial search engines (Guevara, 2010). Bokmål is the most widely used written standard in Norway, regardless of dialect. Thus, we were able to include a range of dialects among participants while using the same written standard. The advantage of using the corpus is its scope; the corpus is based on web use among Norwegian speakers, therefore reflecting contemporary Norwegian use. The disadvantage is that the corpus has misclassifications, double entries and includes words from Nynorsk (the other Norwegian written standard), which can affect the distribution. The frequency of the nouns ranged from 440 to 295320, while the frequency of the adjectives (including adverbs) ranged from 79 to 128710. See Table 2 and Table 3 below for more details of the adjectives' average length and frequency in each condition.

<b>Length</b>	<i>Agreement</i>	<i>Non-privative</i>	<i>Privative</i>	<i>Semantic</i>	<i>Submodifier</i>
<i>Mean</i>	8.2	8.4	7	7.6	8.2
<i>Stdv</i>	2.59	2.88	1.83	2.30	2.17

Table 2: Mean length and standard deviation for each adjective in each condition.

<b>Frequency</b>	<i>Agreement</i>	<i>Non-privative</i>	<i>Privative</i>	<i>Semantic</i>	<i>Submodifier</i>
<i>Mean</i>	10067.8	43980.8	5549.5	1192.4	9444
<i>Stdv</i>	10869.62	56168.05	8277.26	1252.86	10757.89

Table 3: Frequency mean and standard deviation for each adjective in each condition as they appeared in the corpus.

### 5.1.2 Critical words

The nouns in each trial were used as the critical word at which the ERP readings would be derived. Every noun was repeated 7 times each in the stimuli. Nouns were chosen on a basis of being applicable for the adjective-noun combination for the privative and non-privative adjectives. The nouns chosen were either masculine or neutral gendered nouns, due to the variability of the feminine gender for nouns in Norwegian dialects (Språkrådet, n.d.). Nouns used in the experiment were referring to persons, occupations, or relationships, e.g., *pasient* (“patient”), *prins* (“prince”) and *ekteskap* (“marriage”). The nouns' length ranged from 4 to 11 letters (M=6.64, SD=2.04).

### 5.1.3 Fillers

42 filler items were created in addition to the stimuli with the syntactic form [Det Adj N]. The fillers were grouped into two: one group used the same adjectives as in the experimental conditions, while the other group used adjectives that were not included in the experimental conditions. The two adjective groups were again grouped into a non-syntactic violation-category using adjectives referring to nationalities, and a non-semantic violation-category using intersective adjectives. The nouns of the filler phrases varied in length, ranging from 3 to 9 letters ( $M=5.67$ ,  $SD=1.76$ ). Nouns already used in the experimental conditions were not used in the fillers. Fillers were followed by a question similar to the experimental trials. The structure of the fillers followed the same structure as the experimental phrases to make sure that there was no obvious difference between the fillers and the experimental trials. The full set of fillers are presented in Appendix A.

### 5.1.4 Questions

After each trial, the participant would answer one yes/no question. This question was used to see whether participants registered the distinction between non-privative and privative conditions, and to make sure participants were able to compose the meaning of the phrase they just read. To be able to answer rapidly and correctly one would have to compose the entire meaning of the phrase. The response keys on the keyboard were F and J, and the value of these were switched for each participant. This was done to avoid a prepared motor response affecting our results if only F was used or “yes” and J for “no”. Example of a question following a trial:

“en oppdiktet maler” [privative, Syn + Sem+] (*a fictitious painter*)

Q: “Er det faktisk en maler?” (*Is it actually a painter?*)

A: “Nei.” (*No.*)

## 5.2 Counterbalancing the experiment

The experiment used a within-subject design where each participant is exposed to every trial in the experiment. In this type of design, the internal validity of the experiment does not rely on random assignment and offers a boost in statistical power by gaining as much data as possible for all the participants (Charness et al., 2011). The experiment contained seven blocks with 31 trials each, fillers included. We grouped the experiment into seven blocks, then divided

the blocks into four groups. Each block was constructed so as to avoid two trials from the same condition in a row. A Latin square design was used to further group the four groups into four lists. By using the Latin square design, we made sure that every participant saw every trial once. By counterbalancing the trials into blocks and lists, we avoid the experiment suffering from unforeseen variables affecting our results, such as inexperience during the first trials or tiredness during the final trials.

### **5.3 Participants**

37 right-handed Norwegian native speakers were recruited via flyers in Trondheim and posts on social media. Each participant was contacted via email after voluntarily signing up on a form with their name and email address. Each participant received a gift card in value of 150 NOK after their participation. The age of the participants ranged from 19 to 52 years old ( $M=24.86$  years). Data from 7 participants (including 3 pilot participants) were excluded due to excessive EEG artefacts or unviable behavioural data. Among the data from the 30 eligible participants, the mean age was 24.97 years (range=19-52,  $SD=7.14$ ), consisting of 33% males and 67% females. The participants had to fulfil several criteria to participate. These criteria were set to give us a similar comparative base for each participant, and to avoid unknown factors leading to an inaccurately analysed result. The participants needed to be over 18 years of age, right-handed, and have Norwegian as their only native language. The participants reported that their written language was Bokmål, their vision was normal or corrected to normal, and that they grew up in a monolingual household. The participants spoke a wide range of Norwegian dialects. They also had no history of neuro-cognitive impairment or use of medications that could affect the EEG recording, as declared in a health and consent form they signed as the first step of the experiment. The study was approved by *Norsk Senter for Forskningsdata* (NSD, project nr. 965339) and was conducted in compliance with NSD regulations.

### **5.4 Procedure**

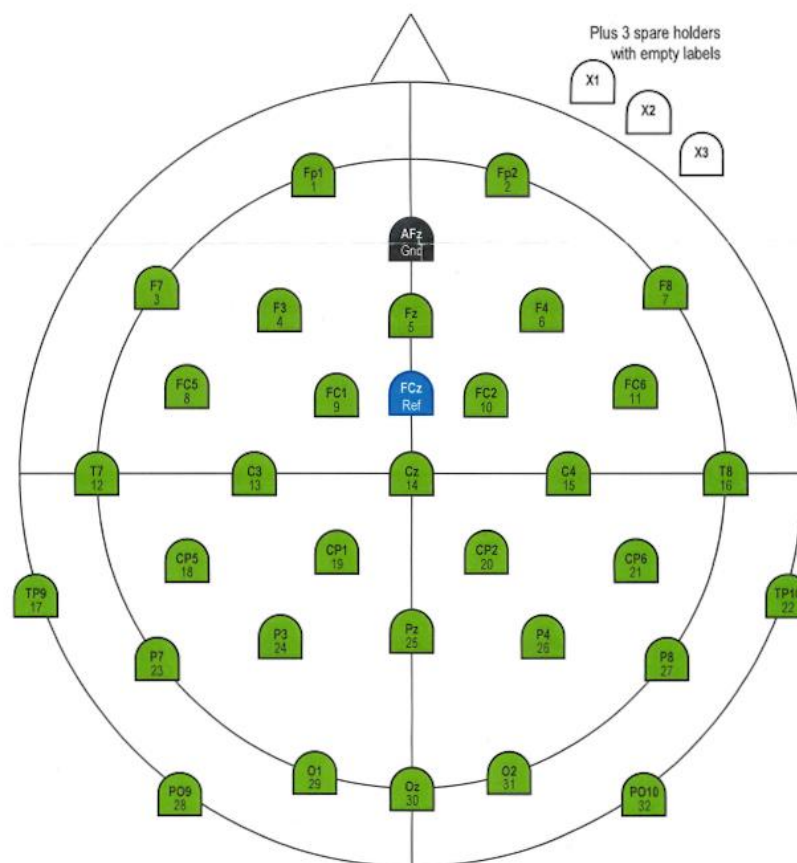
Upon entering the lab, participants filled out a health and consent form (see Appendix B and C). Following this, participants were provided an A4-paper with instructions and seven training questions (see Appendix D). If the participants had questions regarding the instructions, we told them to read the instructions for an answer. This was done to make sure all the participants

received the same instructions. When participants finished the training questions, they were given the solution for the questions with an explanation on a separate paper. If they made any mistakes, we asked them to read the explanation until they understood the correct answer. After the training, they were equipped with an elastic cap with the attached electrodes (see map of electrodes in Figure 3).

The experiment was conducted in the fall semester of 2020, during the Covid-19 pandemic. The use of the lab and infection control procedures were approved by the Department of Language and Literature on NTNU. Participants were informed of lab regulations for infection control twice by email before arriving: the first time when they registered their contact information, and the second time two days prior to their scheduled experiment. The researchers and the participants wore masks upon meeting, and the researchers wore gloves during the attachment of electrodes and throughout the test. The participant was only allowed to remove their mask while sitting isolated in the electrically proof, sound attenuating testing-booth. The participants were seated in a chair approximately 90 cm away from an LCD-screen. The stimuli were visually presented on the screen with a dark grey background, lower case letters and in 30-point sized Arial font. Each trial began with a fixation cross shown on screen for 500 ms, followed by a word-by-word presentation of a phrase. Each of the items in the phrase were shown for 400 ms. The inter-word intervals were a blank screen for 400 ms. Following the NP, another fixation cross was shown for 500 ms, before the question was shown. Each question was shown for a maximum of 4 seconds. The question would proceed to the next trial when the participant answered, or automatically if the participant did not answer within the 4 seconds. Participants used the F and J-buttons on a standard QWERTY keyboard. The pairing of the respondent keys was counterbalanced between participants. On average, participants spent 31.25 minutes in the testing-booth ( $SD=4.54$  minutes). The experiment contained six breaks, and participants were allowed to spend them as long as they needed. After the test, the participant filled out a final questionnaire with eight trials; 4 of the trials were from the experiment and 4 trials were fake. The participants were asked to write which trials was taken from the experiment. This questionnaire was used to keep the participants focused throughout the experiment and was not analysed further.

## 5.5 Data acquisition and analysis

The EEG was recorded from 32 active electrodes: Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, CP5, CP1, CP2, CP6, TP10, P7, P3, Pz, P4, P8, PO9, O1, Oz, O2, PO10. We used the actiCap system by Brain Products GmbH. The implicit reference was placed on the left mastoid bone, not on the scalp as pictured in Figure 3. The active electrodes were online referenced to this. TP10 was also placed directly on the right mastoid bone and used to re-reference the signal in the final data; all channels were re-referenced offline to the average mastoids. EEG data were sampled at a 1000 Hz high cutoff filter and a 10s time constant. Impedance was kept on 1 kOhm and below across all channels for the entire experiment. We used the 1-32 system of electrodes shown in Figure 3 below:



*Figure 3: The EEG CAP: Standard 64Ch-actiCAP-Slim with Built-In Electrodes (Brain Support, 2017). The reference electrode was placed on the left mastoid. TP10 was placed directly on the right mastoid, not on the cap.*

The observed ERPs are the difference in electrical potential between two electrodes: an active and a ground electrode (Luck, 2014, p. 150). Thus, we do not observe one voltage from a single electrode. EEG data is noisy; the signal must be filtered, and artefacts must be rejected

in order to analyse the potentials. The EEG data was analysed using the Matlab Toolbox software Fieldtrip. Epochs of the data were extracted starting at 200 ms before onset of the critical noun and with an 800 ms post-stimulus interval. The 200 ms pre-stimulus interval was used for baseline correction. Only trials with an amplitude exceeding  $\pm 150 \mu\text{V}$ , relative to the baseline, were kept. Trials containing eye blinks or movement were rejected by looking at the channels Fp1 and Fp2, in the 1-15 Hz band. The data were filtered using a digital low-pass filter at 30 Hz. Participants with less than 15 good trials in a condition was excluded. Additionally, participants with low accuracy on the questions were excluded. Based on these rejection criteria, 30 participants out of 34 (excluding 3 pilot participants) were used in the analysis.

A nonparametric statistical test was conducted for the analysis of data from the EEG. This is a cluster-based approach, used to see whether there was a difference between the conditions in our experiment, and if this difference is based on chance. EEG data have a spatiotemporal structure, i.e., the signal is sampled at multiple sensors (electrodes) and multiple timepoints (Maris & Oostenveld, 2007, p. 181), so it generates a lot of data. The alpha level for the p-value was set to  $\alpha < 0.05$ . ERPs were compared by a t-test in every (electrode, time)-pair. Pairs where t-value exceeded the 95<sup>th</sup> quantile of a T-distribution were used to select spatial-temporally connected clusters of (electrode, time)-samples. The nonparametric analysis was performed by calculating a p-value under a permutation distribution, then comparing it with the alpha-level. A permutation distribution is done by using the Monte Carlo estimate by drawing trials into a random partition a large number of times, then calculating the statistics on each partition (Maris & Oostenveld, 2007, p. 180-181). The accuracy of this estimate increases with the number of draws from this distribution.

The data from the behavioural responses were analysed in R. A mixed effects logistic regression model was used to analyse the behavioural data. By using this model, the variability between participants and items is controlled for (Shrikanth, 2017). This was to study the relationship between the dependent (response time and accuracy) and independent variable (the conditions). Clear outliers with low accuracy in conditions were excluded. For response time, only correct answers were used. In this model, more than two conditions can be compared at once. We compared the submodifier violation against the non-privative, privative and agreement violation. We also compared the agreement violation against the non-privative and privative condition.





## 6. Results

Behavioural results for the agreement violation and submodifier violation conditions are reported in this chapter. The ERP results from the composition conditions and the agreement violation and submodifier violation conditions are also reported in this chapter. Subjects with less than 15 good trials in the EEG data in each condition after filtering and artefact rejection were excluded in the final data analysis. Additionally, a number of subjects were excluded due to low accuracy in the behavioural data. 30 out of 34 participants were included in the final analysis based on qualified ERP and behavioural data. The noun was used as the critical word at which the ERP data was collected. The processing of the ERP and behavioural data was done in collaboration with my supervisor Giosuè Baggio and PhD candidate Lia Calinescu.

### 6.1 Behavioural data results

Descriptive results from the behavioural data are presented in Table 4, Figure 4 and Figure 5 below. For response times (RTs), the non-baseline conditions had a longer response time than the baselines. Accuracies for all conditions were high throughout the behavioural results with over 90% accuracy for all conditions. The baseline conditions had the highest accuracies, with pseudo-word and non-word both on 96% accuracy. The high accuracy and fast response time for baseline conditions indicates that the experiment worked as we intended to.

	<i>Mean RT</i>	<i>Std. RT</i>	<i>Mean Accuracy</i>	<i>Std. Accuracy</i>	<i>n</i>
<i>Agreement violation</i>	1377.512	613.653	0.952	0.215	745
<i>Submodifier violation</i>	1067.761	477.739	0.981	0.136	749
<i>Pseudo-word</i>	1058.904	446.198	0.996	0.063	749
<i>Non-word</i>	1040.345	445.199	0.996	0.063	750

*Table 4: Descriptive statistics summarized. Mean and standard deviation from the experimental conditions are categorized into response time (ms) and accuracy (%), as well as number of observations (n).*

We ran a mixed effects logistic regression analysis to compare more than two conditions at once to control for variation between items and participants. The reason for doing this was to study the relationship between the dependent (RT and accuracy) and independent variable (the conditions). When comparing the submodifier violation condition to the privative, non-privative and agreement violation conditions, the results show

significant comparisons for both response time and response accuracy. In contrast, the agreement violation compared against non-privative and privative shows no significance in either response time or accuracy among the participants. This will be illustrated in more detail in this chapter, categorized into the response time and accuracy among participants between the conditions.

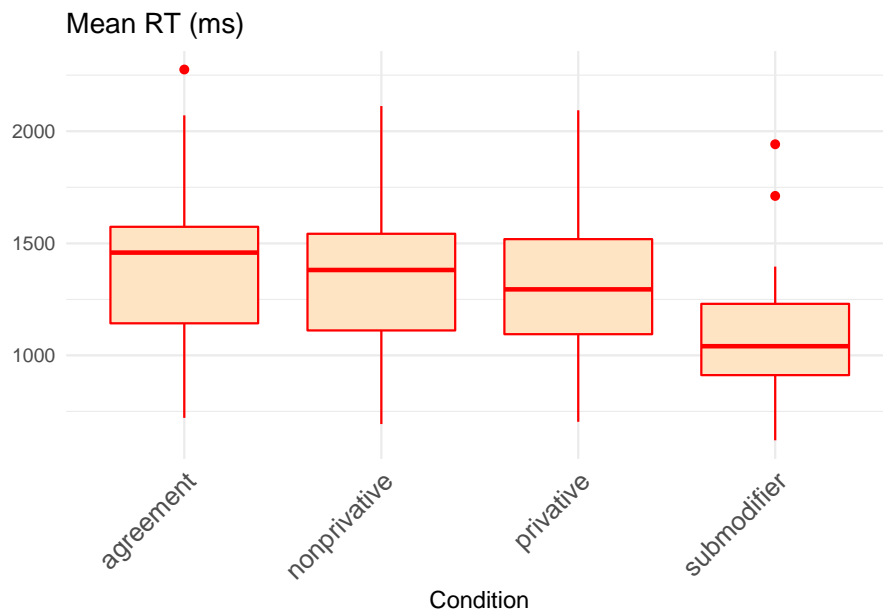


Figure 4: Box plot overview of response time (ms) of correct responses for questions in each condition.

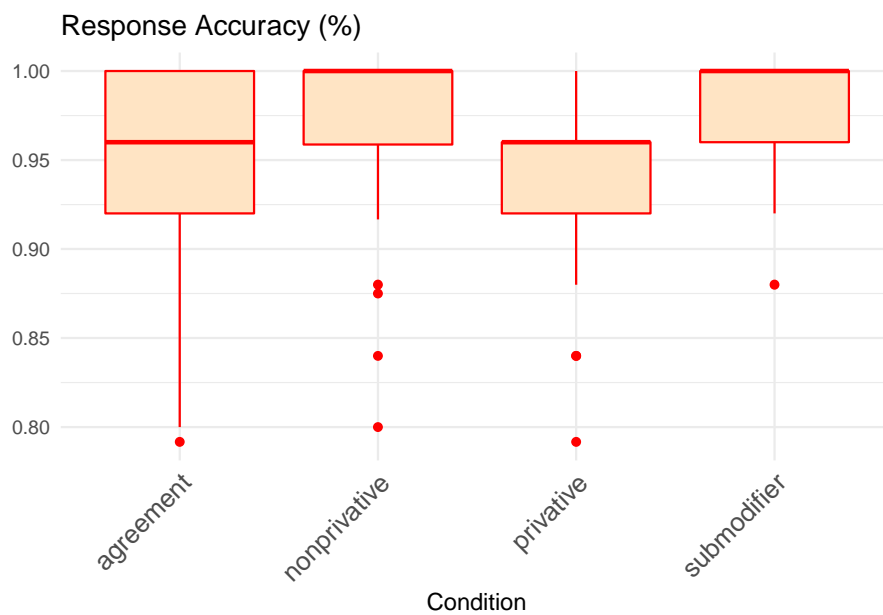


Figure 5: Box plot overview of response accuracy in percentage of correct responses for questions in each condition.

### 6.1.1 Response times

For the behavioural data on response times, only data from correct responses were used in the analysis. The submodifier violation condition was compared independently against the privative, non-privative and agreement violation condition. The intercept in Table 5 is the mean RT in the submodifier violation condition, to which the other conditions are compared. The p-value shows significant differences in all the conditions, indicating that participants were slowest to answer in the agreement violation condition when compared to the submodifier violation condition. The participants are also slower to respond for the agreement violation condition than the composition conditions when compared to the submodifier violation condition.

	<i>Estimate</i>	<i>Std. Error</i>	<i>df</i>	<i>T value</i>	<i>p-value</i>
<i>Intercept</i>	6.89011	0.04747	37.62539	145.150	<.0001
<i>Non-privative</i>	0.22572	0.04063	23.98572	5.555	<.0001
<i>Privative</i>	0.24053	0.03472	24.02987	6.928	<.0001
<i>Agreement</i>	0.24293	0.04698	23.95450	5.172	<.0001

*Table 5: Summary of the effects of the mixed effects logistic regression analysis for response time for questions in non-privative, privative and agreement violation condition against the submodifier violation condition. Slope estimates are the predicted change in log odds for each condition compared.*

The agreement violation condition was also analysed through a mixed effects logistic regression model, compared independently with the privative and non-privative conditions. However, there were no significant differences in response time for the agreement violation condition in comparison with the composition conditions. The intercept below is the mean response time for the agreement violation condition. The analysis for the logistic regression of mean RT compared to the agreement violation condition is in Table 6.

	<i>Estimate</i>	<i>Std. Error</i>	<i>df</i>	<i>T value</i>	<i>p-value</i>
<i>Intercept</i>	7.133795	0.061333	51.750098	116.312	<.0001
<i>Non-privative</i>	-0.018121	0.067057	23.985690	-0.270	0.789
<i>Privative</i>	-0.002901	0.050332	23.984052	-0.058	0.955

*Table 6: Summary of the effects of the mixed effects logistic regression analysis for RT for the questions. Compared is the agreement violation vs privative, and agreement violation vs non-privative conditions.*

### 6.1.2 Response accuracy

For response accuracy, the same variables were tested with the same mixed effects logistic regression model. The effects are illustrated in Table 7 and Table 8. For the submodifier violation condition compared separately to privative and non-privative, the table shows that there are significant differences for all three conditions in accuracy. The submodifier violation condition had a higher accuracy than the compositional conditions with no grammar anomalies. The log odds for the intercept is 55.53 ( $\ln(55.5)=4.0170$ ), thus participants were 55.53 times more likely to answer correct than incorrect for the submodifier violation condition. The agreement violation condition also had a higher accuracy than the compositional conditions, compared to the submodifier violation. Participants were less likely to answer correct for the agreement violation than for the submodifier violation condition.

	<i>Estimate</i>	<i>Std. Error</i>	<i>Z value</i>	<i>p-value</i>
<i>Intercept</i>	4.0170	0.2792	14.388	<.0001
<i>Privative</i>	-0.6852	0.3321	-2.065	0.0389
<i>Non-privative</i>	-1.2406	0.3086	-4.021	<.0001
<i>Agreement</i>	-0.9835	0.3181	-3.092	0.0020

*Table 7: Summary of the effects of the mixed effects logistic regression analysis for response accuracy data for the questions in the submodifier violation, privative, non-privative and agreement violation conditions. Slope estimates are the predicted change in log odds for each condition compared.*

In contrast, the agreement violation conditions compared to conditions without grammar anomalies revealed no significant results between the conditions in response accuracy. The log odds for the agreement violation is 21.9 ( $\ln(21.9)=3.0856$ ), thus participants were about 21.9 times more likely to pick a correct answer than an incorrect answer. See Table 8 below.

	<i>Estimate</i>	<i>Std. Error</i>	<i>Z value</i>	<i>p-value</i>
<i>Intercept</i>	3.0856	0.2002	15.413	<.0001
<i>Non-privative</i>	0.2992	0.2582	1.159	0.247
<i>Privative</i>	-0.2585	0.2276	-1.136	0.256

*Table 8: Summary of effects of the mixed effects logistic regression model analysis for response accuracy for questions in the agreement violation, non-privative and privative conditions.*

## 6.2 ERP Results

The ERP data analysis was done using spatial-temporal clusters, with cluster-level Monte Carlo  $\alpha < 0.05$ . The composition effect was assessed by comparing the composition conditions privative, non-privative and semantic anomaly against the baseline conditions non-word, pseudo-word and submodifier violation condition. For the grammar violation conditions, the submodifier violation and agreement violation conditions were compared to the baseline conditions pseudo-words and non-words.

### 6.2.1 Composition results

As explained in the introduction of the thesis, we sought to replicate the composition results from the experiment by Fritz & Baggio (2020). A P600 component effect was replicated in the combined composition conditions privative, non-privative and semantic anomaly against the baselines pseudo-word, non-word and submodifier violation conditions. The baseline conditions were non-compositional conditions.

The ERP waveform elicited by the noun show a late positive amplitude around 600-800 ms. The parietal effect can be seen at the 400-800 ms mark in Figure 6, right panel. This is in the P600 effect. The compositional effects are illustrated in Figure 6 on the posterior P3 electrode. The cluster observed is large for the composition against non-composition results in terms of size for the P600. The p-value of 0.028 indicate that the results are significant. The significant cluster in the composition comparison is described in Table 9. This means that the null hypothesis suggesting no difference between the conditions can be rejected. Additionally, we observed a strong positive amplitude from around 150 ms to 300 ms after onset of the critical word. This effect could be assumed to be a P200 effect, but the effect is also seen in the other conditions and does not differ between any of them. Therefore, it is not considered to be a P200 effect as a result of the composition in our experiment.

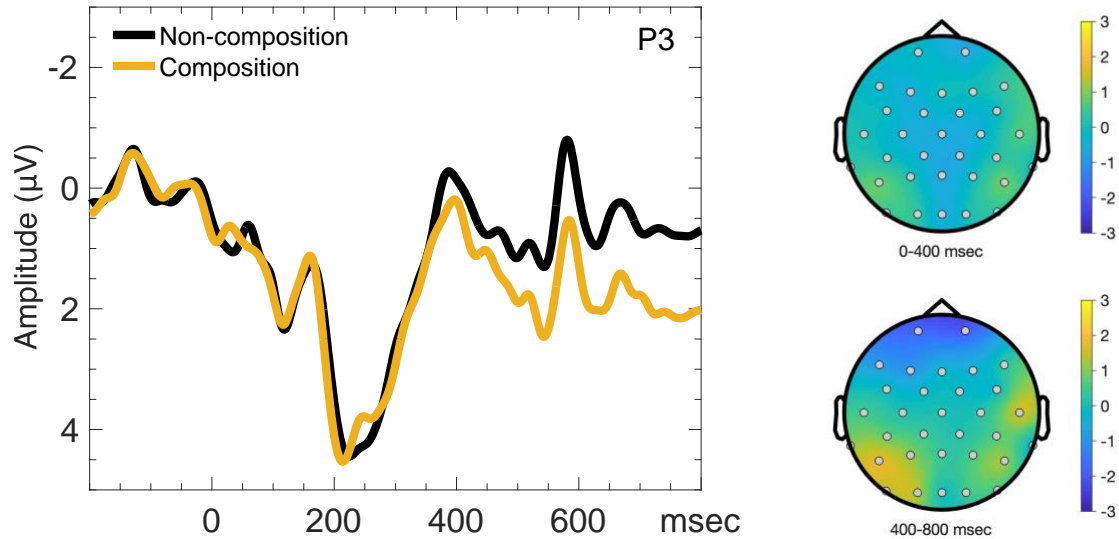


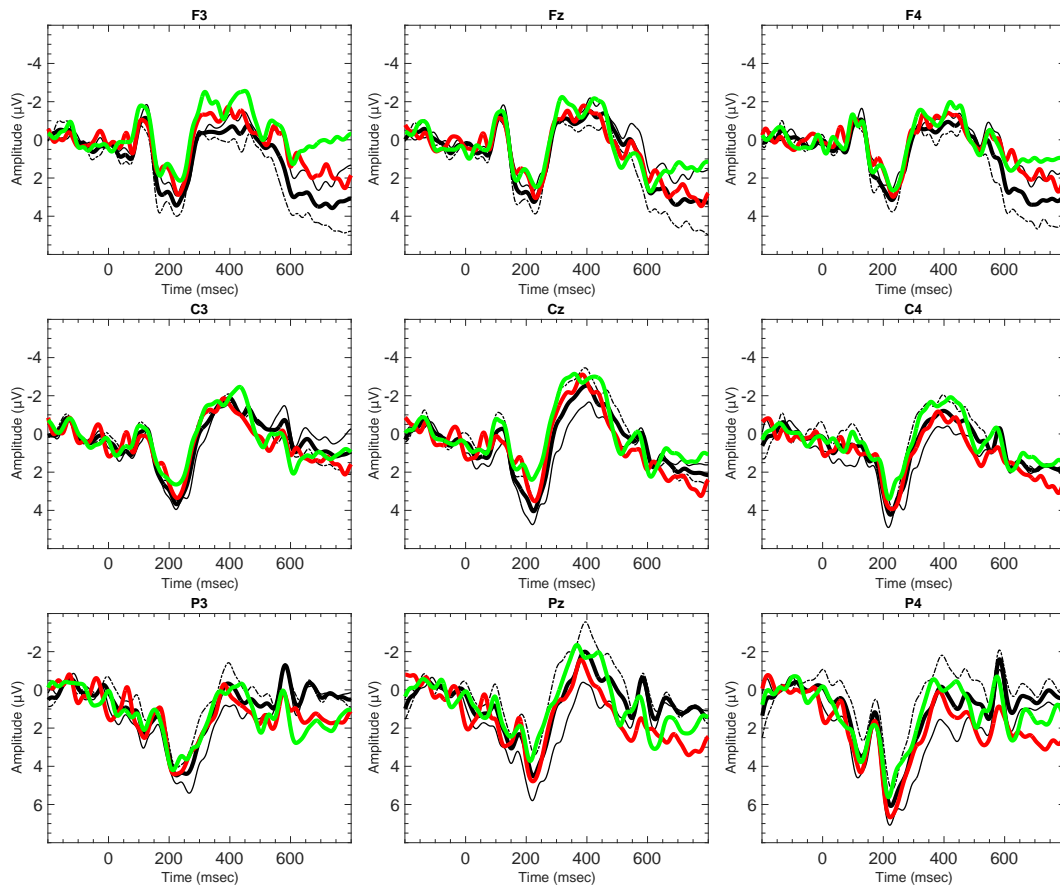
Figure 6: A significant elicited P600 effect compared between conditions non-composition (pseudo-word, non-word and submodifier violation) versus composition (non-privative, privative and semantic anomaly) on the posterior P3 electrode ( $N=30$ ).

	$T_{sum}$	$p$ -value	size
Composition vs non-composition	3.5379e+03	0.0280	1131

Table 9: Summary of results of the compositional non-parametric cluster-based statistics on ERP data from the onset of the critical noun. The table shows the sum of  $t$ -statistics in that cluster ( $T_{sum}$ ), Monte Carlo  $p$ -value, and cluster size in (electrode, time point)-pairs. The composition conditions consist of the privative, non-privative and semantic anomaly conditions. The non-composition conditions consist of pseudo-word, non-word and submodifier violation conditions.

### 6.2.2 Grammar violation results

As seen in Figure 7, we compared the results for the submodifier violation and agreement violation conditions (coloured red and green respectively in the figure) against the two baselines. For those two grammar conditions we observed significant clusters around the 600 ms mark and onwards to the 800 ms mark compared to the baselines, indicating a P600 effect on the noun. The effect is parietal, and can be seen around the posterior electrodes P3, Pz, P4. The timing of the effect is similar to the composition results reported above. The submodifier violation and agreement violation do not differ in response. They may seem to differ in F3 and P4, but this is not a significant difference in terms of cluster size and significance level. No LAN effect was observed in the ERP data in the comparison for the grammar conditions.



**Submodifier violation vs Agreement violation vs baselines**

Figure 7: Grand average ERP waveforms in the grammar violation conditions, compared to the baseline (pseudo-word and non-word). A P600 effect for both submodifier and agreement violation conditions against baselines can be seen on the posterior electrodes P3, Pz, P4 (N=30).

The results show no difference in processing in the ERP data between the submodifier violation and agreement violation condition when compared to the baselines, see Figure 8 and Table 10. The only significant cluster found is posterior around the 600 ms mark and onwards for both conditions (the P600 effect). The two violations match each other with their significant clusters in size and time, as seen in the size of the pseudo-word comparisons and the non-word comparisons for both submodifier and agreement violations in Table 10. The results indicate that the participants did not process the grammar violations at the noun differently between each other or between the noun at the compositional phrases. Comparisons with submodifier and agreement violation conditions against baselines were significant, except for submodifier violation compared to pseudo-word, where no significant cluster was found.

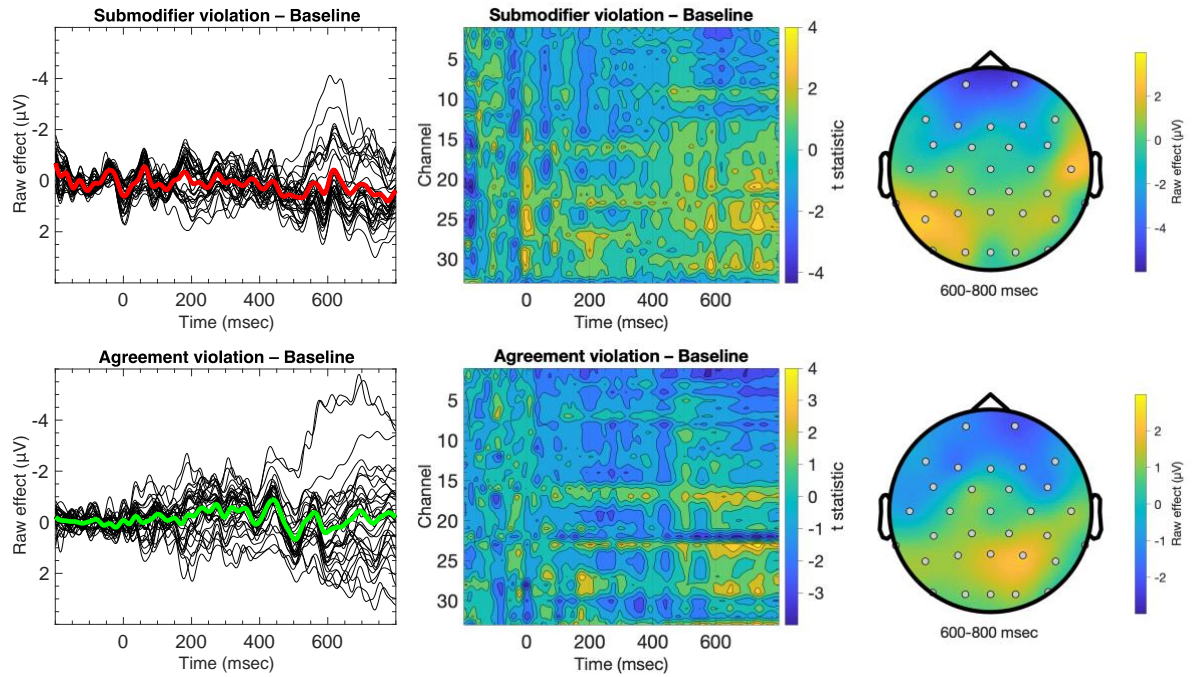


Figure 8: Result of non-parametric cluster-based statistics (left). The left columns show the raw ERP effect averaged from each electrode: each line is an ERP difference in waveform from one channel (grammar violation minus baseline). The middle and right panels show topographies for submodifier violation (top) and agreement violation (bottom). They are processed similarly in clusters and size ( $N=30$ ), with difference from the baselines measured in  $t$ -values.

	$T_{sum}$	$p$ -value	size
<i>Submodifier vs baselines</i>	1.4420e+03	0.0760	513
<i>Submodifier vs non-word</i>	2.8356e+03	0.0350	1042
<i>Submodifier vs pseudo-word</i>	-	-	-
<i>Agreement violation vs baselines</i>	-1.8536e+03	0.0560	713
<i>Agreement violation vs non-word</i>	-3.6100e+03	0.0300	1265
<i>Agreement violation vs pseudo-word</i>	-2.3809e+03	0.0440	929

Table 10: Summary of grammar violation results of non-parametric cluster-based statistics on ERP data from the onset of the critical noun. (-) indicates no significant clusters. The table shows the sum of  $t$ -statistics in clusters ( $T_{sum}$ ), Monte Carlo  $p$ -value, and cluster size in (electrode, time point)-pairs.



## 7. Discussion

The aim of the present thesis was twofold. First, we wanted to replicate the composition results by Fritz and Baggio (2020). Second, I examined how grammar errors are processed by comparing a P600 elicited by two types of grammar violations to the baselines. Specifically, we manipulated the type of adjective preceding the noun to determine the processing of adjective-noun phrase composition and the processing of two different grammar violations. The current thesis focused on two parts of the experiment: (1) the grammar violations consisting of submodifier and agreement violations, and (2) the composition conditions consisting of privative adjectives, non-privative adjectives and a semantic violation. These were compared against the baselines pseudo-word and non-word (the submodifier was also included in the baselines against composition conditions). I expected a P600 effect for the critical noun of the grammar violations, paired with a LAN effect for the agreement violation condition due to the morphosyntactic error. We also expected a P600 effect for the composition conditions due to the sentences being more costly to process. Interestingly, we found a P600 effect for both the grammar conditions and the composition conditions, but no LAN effect for the agreement violation. Surprisingly, the similar results indicate that the two grammar violations were processed the same way. These points will be discussed further in this chapter.

### 7.1 Main findings in results

The behavioural data revealed high accuracies overall across the conditions. The submodifier violation condition had the highest accuracy excluding the baselines. High accuracy for the baselines indicates that participants composed them as intended; either the adjective was not a lexical word, or it was not present in the phrase at all, as seen in the submodifier violation. The agreement violation condition revealed a higher accuracy than non-privatives but lower accuracy than the privatives, when compared to the submodifier. This indicates that a syntactic error was easier to process offline than adjectives providing redundant information regarding the noun.

The response time matches the overall accuracy to some extent; the data from the submodifier violation condition is the fastest and most accurate, excluding baselines. In contrast, a longer response time is observed in the agreement violation than for the submodifier violation, indicating that the agreement violation condition required more offline processing than the submodifier violation. A difference between these two violations is expected, since

these are two different grammar violations. The high accuracy and fast reaction time in the submodifier violation may be due to the language system recognizing a non-lexical “adjective” and discarding any processing effort for adjective-noun composition. Considering the longer reaction time for agreement violation compared to the submodifier, the system may attempt to reanalyse and repair the composition by the time the noun appears.

The ERP effects reveal a P600 effect at both composition conditions against baseline conditions, and grammar violations against baseline conditions. Thus, a P600 was elicited for phrases with a real adjective (or more interesting, an adverb without an adjective to modify) relative to a non-word or pseudo-word. The significant clusters for the grammar conditions are similar in channel and time point-pairs, indicating a similar processing of the noun among the submodifier violation and the agreement violation. This was not expected, due to the different origins of the two grammar violations. Whereas the agreement violation is a morphological error in the inflection of the determiner from the noun, the submodifier violation represents a word category error where the structure of the phrase does not work without an adjacent adjective. These similarities might be an indication that the experiment did not work as we indicated, or that the grammar violations could be too subtle to differentiate between.

Interestingly, this cluster is similar for the composition condition as well. A possible consideration for this reaction could be the P600 reflecting effort to process meaning, without a necessarily successful result. This approach is similar to the claim that the P600 reflects the interplay between grammar and meaning (Kuperberg, 2007; Fritz & Baggio, 2020). However, an ERP reading is not one neural event, but several events recorded at one electrode. Different kinds of conditions can give rise to the same ERP component, and as such we cannot conclude that the similar processing in our results is different at a neural level, but we cannot exclude it. The ERP signals acquired could perhaps not be sensitive enough to make distinctions between the two grammar violations, since ERPs are time-locked events that are always triggered by fixed latencies from the stimulus. An fMRI experiment could be conducted to search for a similar neural response to the stimuli.

The ERP results replicate the P600 from Fritz and Baggio (2020), indicating that the P600 is present in meaning processing. In processing of the noun, the composition conditions “en autentisk/oval/oppdiktet maler” (“an authentic/oval/fictitious painter”) reveal a slightly bigger effect than the grammar conditions “et australsk maler”, “en tydeligvis maler” (“a Australian painter”, “an apparently painter”). Nevertheless, this difference is only by a small margin. The P600 effect in composition against non-composition thus indicates that privatives

and non-privatives are more difficult to process than non-real adjectives or minimal phrases with adverbs lacking an adjective to modify.

I am careful about relating the ERP effects to the behavioural data, due to the results indicating no clear patterns that the participants judged the noun similarly offline as online. The difference between the agreement violation compared to the submodifier violation is the longer reaction time for the agreement violation, indicating more processing of the phrase. However, the ERP data between the two grammar violation conditions are too similar to conclude what the difference indicates.

## **7.2 P600 effect in grammar and composition conditions: What does it reflect?**

The composition conditions and the grammar violation conditions were compared against the baseline conditions pseudo-word and non-word. Additionally, the baselines included the submodifier violation condition when compared to the composition conditions. Our experiment and stimuli were designed on the assumption that a noun following a privative or a non-privative adjective would elicit a P600 compared to baselines due to more processing costs. I also assumed that the submodifier and agreement violations would elicit a P600 due to violated syntax, including a LAN effect for the agreement violation. The results do not confirm nor refute whether the P600 is triggered due to the violation of syntactic constraints, semantic constraints, or both. Implications for both views are discussed in this section.

### **7.2.1 Arguments for a syntax driven P600 effect**

A P600 component was observed in the two grammar conditions. The argument that the P600 reflects syntactic violations or ambiguities seems plausible in this setting. Traditionally, research reported that the P600 responds to syntactic violations, ambiguities or complexities (e.g., Hagoort, 2003; Friederici et al., 1996; Friederici & Meyer, 2004. Silva et al. (2017) exclude the possibility that the P600 as triggered by local familiarity of segments, and presents data pointing towards the P600 as a reaction to structure processing by using artificial grammar. Our results show a P600 in the grammar violations, even for the submodifier violation phrases. The submodifier violation condition should not convey any meaning and may respond to participants detecting the structural mistake. Thus, the results may be compatible with the earlier research claiming that the P600 is elicited by syntax. However, the P600 effect elicited in the composition conditions does not suggest that this is the case.

The P600 component was observed with the same cluster at the same time period (~600-800 ms) for both of the grammar violations. This indicates that the agreement violation and submodifier violation were processed the same way. This was not expected, as the two conditions show different types of grammar violations. The submodifier violation requires a different word in its position; an adverb is placed in the submodifier position without an adjective, and therefore needs to be followed by an adjective in order to construct meaning. In Norwegian, some adverbs have a suffix to distinguish them from adjectives: the suffix *-vis* (Holmes & Enger, 2018). However, this is not a consistent pattern for all the adverbs in our stimuli. We used *tydeligvis*, derived from the adjective *tydelig*, but we also used *aldeles* and *cirka*. These do not have an adjective-equivalent to differentiate the word category from. A faint difference between adverbs and adjectives in a context where they are put in the same position may cause the brain to not always differentiate between them in a minimal context. Thus, one may speculate whether participants recognized a structural violation, but parsed the minimal phrase as a metaphorical meaning.

In the agreement violation condition, there is a clear morphosyntactic violation in which the determiner does not show agreement with the noun. However, the noun used in the current experiment were indefinite singular nouns, and the adjectives followed the inflection of the noun. See (5):

- (5) \*Et gresk\_ forfatter  
 [Det<sub>[neutral]</sub> A<sub>[masculine?]</sub> N<sub>[masculine]</sub> ]  
*An Greek author*

“Et gresk forfatter” do not contain an affix illustrating inflection on the adjective based on the neutral determiner instead of the masculine noun, while “et greskt forfatter” contains the suffix *-t* when inflecting the adjective after what would have been a neutral noun. The inflection on the adjective from the noun and the only error in the determiner may have contributed to a P600 effect on the same scale as the submodifier violation condition. One may speculate whether a more severe agreement violation would trigger a P600 effect with a bigger amplitude due to a more costly reanalysis- and repair-process. If that is the case, the proposition that P600 reflects syntactic violations could possibly be supported, as it would show explicit sensitivity to grammar violations.

### 7.2.2 Arguments for a syntax and semantics driven P600 effect

In more recent times, research has proposed the idea that the P600 may reflect more than syntactic structure violations. Our experiment elicited an P600 effect for composition conditions compared to the baselines in addition to the grammar violations compared to the baselines. This P600 effect raises points about the possibly semantic effect in the P600 component and against a syntax driven P600, since the composition conditions in the experiment did not include any syntactic violations. When taking a syntactic-semantic approach to the P600 effect, the effect could be argued as a reaction to the interplay between morphosyntax and thematic sensitivity (Kuperberg, 2007; Kim & Sikos, 2011) or interpretation of the phrase (Bambini et al., 2016). Interpretation of the phrase is relevant to the submodifier effect as well if the phrases were processed metaphorically, but this proposal is only speculation. The P600 component in a composition condition may be due to a privative or non-privative adjective having a bigger effect on the noun than an intersective adjective (e.g., *fake* versus *grønlandsk*).

In earlier research by Schumacher et al. (2018), privative adjectives were observed as more computationally demanding than an intersective or subsective adjective, as it completely negated the meaning of the head noun. Thus, a more demanding reanalysis of the noun could be observed in their ERP data on composition, resulting in a late positivity. Schumacher et al. (2018) proposed that this late positivity was due to computational costs involving repair on structures violating the assumed meaning of the head noun in the adjective-noun phrase. The elicited P600 in our composition conditions involves privatives and could therefore be an argument towards the P600 component reflecting some repair on the semantic composition of the phrase. However, the composition comparison in this thesis involved the semantic anomaly and the non-privative condition as well. Schumacher et al. (2018) did not find a P600 effect for the non-privatives, while our experiment did reveal a P600 effect combined with the privative and semantic anomaly.

As intended to, the composition effect was replicated from Fritz and Baggio (2020). In their research, they proposed one way of looking at their results for denotation as a P600 effect instead of a late-N400. Here, the non-privatives could evoke a larger P600 effect than privatives, strengthening the belief that the P600 reflects a conflict between meaning and form (also discussed by Kuperberg, 2007). This is a possibility for our results as well, since the composition conditions evoked a P600 compared to the baselines. If the P600 indeed reflects obstacles in the processing of meaning and form, it may explain why we encountered an effect

in both the composition conditions and grammar violation conditions compared to the baselines.

Whether pseudo-words involve syntactic composition or not is a debated issue. On the assumption that pseudo-words *do* have syntactic composition, the data again point towards the P600 effect as a reaction to semantic composition (Fritz & Baggio, 2020). What differentiates real adjectives from pseudo-words is the fact that only real adjectives involve semantic composition. Alternatively, Fritz and Baggio (2020) suggest that if pseudo-words and non-words prevent the deployment of syntactic and semantic composition, one cannot entirely exclude that the P600 effect can reflect *both* semantic and syntactic composition. This can be reflected in the results of this thesis, since we observe a P600 effect in both syntactic violations and semantic violation conditions, but not in the pseudo-word condition. Hence, if the P600 reflects processing, our findings for both conditions are probable; the P600 may reflect effort of processing meaning during reading, with or without a successful result.

### **7.3 The LAN effect: Why is it not produced?**

From earlier research, phrase structure violations such as word category or morphosyntactic errors appear to elicit the LAN effect, often followed by a P600 (Friederici & Meyer, 2004; Morris & Holcomb, 2005). While the LAN has been observed in relation to syntactic violations, it appears to remain unaffected by ambiguity or complexity (Friederici et al., 1996). We expected a LAN effect in our agreement violation condition but did not observe this effect in the ERP data. The agreement violation condition contained one violation in the determiner of the phrase. In Norwegian, monosyllabic adjectives receive a *-t* suffix when paired with a neutral noun (Holmes & Enger, 2018), as in “*et nytt hus*”. Adjectives used in the agreement violation described nationalities, e.g., *australsk*, and do not get a *-t* suffix inflection when paired with a neutral verb, e.g., *band – et australsk band*. One consideration could be that the agreement violation in “*en australsk band*” (“*a Australian band*”) is not strong enough to produce a LAN effect when participants see the noun. Thus, the violation happens too early in the stimuli for participants to reanalyse the phrase by the time the noun appears. The language system may not be as intolerant to language violations in the beginning of sentences. Therefore, the lack of context in the current experiment may result in the system waiting until reanalysis to judge whether it should process meaning (triggering only a P600 effect). Following the claims of Friederici et al. (1996) and Friederici and Meyer (2004), the agreement violation should have produced a LAN effect due to the morphological error, but lack of context may block this

processing. This may be a possible explanation, as the LAN effect is reported in stimuli with context (Morris & Holcomb, 2005, p. 969). On the other hand, following the argument of Steinhauer & Drury (2012) and their criticism toward the ELAN as artefacts unrelated to language processing, then the lack of (E)LAN effects in our data should not come as a surprise.

Another consideration to reflect upon is whether participants felt stimulated throughout the experiment. Due to the design of the experiment, the violation in the phrase appeared in the first unit. Participants may not pay enough attention to this part of the experiment, as adjective is the manipulated element and participants' main focus is therefore on the adjective or noun. Thus, if the brain did not pay attention to the determiner, the LAN effect in the agreement violation could be compromised.

## **7.4 Limitations and further research**

In psycholinguistic research, drawing conclusions based on one study alone is not possible. This thesis gave me insight to the psycholinguistic field of research, but the conclusions drawn here are only preliminary and will need further investigation.

The first issue is the extent of the study. Our experiment had a sample size of 30 participants, while a more ideal experiment would include a sample of a larger size. The sampling of participants was done during the Covid-19 pandemic in fall 2020. Following the new year 2021, a stricter restriction on social contacts forced the lab to close. This halted the possibility of collecting more participants to increase our sample. The experiment took on average 30 minutes to complete. In this field of study, it is considered a short experiment. However, longer experiments often lead to habituation effects, such as decreasing signal strength as participants are exposed to more and more stimuli of the same type. In addition, our material consisted of 175 items (excluding fillers). To further improve the statistics of the ERPs in search for bigger clusters of significant reactions, a longer experiment with more stimuli in the different conditions need to be made.

Another issue is the question regarding what language processes the P600 effect corresponds to. Since we received a P600 for both the composition condition and the grammar conditions, one cannot draw a conclusion on the nature of the P600 component. The violations in the grammar conditions can be even more accentuated in a future experiment. The agreement violation in the current study is only visible in the determiner-position, whereas nationality adjectives can be replaced with a monosyllabic adjective with inflection in the suffix. These adjectives would also correspond in length with each other more than the current adjectives

used in the agreement violation condition. Regarding the submodifier violation, being consistent with using adverbs requiring suffixes may be a better way to differentiate the submodifier violation from the agreement violation. In conversation with the participants post-experiment, they mentioned the agreement violation condition when asked if they noticed strange constructions. The submodifier violation condition was rarely mentioned. However, we do not have a way of analysing their verbal feedback quantitatively and this is merely an observation. In addition, there is a possibility that participants processed the submodifier violation phrases metaphorically even with strict instructions not to do so. Creating a stronger grammar violation and comparing that to the composition condition may help to clarify what the P600 reflects in language processing, and whether it is the interaction between form and meaning. Alternatively, if the ERP signals as such are not sensitive enough to make distinctions between grammar violations, another method examining the same minimal composition may be a better suited approach.

It is also worth mentioning that experiments using minimal phrases excludes context. Several experiments eliciting ERP effects (such as LAN) did have context, which may be seen as a reason for the lack of LAN effects in the current experiment. Finally, we observed a considerable activity surrounding the adjectives. To understand the data from the nouns better (which is when the participants should process the violation of the phrase) we may need to look at the activity in the adjectives first.



## 8. Conclusion

This study investigated how we compose form and meaning in an adjective-noun minimal phrase context. This was done by using the ERP technique in attempts to find components known to grammar violations: the P600 effect and the LAN effect. Our results show a P600 effect for both composition conditions and grammar violation conditions, thereby providing additional data undermining the P600 as strictly triggered by syntactic anomalies. The ERP effects suggests that the P600 component might reflect processing of both syntactic and semantic composition.

The P600 effect in the composition contrast was replicated from the former research by Fritz & Baggio (2020). The composition condition consisted of privative, non-privative and intersective semantic anomalies, contrasted against the baselines. With the use of cluster-based statistics, we observed that the composition condition elicited the P600 effect at the critical noun. The adjective-noun phrases in these conditions do not contain any syntactic anomaly, thus these results may suggest that the P600 effect can be interpreted as an effect of meaning in addition to form. The neurological components of form and meaning composition is still unknown.

The experiment included two conditions with grammar violations. They targeted different grammatical aspects: a submodifier violation and an agreement violation. Each of these conditions also elicited a P600 effect on the critical noun. As seen in literature presented, this effect has traditionally been connected to syntactic anomalies, which both of the grammar violations contain. The grammatical violations are different type of violations, the submodifier requires an adjective to modify, and the agreement violation requires a determiner with the right inflection from the noun. The two violations should therefore be processed differently; the submodifier violation should not be processed at all due to violating the adjective-noun pattern, while the agreement violation should elicit reactions to the morphosyntactic violation and reanalysis. In contrast, the results show similar processing for these two violations; the P600 effect for both grammar conditions do not differ in cluster size or significance level. The similar processing could be an indication that the participants are not differentiating between the adverb and adjectives when processing the adjective-noun phrases, or that the experiment did not work as intended. Additionally, we did not find the expected LAN effect for the agreement violation condition. This observation might be an indication that minimal adjective-noun phrases without context are not enough for the language system to detect a violation, but further research must be done in order to conclude this.

Lastly, the P600 effect was processed similarly for the composition and the grammar violation comparisons. This further indicates that the effect is triggered by the interplay between form and meaning. One possible indication of this effect may be that the P600 component reflects the effort of composing form and meaning, with or without a necessarily successful result.

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# Appendices

## Appendix A: Full Set of Stimuli and Fillers

### Stimuli

#	Det.	Adjective	Noun	Syntax	Semantic	Condition	Question	A
1	en	qxflnhjpsz	lege	Syn-	Sem-	non-word	Er det snakk om en lege?	yes
2	en	rlpz	pasient	Syn-	Sem-	non-word	Er det snakk om en pasient?	Yes
3	en	tvbmpl	student	Syn-	Sem-	non-word	Er det snakk om en fisker?	No
4	en	xqprngk	konge	Syn-	Sem-	non-word	Er det snakk om et lag?	No
5	en	scglqmpkn	idrettsmann	Syn-	Sem-	non-word	Er det snakk om en snekker?	No
6	en	qpsljg	investor	Syn-	Sem-	non-word	Er det snakk om en prins?	No
7	en	slkjtvmql	kunde	Syn-	Sem-	non-word	Er det snakk om en kunde?	Yes
8	en	tqlskclfbqlf	kunstner	Syn-	Sem-	non-word	Er det snakk om en kunstner?	Yes
9	en	thrlpvn	lærer	Syn-	Sem-	non-word	Er det snakk om en politiker?	No
10	en	cfhrmpkqxr	forfatter	Syn-	Sem-	non-word	Er det snakk om en forfatter?	Yes
11	et	tpcfmjzwrp	medlem	Syn-	Sem-	non-word	Er det snakk om en skuespiller?	No
12	en	qcfnjrmtpvx	president	Syn-	Sem-	non-word	Er det snakk om en danser?	No
13	en	mdcflpxjzk	musiker	Syn-	Sem-	non-word	Er det snakk om en pilot?	No
14	et	htrp	parti	Syn-	Sem-	non-word	Er det snakk om et parti?	Yes
15	en	kvgnj	eier	Syn-	Sem-	non-word	Er det snakk om en eier?	Yes
16	et	cpgqm	band	Syn-	Sem-	non-word	Er det snakk om en regjering ?	No
17	en	txjknq	forsker	Syn-	Sem-	non-word	Er det snakk om en forsker?	Yes
18	en	nbqvlp	sjef	Syn-	Sem-	non-word	Er det snakk om en sjef?	Yes

19	en	fmgqlcgq	ordfører	Syn-	Sem-	non-word	Er det snakk om en ordfører?	Yes
20	et	jgmqlxz	korps	Syn-	Sem-	non-word	Er det snakk om en svømmer?	No
21	en	bcqdpkm	professor	Syn-	Sem-	non-word	Er det snakk om en professor?	Yes
22	en	hvpqslkqwq	maler	Syn-	Sem-	non-word	Er det snakk om en elev?	No
23	en	sglncfwpq	sanger	Syn-	Sem-	non-word	Er det snakk om en sanger?	Yes
24	et	xdpkjsqm	ekteskap	Syn-	Sem-	non-word	Er det snakk om et ekteskap?	Yes
25	en	grlpmdqr	forhandler	Syn-	Sem-	non-word	Er det snakk om en psykolog?	No
26	en	klåkkerlig	lege	Syn+	Sem-	pseudo-word	Er det snakk om en lege?	Yes
27	en	råsk	pasient	Syn+	Sem-	pseudo-word	Er det snakk om en kaptein?	No
28	en	vurlig	student	Syn+	Sem-	pseudo-word	Er det snakk om en organisasjon?	No
29	en	trådisk	konge	Syn+	Sem-	pseudo-word	Er det snakk om en konge?	Yes
30	en	råstkende	idrettsmann	Syn+	Sem-	pseudo-word	Er det snakk om en sykepleier?	No
31	en	bræst	investor	Syn+	Sem-	pseudo-word	Er det snakk om en investor?	Yes
32	en	stråndlig	kunde	Syn+	Sem-	pseudo-word	Er det snakk om en pilot?	No
33	en	stalråmmende	kunstner	Syn+	Sem-	pseudo-word	Er det snakk om en kunstner?	Yes
34	en	våsklig	lærer	Syn+	Sem-	pseudo-word	Er det snakk om en lærer?	Yes
35	en	frøstitten	forfatter	Syn+	Sem-	pseudo-word	Er det snakk om en alpinist?	No
36	et	leståmmende	medlem	Syn+	Sem-	pseudo-word	Er det snakk om en forbryter?	No
37	en	slikåmmende	president	Syn+	Sem-	pseudo-word	Er det snakk om en elektriker?	No
38	en	trostenlig	musiker	Syn+	Sem-	pseudo-word	Er det snakk om en musiker?	Yes
39	et	nirt	parti	Syn+	Sem-	pseudo-word	Er det snakk om et parti?	Yes
40	en	garsk	eier	Syn+	Sem-	pseudo-word	Er det snakk om en politiker?	No
41	et	stirt	band	Syn+	Sem-	pseudo-word	Er det snakk om et band?	Yes



42	en	kullig	forsker	Syn+	Sem-	pseudo-word	Er det snakk om en forsker?	Yes
43	en	nårisk	sjef	Syn+	Sem-	pseudo-word	Er det snakk om et orkester?	No
44	en	fråstisk	ordfører	Syn+	Sem-	pseudo-word	Er det snakk om et postbud?	No
45	et	skømmelt	korps	Syn+	Sem-	pseudo-word	Er det snakk om et korps?	Yes
46	en	tikelig	professor	Syn+	Sem-	pseudo-word	Er det snakk om en prins?	No
47	en	resimmende	maler	Syn+	Sem-	pseudo-word	Er det snakk om en forbryter?	No
48	en	strøkklig	sanger	Syn+	Sem-	pseudo-word	Er det snakk om en sanger?	Yes
49	et	størvitt	ekteskap	Syn+	Sem-	pseudo-word	Er det snakk om en identitet?	No
50	en	grustisk	forhandler	Syn+	Sem-	pseudo-word	Er det snakk om en forhandler?	Yes
51	en	ekte	lege	Syn+	Sem+	Non-privative	Er det faktisk en lege?	Yes
52	en	virkelig	pasient	Syn+	Sem+	Non-privative	Er det faktisk en pasient?	Yes
53	en	ekte	student	Syn+	Sem+	Non-privative	Er det faktisk en student?	Yes
54	en	ekte	konge	Syn+	Sem+	Non-privative	Er det faktisk en konge?	Yes
55	en	autentisk	idrettsmann	Syn+	Sem+	Non-privative	Er det snakk om en uekte idrettsmann?	No
56	en	eksisterende	investor	Syn+	Sem+	Non-privative	Er det en uekte investor?	No
57	en	virkelig	kunde	Syn+	Sem+	Non-privative	Er det snakk om en uekte kunde?	No
58	en	virkelig	kunstner	Syn+	Sem+	Non-privative	Er det faktisk kunstner?	Yes
59	en	ordentlig	lærer	Syn+	Sem+	Non-privative	Er det en uekte lærer?	No
60	en	ekte	forfatter	Syn+	Sem+	Non-privative	Er det faktisk en forfatter?	Yes
61	et	eksisterende	medlem	Syn+	Sem+	Non-privative	Er det snakk om et uekte medlem?	No
62	en	ordentlig	president	Syn+	Sem+	Non-privative	Er det en uekte president?	No
63	en	virkelig	musiker	Syn+	Sem+	Non-privative	Er det en uekte musiker?	No
64	et	eksisterende	parti	Syn+	Sem+	Non-privative	Er det snakk om et uekte parti?	No

65	en	eksisterende	eier	Syn+	Sem+	Non-privative	Er det faktisk en eier?	Yes
66	et	autentisk	band	Syn+	Sem+	Non-privative	Er det faktisk et band?	Yes
67	en	ordentlig	forsker	Syn+	Sem+	Non-privative	Er det faktisk en forsker?	Yes
68	en	autentisk	sjef	Syn+	Sem+	Non-privative	Er det en uekte sjef?	No
69	en	ordentlig	ordfører	Syn+	Sem+	Non-privative	Er det snakk om en uekte ordfører?	No
70	et	eksisterende	korps	Syn+	Sem+	Non-privative	Er det faktisk et korps?	Yes
71	en	ekte	professor	Syn+	Sem+	Non-privative	Er det faktisk en professor?	Yes
72	en	autentisk	maler	Syn+	Sem+	Non-privative	Er det en uekte maler?	No
73	en	ordentlig	sanger	Syn+	Sem+	Non-privative	Er det en uekte sanger?	No
74	et	autentisk	ekteskap	Syn+	Sem+	Non-privative	Er det faktisk et ekteskap?	Yes
75	en	virkelig	forhandler	Syn+	Sem+	Non-privative	Er det en uekte forhandler?	No
76	en	kvadratisk	lege	Syn+	Sem?	anomalous semantic	Er det snakk om en uekte lege?	Yes
77	en	kvadratisk	pasient	Syn+	Sem?	anomalous semantic	Er det en mulig pasient?	No
78	en	trekantet	student	Syn+	Sem?	anomalous semantic	Er det en mulig student?	No
79	en	oval	konge	Syn+	Sem?	anomalous semantic	Er det en mulig konge?	No
80	en	oval	idrettsmann	Syn+	Sem?	anomalous semantic	Er det snakk om en uekte idrettsmann?	Yes
81	en	oransje	investor	Syn+	Sem?	anomalous semantic	Er det en mulig investor?	No
82	en	sirkulær	kunde	Syn+	Sem?	anomalous semantic	Er det en uekte kunde?	Yes
83	en	oval	kunstner	Syn+	Sem?	anomalous semantic	Er det snakk om en uekte kunstner?	Yes
84	en	oransje	lærer	Syn+	Sem?	anomalous semantic	Er det en mulig lærer?	No
85	en	oval	forfatter	Syn+	Sem?	anomalous semantic	Er det en uekte forfatter?	Yes
86	et	oransje	medlem	Syn+	Sem?	anomalous semantic	Er det et uekte medlem?	Yes
87	en	kvadratisk	president	Syn+	Sem?	anomalous semantic	Er det en mulig president?	No

88	en	sirkulær	musiker	Syn+	Sem?	anomalous semantic	Er det en mulig musiker?	No
89	et	trekantet	parti	Syn+	Sem?	anomalous semantic	Er det snakk om et uekte parti?	Yes
90	en	oransje	eier	Syn+	Sem?	anomalous semantic	Er det en mulig eier?	No
91	et	trekantet	band	Syn+	Sem?	anomalous semantic	Er det et uekte band?	Yes
92	en	kvadratisk	forsker	Syn+	Sem?	anomalous semantic	Er det snakk om en uekte forsker?	Yes
93	en	sirkulær	sjef	Syn+	Sem?	anomalous semantic	Er det en uekte sjef?	Yes
94	en	kvadratisk	ordfører	Syn+	Sem?	anomalous semantic	Er det en uekte ordfører?	Yes
95	et	sirkulært	korps	Syn+	Sem?	anomalous semantic	Er det et mulig korps?	No
96	en	trekantet	professor	Syn+	Sem?	anomalous semantic	Er det en mulig professor?	No
97	en	oval	maler	Syn+	Sem?	anomalous semantic	Er det en mulig maler?	No
98	en	trekantet	sanger	Syn+	Sem?	anomalous semantic	Er det en uekte sanger?	Yes
99	et	oransje	ekteskap	Syn+	Sem?	anomalous semantic	Er det et mulig ekteskap?	No
100	en	sirkulær	forhandler	Syn+	Sem?	anomalous semantic	Er det en mulig forhandler?	No
101	en	falsk	lege	Syn+	Sem+	Privative	Er det en uekte lege?	Yes
102	en	imaginær	pasient	Syn+	Sem+	Privative	Er det en uekte pasient?	Yes
103	en	imaginær	student	Syn+	Sem+	Privative	Er det snakk om en uekte student?	Yes
104	en	fiktiv	konge	Syn+	Sem+	Privative	Er det en uekte konge?	Yes
105	en	falsk	idrettsmann	Syn+	Sem+	Privative	Er det faktisk en idrettsmann?	No
106	en	fiktiv	investor	Syn+	Sem+	Privative	Er det snakk om en uekte investor?	Yes
107	en	imaginær	kunde	Syn+	Sem+	Privative	Er det faktisk en kunde?	No
108	en	imaginær	kunstner	Syn+	Sem+	Privative	Er det faktisk en kunstner?	No
109	en	falsk	lærer	Syn+	Sem+	Privative	Er det en uekte lærer?	Yes
110	en	imaginær	forfatter	Syn+	Sem+	Privative	Er det faktisk en forfatter?	No
111	et	oppdiktet	medlem	Syn+	Sem+	Privative	Er det faktisk et medlem?	No

112	en	fiktiv	president	Syn+	Sem+	Privative	Er det en uekte president?	Yes
113	en	fiktiv	musiker	Syn+	Sem+	Privative	Er det snakk om en uekte musiker?	Yes
114	et	oppdiktet	parti	Syn+	Sem+	Privative	Er det faktisk et parti?	No
115	en	fiktiv	eier	Syn+	Sem+	Privative	Er det snakk om en uekte eier?	Yes
116	et	oppdiktet	band	Syn+	Sem+	Privative	Er det faktisk et band?	No
117	en	falsk	forsker	Syn+	Sem+	Privative	Er det faktisk en forsker?	No
118	en	oppdiktet	sjef	Syn+	Sem+	Privative	Er det faktisk en sjef?	No
119	en	falsk	ordfører	Syn+	Sem+	Privative	Er det snakk om en uekte ordfører?	Yes
120	et	imaginært	korps	Syn+	Sem+	Privative	Er det et uekte korps?	Yes
121	en	imaginær	professor	Syn+	Sem+	Privative	Er det en uekte professor?	Yes
122	en	oppdiktet	maler	Syn+	Sem+	Privative	Er det faktisk en maler?	No
123	en	oppdiktet	sanger	Syn+	Sem+	Privative	Er det faktisk en sanger?	No
124	et	falskt	ekteskap	Syn+	Sem+	Privative	Er det et uekte ekteskap?	Yes
125	en	fiktiv	forhandler	Syn+	Sem+	Privative	Er det faktisk en forhandler?	No
126	et	australsk	lege	Syn?	Sem+	agreement violation	Er det snakk om en uekte lege?	No
127	et	nederlandsk	pasient	Syn?	Sem+	agreement violation	Er det en uekte pasient?	No
128	et	indisk	student	Syn?	Sem+	agreement violation	Er det en mulig student?	Yes
129	et	nederlandsk	konge	Syn?	Sem+	agreement violation	Er det snakk om en uekte konge?	No
130	et	nederlandsk	idrettsmann	Syn?	Sem+	agreement violation	Er det en uekte idrettsmann?	No
131	et	grønlandsk	investor	Syn?	Sem+	agreement violation	Er det en mulig investor?	Yes
132	et	indisk	kunde	Syn?	Sem+	agreement violation	Er det faktisk en kunde?	Yes
133	et	indisk	kunstner	Syn?	Sem+	agreement violation	Er det snakk om en uekte kunstner?	No
134	et	gresk	lærer	Syn?	Sem+	agreement violation	Er det en mulig lærer?	Yes
135	et	gresk	forfatter	Syn?	Sem+	agreement violation	Er det faktisk en forfatter?	Yes
136	en	grønlandsk	medlem	Syn?	Sem+	agreement violation	Er det et mulig medlem?	Yes

137	et	indisk	president	Syn?	Sem+	agreement violation	Er det en uekte president?	No
138	et	gresk	musiker	Syn?	Sem+	agreement violation	Er det faktisk en musiker?	Yes
139	en	nederlandsk	parti	Syn?	Sem+	agreement violation	Er det et mulig parti?	Yes
140	et	grønlandsk	eier	Syn?	Sem+	agreement violation	Er det snakk om en uekte eier?	No
141	en	australsk	band	Syn?	Sem+	agreement violation	Er det snakk om et uekte band?	No
142	et	grønlandsk	forsker	Syn?	Sem+	agreement violation	Er det snakk om en uekte forsker?	No
143	et	australsk	sjef	Syn?	Sem+	agreement violation	Er det en mulig sjef?	Yes
144	et	gresk	ordfører	Syn?	Sem+	agreement violation	Er det faktisk en ordfører?	Yes
145	en	gresk	korps	Syn?	Sem+	agreement violation	Er det et uekte korps?	No
146	et	indisk	professor	Syn?	Sem+	agreement violation	Er det faktisk en professor?	Yes
147	et	australsk	maler	Syn?	Sem+	agreement violation	Er det en uekte maler?	No
148	et	grønlandsk	sanger	Syn?	Sem+	agreement violation	Er det faktisk en sanger?	Yes
149	en	australsk	ekteskap	Syn?	Sem+	agreement violation	Er det et uekte ekteskap?	No
150	et	nederlandsk	forhandler	Syn?	Sem+	agreement violation	Er det en mulig forhandler?	Yes
151	en	cirka	lege			submodifier violation	Er det snakk om en elev?	No
152	en	aldeles	pasient			submodifier violation	Er det snakk om en pasient?	Yes
153	en	tydeligvis	student			submodifier violation	Er det snakk om en student?	Yes
154	en	uheldigvis	konge			submodifier violation	Er det snakk om en konge?	Yes
155	en	vekselvis	idrettsmann			submodifier violation	Er det snakk om en mekaniker?	No
156	en	uheldigvis	investor			submodifier violation	Er det snakk om en investor?	Yes
157	en	aldeles	kunde			submodifier violation	Er det snakk om en kunde?	Yes
158	en	cirka	kunstner			submodifier violation	Er det snakk om en forbryter?	No
159	en	tydeligvis	lærer			submodifier violation	Er det snakk om en lærer?	Yes

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

## Fillers

#	Det	Adjective	Noun	Condition	Question	A
1	en	gul	stjerne	non-semantic violation intersective adj	Er det en mulig stjerne?	yes
2	et	firkantet	papir	non-semantic violation intersective adj	Er det faktisk et bord?	no
3	en	rund	planet	non-semantic violation intersective adj	Er det faktisk en planet?	yes
4	en	grønn	skilpadde	non-semantic violation intersective adj	Er det snakk om en løve?	no
5	en	gul	sjiraff	non-semantic violation intersective adj	Er det faktisk en sjiraff?	yes
6	en	rund	stein	non-semantic violation intersective adj	Er det faktisk en stein?	yes
7	et	firkantet	hus	non-semantic violation intersective adj	Er det snakk om et fly?	no
8	et	grønt	blad	non-semantic violation intersective adj	Er det et uekte blad?	no
9	et	lilla	fly	non-semantic violation intersective adj	Er det faktisk et kontor?	no
10	en	firkantet	mobil	non-semantic violation intersective adj	Er det snakk om en måne?	no
11	et	turkist	armbånd	non-semantic violation intersective adj	Er det faktisk et armbånd?	yes
12	en	rund	klokke	non-semantic violation intersective adj	Er det snakk om en sko?	no
13	et	ovalt	speil	non-semantic violation intersective adj (same as experimental adj)	Er det et mulig speil?	yes
14	en	sirkulær	bane	non-semantic violation intersective adj (same as experimental adj)	Er det faktisk en bane?	yes
15	en	oransje	blomst	non-semantic violation intersective adj (same as experimental adj)	Er det en uekte blomst?	no
16	et	trekantet	skilt	non-semantic violation intersective adj (same as experimental adj)	Er det snakk om et skilt?	yes
17	en	kvadratisk	pute	non-semantic violation intersective adj (same as experimental adj)	Er det faktisk en pute?	yes
18	en	oransje	vegg	non-semantic violation intersective adj (same as experimental adj)	Er det en mulig bukse?	no

19	et	kvadratisk	kort	non-semantic violation intersective adj (same as experimental adj)	Er det faktisk et belte?	no
20	et	trekantet	vindu	non-semantic violation intersective adj (same as experimental adj)	Er det faktisk et vindu?	yes
21	En	sirkulær	frisbee	non-semantic violation intersective adj (same as experimental adj)	Er det faktisk et tau?	no
22	et	ovalt	egg	non-semantic violation intersective adj (same as experimental adj)	Er det faktisk et egg?	yes
23	en	spansk	pilot	non-syntactic violation nationalities	Er det faktisk en pilot?	yes
24	en	amerikansk	danser	non-syntactic violation nationalities	Er det faktisk en danser?	yes
25	et	tysk	firma	non-syntactic violation nationalities	Er det faktisk et basseng?	no
26	et	fransk	lag	non-syntactic violation nationalities	Er det et mulig soverom?	no
27	et	tysk	orkester	non-syntactic violation nationalities	Er det et uekte orkester?	no
28	en	amerikansk	millionær	non-syntactic violation nationalities	Er det faktisk en millionær?	yes
29	en	fransk	minister	non-syntactic violation nationalities	Er det en mulig minister?	yes
30	et	amerikansk	samfunn	non-syntactic violation nationalities	En det faktisk et verksted?	no
31	en	japansk	rektor	non-syntactic violation nationalities	Er det snakk om en rektor?	yes
32	en	svensk	snekker	non-syntactic violation nationalities	Er det snakk om en pilot?	no
33	en	britisk	kokk	non-syntactic violation nationalities	Er det snakk om en kokk?	yes
34	en	australsk	pilot	non-syntactic violation nationalities (same as experimental adj)	Er det en mulig pilot?	yes
35	en	nederlandsk	danser	non-syntactic violation nationalities (same as experimental adj)	Er det en mulig frisør?	no
36	et	indisk	firma	non-syntactic violation nationalities (same as experimental adj)	Er det faktisk et kamera?	no
37	et	grønlandsk	lag	non-syntactic violation nationalities (same as experimental adj)	Er det snakk om et lag?	yes



38	et	gresk	orkester	non-syntactic violation nationalities (same as experimental adj)	Er det faktisk et bilde?	no
39	et	australsk	samfunn	non-syntactic violation nationalities (same as experimental adj)	Er det faktisk et samfunn?	yes
40	en	gresk	ingeniør	non-syntactic violation nationalities (same as experimental adj)	Er det en mulig matrett?	no
41	en	nederlansk	designer	non-syntactic violation nationalities (same as experimental adj)	Er det faktisk en designer?	yes
42	en	indisk	smed	non-syntactic violation nationalities (same as experimental adj)	Er det snakk om en sang?	no



## Appendix B: Informed Consent Form



### *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 C: Background Health Form



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: Training Sheet and Solution

### 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 tznx 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 ksjool 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 ksjool 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.



## **Appendix E: Pedagogical Implications (Relevance for the Teaching Profession)**

This project has given me new insight into how language actually works in our brains. I will argue that having a general knowledge of how sentences are processed provides a deeper insight into the general mechanisms of language. Reflecting over how language is perceived when presented in minimal phrases is important to an English teacher, since the students at a lower level are often presented to these types of out-of-context phrases. The experiment concerns Norwegian, while my degrees is in English Language studies with teacher training. Knowing the difference between how small phrases work in Norwegian compared to English is vital for effectively catching students' mistakes and helping them in advancing their own knowledge in English grammar. To use an L2, a general knowledge of the L2's grammar compared to the student's L1 grammar is crucial. Second language learning does not happen in an isolated box, and students use their L1 as a starting point.

Another important aspect of this thesis' relevance to the teaching profession is the ability to act as an authority figure during a project. This can be compared to classroom management, where the teacher's role is to be able to guide students' educational, social and emotional learning and development. While running the experiment, it is crucial for the researcher to be explicit about the goals for the experiment and what the participants need to do. The instructions need to be presented to every participant uniformly, and the training need to be the same for each individual participant. The participant needs to feel safe and comfortable in order to give us clear ERP data, thus the course of the experiment needs to be presented with a clear framework. This is important in the teacher role as well. For students to feel safe and included in the classroom, a clear framework needs to be presented to increase the feeling of predictability. This way, the students can focus on doing the tasks they are given. An approachable and organized teacher is a good starting point for a safe learning space. The same is the case for the participants; if the course of the experiment is unclear, the participants will not perform satisfactorily. Therefore, my thesis has been great help when reflecting around the role a teacher has, and what kind of teacher or guidance I want to be for my future students.

