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The Online Processing of Norwegian Intensional Verbs

An ERP Study

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Abstract

The properties of language that allow us the freedom of stepping outside the world of facts into an almost infinite number of possible worlds, where things are how they could be, how they should be and how we hope and imagine them to be, are still unsolved puzzles that have captured the fascination of philosophers and linguists for centuries. Modality is one such property and the more common and natural it is in our everyday speech, the more complex and difficult to formally describe it becomes when placed under the scrutinizing inspection of scholars. Indeed, as many other aspects of language that seem so intuitive to us and which the brain achieves with incredible speed and efficiency, semantic modality has proven to hide many complicated layers of meanings when studied up close. Through this study we have tried to capture a glimpse of the brain's activity while engaged in the processing of Norwegian modal verbs which quantify the speaker's/subject's degree of certainty that certain possible worlds coincide with the factual world. We conducted an EEG experiment that pits the semantics of modal verbs against what is commonly known about the world ("John dreams/imagines that birds have wings/ gills"), and asked whether Norwegian intensional modal verbs of imagination like "å drømme" ("to dream") and "å innbille seg" ("to imagine") are processed fully and incrementally during online comprehension in a way that affects the downstream processing of upcoming words as indexed by the N400 event related potential. The results point towards the fact that these verbs are processed incrementally and can affect the processing of upcoming words as no N400 effect was observed for typical ("wings") versus atypical ("gills") words in the context of either "innbille seg" or "drømme." The fact that a strongly counterfactual verb like "innbille seg" did not cause a larger N400 response for typical versus atypical words, may suggest however that the full semantic meaning of this verb may not impact processing fast enough in order to override lexical-semantic associations between words and reverse the N400 effect.

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1. Introduction

The present study represents one part of a larger experiment meant to investigate the processing of Norwegian intensional modal verbs like "å vite" ("to know"), "å tro" ("to believe"), "å tvile på" ("to doubt"), "å drømme" ("to dream") and "å innbille seg" ("to imagine") by looking at ERP patterns recorded from Norwegian participants who read complex sentences containing these verbs followed by a complement clause. Through their lexical-semantic properties modal verbs allow speakers to freely talk about things that might or might not be real and to create worlds distinct from our own. We can talk about imagining that pigs fly and dreaming about winning the lottery without violating any of the well-established conventions of communication that hold speakers committed to speaking the truth. One important question addressed by this study is whether the ease with which we interpret such statements offline is reflected online in the short time span the brain takes to decode language. The study aims to see if the semantic modal information encoded in these verbs is processed fast enough to influence the online processing of downstream words, by looking at the N400 event related potential, the so called index of semantic processing, recorded at words whose interpretation is affected by the sentential context given by the specific modal verb. In short, our research question is whether modality is processed incrementally and fully in order to affect the amplitude of the N400.

This research is the result of the collaborative effort between the writer of this thesis and fellow student Anna Giskes. Together we have constructed and evaluated the stimuli for the whole experiment, recruited participants and spent many hours in the EEG lab while recording data. The present thesis will only be concerned with presenting the ERP results for the verbs "å vite," "å drømme" and "å innbille seg" while the results for verbs "å vite," "å tvile på" and "å tro" will be presented by Anna.

After first describing the phenomenon of semantic modality in a way that is relevant to understanding the properties of the verbs investigated in this thesis, I will describe the N400 component and review literature showing what kind of experimental manipulations modulate it, and why it is an ideal measure for studying the online processing of modal verbs.

2. Modality

Human beings are equipped with a cognitive system capable of incredibly complex alterations of reality, and creating very diverse unrealistic scenarios that are not compatible with the world of facts around us. We often imagine better or worse alternatives to reality and create different scenarios in our head that might be similar or very different from actual facts. The process of thinking about how things could have been or how they should be is associated with the term "counterfactual thinking" and is often triggered, as Ruth Byrne (2005) explains, by certain fault lines in reality like events that deviate for normality, and which people try to correct often through the use of conditionals like "If only…".(Byrne 2005) Because we have the ability of thinking and speaking counterfactually, we can hypothesize and make predictions about the future, invent new things and strive for a better world.

One property of language that enables us to speak counterfactually is its displacement quality, which allows us the freedom to escape our world by speaking about things happening in other possible worlds.(von Fintel and Heim 2011: 3) Modality, like mood or aspect, is one dimension of displacement, and although commonly used in everyday speech, this phenomenon has often been described as elusive, proving to resist attempts from both linguists and philosophers to encapsulate it under a single description and an exhaustive classification. Some frequent examples of modal use include modal auxiliaries like *can, might, should, could*, adverbs *possibly, necessarily* and intensional verbs like *dream, imagine, believe*.

Modality is an interesting and puzzling phenomenon well worth the attention of scholars. Studying it lets us examine how we are able to easily say and understand a sentence like: "Shakespeare could have invented the submarine." "John dreams that cars have wings." This property of language is crucial to our ability to think and speak counterfactually and deserves a much more attentive and detailed analysis than what is provided below. The following description of modality is only an attempt at paving the road towards a comprehensive definition of our verbs of interest: "drømme" and "innbille seg." ("dream" and "imagine")

2.1 Possible worlds

To understand how the semantics of modality works we need to first introduce the concept of possible worlds as described by David Lewis (1986). The world we exist in is called the factual world and is very inclusive, containing all elements making up our world regardless of their distance in time and space. It is the world in which things are as we experience them and it contains events distant in time "Dinosaurs used to roam the earth" or in space "There is a robot collecting samples on Mars" as well as present situations "There is a flower pot on my desk." But in our thinking and speech, we are not prisoners of this realm. Our world is not singular but is just one of many other possible worlds, existing like enormous isolated planets with no spatial or temporal relation connecting them to the actual world. Possible worlds differ from our world in different ways, some more than others. There is a possible world where there are two flower pots on my desk but everything else is the same, as well as a world in which flowers do not exist at all. (Lewis 1986)

Renaat Declerck (2011) further introduces the notion of non-factual world, which is a possible world not interpreted as being factual, but which may or may not coincide with the factual one. The complex sentence "It is possible that the morning train is delayed" is true of a non-factual world represented in the proposition "the morning train is delayed" which may or may not coincide with the factual world. Non-factual worlds can be further classified into theoretical worlds and counterfactual worlds. The example above creates a theoretical world: it coincides possibly, but not necessarily, with the factual world. In contrast, counterfactual worlds are, according to Declerck, necessarily incompatible with the factual world. For example, "Roxane should have invited him to the party," describes a situation "Roxane invited him to the party" that is not true in the factual world. (Declerck 2011) Non-factual worlds can be also called a modal world as it will be demonstrated in the below sections. Following this classification we will take counterfactual worlds to strictly mean possible worlds that are incompatible with the factual world and use the term theoretical world for worlds that are not necessarily incompatible with the factual world.

The set of possible worlds can be formally written W and the existing relations between the worlds can be written R. The pair of possible worlds and the relations between them is called a frame and has the form F=<W, R>. A world v is accessible from a world w if there is an

accessibility relation between w and v, of the form R(w, v). Thus, through accessibility relations worlds can be accessed and known, and through an evaluation function, sentences can be evaluated as true or false of specific accessed worlds. (Portner 2009: 9- 45)

A possible world "is always anchored at a given time t." (Declerk 2011: 3) As Declerk further explains, it is possible for a proposition containing a finite verb to be true at a particular t-world (at a certain time) and false in another. This aspect is evident when one uses the present tense to refer to events that take place at different times than the times of speech. For example "Churchill is the prime minister of Great Britain" is true of a different time than the present. An S-world is a world which is anchored at the speech time, and a clause referring to an S-world does not need to specify a certain anchor time, as the sentence is understood as taking place at the speech time. The sentences in our study are all anchored at the speech time. (Declerk 2011)

2.2 Understanding how modality works

Both the fields of philosophy and linguistics have been involved in the study of modality. While philosophers prefer a wider definition of modality which includes the dimensions of time and aspect as well as modality as their interest is above all in systems of reasoning, linguists prefer a narrower definition that focuses on the actual meaning of modal words. According to Paul Larreya (2009) modality is not just a linguistic device but is part of the cognitive system. We can see modality as a mental system which has the concepts of possibility and necessity at its center, describing truths that are possible and necessary, and which are related by a double negation. (Larreya 2009) As Squartini (2016) notes, although negation and modality are independent concepts, their interaction serves to demonstrate the semantics of counterfactuality (that which is contrary to fact). Negation creates the relationship in meaning between possibility and necessity. (Squartini 2016) "It is possible that P = It is not necessary that non-P", "It is necessary that P = It is not possible that non-P" (Larreya 2009: 9) Necessity and possibility are placed at the core of modality but they do not represent the entire range of meanings that modality can have.

More generally, Declerk (2011) defines modality as a situation (a state, event, action expressed by a verb and conveyed in a clause) which is actualized in a non-factual world. Saying that a situation actualizes in a world is equivalent to saying that it takes place in that

world or that it is true of that world. For example in the sentence “Stefan is in the park” the situation conveyed in the proposition “Stefan be in the park” actualizes in a factual world. (Stefan actually is in the park in the factual world) Alternatively, if a situation cannot exist in the factual world, it is actualized in a counterfactual one and is true of that world. In a sentence like “I wish pigs could fly” the situation denoted by the proposition “pigs fly” is represented as actualizing in a counterfactual world triggered by the context “I wish” and is necessarily false of the factual world (it is false that pigs fly in the factual world). A situation which is true in a nonfactual world will be false in the factual world. For example in the sentence “John must take care of the bees” the modal verb “must” establishes access to a nonfactual world in which the situation of John taking care of the bees is actualizing. There is a relation of strong necessity between the two worlds: it is necessary in the factual world that John takes care of the bees. (Declerck 2011)

A situation expressed in a clause may take different values of factuality. Following Declerk (2011), a situation may be: factual, hypothetical, counterfactual or not yet factual with respect to the factual world. For example the situation expressed in “John will go to the beach” has the value not yet factual and does not actualize in the S-world but is true of a not-yet factual t-world that is predicted to coincide with the factual world in the future. Likewise in “John imagines that fish wear hats” the situation expressed in the clause “fish wear hats has” has the value counterfactual and is interpreted as being the opposite of the factual world. These values are conveyed through linguistic devices called modalizers. Declerk further argues that modalizers have the role of accessing possible worlds that are interpreted as nonfactual but depending on the type of modalizer, these worlds can be in a certain relationship with the factual world. As it will be discussed below there is a connection between the possible worlds accessed by modal verbs. (Declerk 2011)

Thus, modality has to do with things happening in nonfactual worlds and the semantically rich modal system helps us establish relations between nonfactual worlds and the factual one, in a way that renders nonfactual worlds accessible and comprehensible from the perspective of the factual world. As has been hinted to in our brief definition of modality, this phenomenon is characterized by many nuances of meaning and therefore needs to be classified and split into different categories. What follows is an attempt of describing how modality can be classified with an emphasis on the category of epistemic modality, which is of direct interest to our study.

2.3 Classifying modality

As Jan Nuyts (2016) points out, some linguists see modality as a supercategory which contains distinct categories that need to be separately defined. The exact set of categories encompassed by the term modality is not unanimously agreed upon, and neither how well they can be separated from each other or how they should be defined. (Nuyts 2016) The main issue with agreeing on one system of categorizing modal meanings is that there are many subtle nuances of meaning encoded into modalizers that specify different relations between the set of possible worlds and the factual world. (Nuyts 2016)

A classical way of classifying modality is to distinguish between dynamic, denotic and epistemic modality. Dynamic modality describes the ability or necessity of the subject to realize the situation expressed by the verb. (e.g. "He can run very fast," "You must eat healthier if you want to lose weight") Denotic modality on the other hand is the expression of "moral desirability of the state of affairs expressed in the utterance." (Nuyts 2016: 36) (e.g. "You may leave the table") Like epistemic modality it has been proposed that denotic modality is gradual with some values indicating more morally acceptable state of affairs than others. Epistemic modality represents the estimation that what is conveyed by a proposition is true of the factual world. (e.g. "It's already Monday," "They must have arrived from their vacation") (Nuyts 2016)

Another distinction is often made between root and epistemic modality. Some scholars use the term root modality to talk about both dynamic and denotic modality while others use it only for demotic. (Nuyts 2016) In contrast to epistemic modality, as pointed out by Declerk, root modality says nothing about the degree of compatibility between the nonfactual and the factual world, but rather characterizes the factors that lead a situation to be actualized in the nonfactual modal world. The situation expressed through root modality does not contain an evaluation of the relationship between a nonfactual world and a factual world. (Declerck 2011)

2.4 Epistemic modality

Epistemic modality represents the use of language in which the relation between the factual world and the accessed modal worlds is assessed by the speaker through the use of specific modalizers.

Epistemic modality covers "linguistic meanings that indicate degree of epistemic support for a proposition, or degree of confidence in a proposition." (Nuyts 2016: 117) The meanings covered by epistemic modality are ordered on a scale and range from strong, neutral to low epistemic support for the "negative counterpart of a proposition." (Nuyts 2016: 118) Epistemic modality can be expressed though verbs, adjectives, nouns or adverbs. The speaker passes judgment on whether and how the modal and factual worlds are actually consistent with one another. (Declerk 2011) As Paul Portner (2009) explains, for a sentence to have epistemic meaning there is a relation R that holds between two worlds: the world in which the situation expressed in the sentence actualizes and the factual world, such that everything the speaker knows in the factual world is true in the nonfactual one. (Portner 2009: 30-31)

This knowledge of the speaker can be quantified and comes in degrees of certainty about the chances that a situation that actualizes in the nonfactual modal world, can actualize in the factual world as well. The speaker therefore expresses an opinion with a certain degree of certainty that the two worlds coincide. The degree of certainty that the worlds are compatible can take certain factuality values along a scale, where on one end there's the value factual, and on the other is the value counterfactual. Declerk (2011) introduces some of the values encoded in the meaning of modalizers: factuality, strong necessity, probability, impossibility, not-yet-factual, counterfactual. The factual value is not modal, as it expresses the certainty that the situation is actualized in the factual world and not in a modal world. If a world is factual it cannot be nonfactual at the same time. If the situation represented in a sentence is given the value counterfactual, then it has no chance of actualizing in the factual world and is false of it and true of the counterfactual world. The counterfactual value does not specify a degree of compatibility between the modal and the factual world and does not imply the speaker's degree of uncertainty, having rather an absolute value. There is no doubt that the situation actualizes in a nonfactual modal world that is the exact opposite of the factual world. (Declerk 2011)

2.5 Modalizers

According to Declerk (2011), non-factual worlds are accessed through certain linguistic devices called modalizers. In a sentence like “John should apologize”, the auxiliary verb “should” is the modalizer and the underlying proposition “John apologize” is true of a non-factual modal world that will or will not coincide with the factual world. (Declerk 2011)

The difference in meaning between the different modalizers is given by the different accessibility relations they have with certain possible worlds. Modalizers let us know which worlds are accessible from the speaker’s point of view. Given W the set of possible worlds modal expressions can be understood as evoking pairs (also called frames in logic) that are made of a set W of possible worlds and a relation of accessibility R that holds between the worlds of the set <W,R>. So the meaning of “can” differs from the meaning of “must” in that they each have different accessibility relations that render certain worlds accessible. The accessibility relations may be epistemic, denotic etc. Accessibility relations give access to certain worlds against which the truth value of a proposition is evaluated. In the case of epistemic modality, the accessed worlds are worlds that, on the basis of evidence from the factual world, can be evaluated as coinciding or not with the factual world by a thinking participant. (von Fintel 2006) The thinking participant need not necessarily be the speaker of an utterance and the knowing time need not be the time when the utterance was made. Both thinking participant and time are extracted from the context. (Portner 2018) For example in “John believes that the housing market will collapse” the thinking entity is John and not the speaker of the utterance, and the fact that the housing market will collapse is evaluated against John’s believes and not the speaker’s.

2.5 Modality in the present study

The modalizers investigated in this study are Norwegian intensional verbs which take *that*-clauses as complements. This category of modalizers access nonfactual worlds that are interpreted as not representing the factual world but which are in an epistemic relationship with the factual world.

These verbs are intensional because the meaning of their complements is understood in relation to possible worlds. The intension of a predicate is a set of pairs, one member of the pair being a possible world and the other being the set of things the predicate applies to in that world. The intension of a predicate contains its extension (the set of objects to which it applies in the factual world). (Forbes 2006)

A sentence's intension consists of pairs made up of possible worlds and the truth values that that sentence has in that world. An expression can be intensional or extensional. An expression is extensional if its meaning is made up from the extensions of its components without the involvement of their intensions. On the other hand the meaning of intensional expressions depends on the intensions of their components. The meaning of a sentence like "John imagines that sugar is sour" is given by computing the extension of the main clause and the intension of the subordinate one. The extension of "John imagines that" is such that when it is combined with a sentence S, the resulting sentence "is true iff the intension S is the set of pairs <w,T> for every possible world w." (Forbes 2006: 11) In other words, intensional verbs access possible worlds in their complement clauses which include the factual world but are not limited to it, and in which the situations that actualize are rendered true with respect to what the speaker or subject of the sentence knows to be true.

The worlds evoked by the intensional verbs: "drømme" ("dream") and "innbille seg" ("imagine") in our study are represented in the subordinate clauses, following the verbs. These verbs assign a factuality value to the situation which actualizes in the nonfactual modal world, value which establishes a degree of connection between this world and the factual world. Thus, "drømme" and "innbille seg" are epistemic modalizers as they encode different degrees of compatibility between the modal world and the factual one. The two verbs differ in that they encode different factuality values and give access to different sets of worlds. Following Declerk's classification of factuality values, through the verb "drømme" ("dream") the thinking

individual assigns a value of 'possibly factual' to the situation represented in the subordinate clause. This verb has the same semantic properties and meaning in English as in Norwegian. The situation represented in its subordinate clause "may or may not coincide with the factual world."(Declerk 2011: 27)

Thus, in the sentence "Annine drømmer at ekorn gjemmer muffins*"*("Annine dreams that squirrels hide muffins"), the situation actualizing in the theoretical world represented by the expresion "squirrels hide muffins" may or may not actualize in the factual world. This verb evokes theoretical worlds that may or may not coincide with the factual world and is therefore equally acceptable to say "Annine dreams that birds have gills" and "Annine dreams that birds have wings" as the verbs gives access to both worlds in which it is true that birds have wings and worlds in which it is true that birds have gills. The fact that some of these worlds are compatible with the factual world does not deny the accessibility to worlds which are not.

In contrast, a verb with a strong intensional meanings like "innbille seg"(approximately translates as "imagine") accesses a set of modal worlds that has no chance of being compatible with the factual world. The verb "innbille seg" has a more powerful counterfactual meaning than the English "imagine." The Norwegian dictionary defines it as a state of having a false notion about something. Thus, it is used to refer to situations actualizing in counterfactual worlds which can't be true of the factual one. In the sentence "Andreas innbiller seg at geiter spiser yoghurt*"* ("Andreas imagines that goats eat yoghurt"), the verb "inbille seg" gives access to possible worlds in which the proposition "goats eat yoghurt" is evaluated as being true by the thinking individual Andreas. These worlds are evaluated as counterfactual with respect to the factual world by the speaker of the utterance as the accessability relations encoded in the verb do not give access to the factual world. By saying "Andreas innbiller seg at geiter spiser gress" ("Andreas imagines that goats eat grass") the situation encoded in the subordinate clause is evaluated as being false of the factual world. This however is a contradiction with what is generally known about the world.

Thus, the verbs "drømme" and "innbille seg" are both intensional modal verbs that connect nonfactual worlds with the factual world in different ways. In contrast, the factive verb "vite" ("know") is not a modalizer and does not access nonfactual worlds in the subordinated clause, but it is intensional as the meaning of its complement clause is defined in relation to the set of worlds the thinking participant evaluates to be true. In a sentence like "Magnus vet at mygg lever

av blod" ("Magnus knows that mosquitoes live off of blood") the situation expressed in the proposition "mosquitoes live off of blood" actualizes in the factual world without any doubt from the thinking participant Magnus. A contradiction arises when saying "Magnus vet at mygg lever av vodka" ("Magnus knows that mosquitoes live off of vodka") as the situation represented in the subordinate clause cannot actualize in the factual world as it violates what is generally known about the world.

3. The N400

3.1 EEG in linguistics

Human beings are endowed with the amazing ability to communicate with each other in a possibly infinite number of ways. We can communicate about our past, our future plans, about hypothetical situations, wishes and dreams and describe events or situations up to the most trivial detail. Our ability to quickly make sense of what we are being told is often taken as an example for the advantage human beings have over other species. But because nature has not provided us with an adequate equivalent in other species, investigating how we are actually capable of such complex communication is a challenging endeavor. Unlike other cognitive processes that can be studied across species, language is uniquely human and until recently the study of its neural bases was mostly confined, to the study of clinical populations, individual with aphasia and language impairment and people undergoing brain surgery. However, the introduction of EEG recording as a method for linguistic investigation has made it possible to non-invasively study what the brain does when dealing with language.

With the use of a cap to which electrodes are attached, we are able to record electricity coming from the brain and know exactly when different stimuli influence the online processing of language. The recorded waveform is visible at scalp level as a series of negative and positive peaks in the EEG (electroencephalogram) that reflect the "sensory, cognitive, affective and motor processes elicited by the stimulus."(Kappenman and Luck 2011: 4) As Luck and Kappenman point out, it is difficult to understand how the signal fluctuations recorded at the scalp actually arise at the neural level. What is known is that the voltage that is seen at the scalp level reflects the summation of post synaptic potentials that occur simultaneously in a very large number of pyramidal neurons which are oriented similarly with respect to the scalp. Post synaptic potentials represent the changes in potentials that occur when neurotransmitters are released from one neuron and bind to the membrane of another neuron, called the postsynaptic cell. This causes ion channels to open or close causing in turn a change in potential along the membrane of the cell. Thus the activity recorded with EEG does not represent electricity traveling through the axons of neurons, but rather is the summation of postsynaptic potentials that are present in the dendrites and body of the neuron. ERP's (event related potentials) are

small fluctuations in the waveform which are time locked to certain events. In order for the ERP to become visible, multiple EEG epochs need to be averaged. Although a unanimously accepted definition of an ERP component does not currently exist, it is useful to see it as a change in the ERP waveform that reflects a certain neural process. (Kappenman and Luck 2011:3-49)

ERP's have proven to be very important in shaping our understanding of the dynamic way in which different types of information are used by the brain in constructing the representation of the linguistic input during online comprehension. As Swaab et al (2011) point out, the advantage of using EEG in studying language is that it allows us to record the activity of the brain, as it occurs naturally, without needing to interrupt subjects in order to perform a task. (Swaab et al. 2011)

3.2 General description of the N400

One particularly important ERP that has been intensively studied over the past 30 years is the N400 component, a negative deflection of the brain wave, starting at about 200-300 ms after stimulus onset for stimuli presented in the visual modality and at 50-150 ms for spoken ones, peaking at about 400 ms and lasting until 600 ms. It is a negative wave observed at particular electrodes relative to a reference location. The N400 effect to a certain stimulus is usually calculated relative to a 100 ms pre-stimulus baseline and is usually computed as the difference between two conditions: control and an experimental. The N400 effect is thus the difference in amplitude between the N400 responses elicited by two conditions with a larger centro-parietal amplitude and a bias towards the right hemisphere. It is usually the amplitude of the N400 that varies with experimental manipulation while latency has been observed to be generally constant across different paradigms. (Kutas and Federmeier 2011)

The N400 effect was discovered in 1980 by Kutas and Hilyard in an experiment which had participants read congruent and incongruent sentences appearing word by word on a screen. Although a well studied P300 response was expected for the semantically incongruent words, which marks a violation of expectancy, a large negative deflection was observed instead, peaking around 400 ms after stimulus onset. The study reports three experiments which had participants read 160 seven word sentences, each experiment manipulating the expectancy for the critical word in a different way. Importantly, for semantically incongruent final words a negative

deflection was observed compared to semantically congruent sentences, larger for strongly incongruent words ("He spread his warm bread with socks") than moderately incongruent ones ("He took a sip from the waterfall"). Physically incongruent but semantically congruent words ("She put on her high heeled SHOES") in contrast did not show this effect, but instead elicited a positive wave. The observed negative wave for semantically incongruous words was largest over cetro-parietal locations and because it peaked at 400 ms after stimulus onset it was labeled the N400 response. (Hilyard and Kutas 1980)

As it will be shown below, the N400 response does not exclusively represent a response to semantic anomalies, but is rather the default response to any meaningful stimuli, its amplitude depending on how much the previous context can contribute to the interpretation of an upcoming word. (Kutas et al. 2006) Because the N400 is seen in response to meaningful stimuli in general, manipulations that affect this component's amplitude have been in a large number of studies attempting to answer questions of how language processing unfolds over time and what kind of information is recruited at different specific points in time by the processing system.

3.3 Review of literature showing which factors modulate the N400

3.3.1 Priming effects and word properties

Before an attempt is made to describe the functional significance of the N400, it is important to first pause over the factors that modulate its amplitude. Lau et al (2008) point out that the two main paradigms used to manipulate the size of the N400 are studies of priming and semantic-anomaly. (Lau et al. 2008) The priming paradigm is used to investigate lower level aspects of language processing regarding the properties of words or the lexical-semantic relationships between them. This method involves presenting pairs of words that are either related or unrelated, with the first word being the prime and the second one being the target. The aim of this design is to see if target words that are preceded by a semantically related word are easier to process. Studies of semantic priming have revealed that a sentential context is not necessary for the elicitation of the N400, and that it can also be observed in response to words

presented in isolation or in pairs. N400 responses with smaller amplitudes have been observed for the second word of a pair when it was preceded by a related word. Thus "nurse" elicited a smaller N400 when it was preceded by "doctor" than when it was preceded by "table". (reviewed in Swaab et al. 2011)

Priming studies have also been used to attempt answering questions about the effect of attention on the N400. An important debate in the early years of psycholinguistic research revolved around whether the N400 arises due to a controlled or automatic process. Chwilla et al (1998) found a reduction of N400 amplitude in a design where there was only a backwards (one way) association between the prime and the target. Thus, lower amplitudes were observed when the prime was not associated with the target but only the target was associated with the prime ("baby –stork"). As the word "baby" would not create an expectation for "stork" it would seem that the N400 is more likely to index an automatic process. (reviewed in Swaab et al. 2011) On the other hand, studies that involve selective attention paradigms seem to point towards the fact that the N400 is sensitive the how attentive the subject is and might index a controlled process. Kutas and Federmeier (2011) review a series of studies that show lower N400 effects for targets that were attended to versus ones that were not. Overall this data seems to show that the N400, although sensitive to attention, does not index a fully controlled process that requires enhanced awareness of the stimuli presented.

Swaab et al. (2011) also review studies that show that words' lexical properties influence the amplitude of the N400, with pseudowords (pronounceable non words) eliciting similar N400 effects as real words when they are primed or repeated. In contrast, Kutas et al. (2006) point out that illegal strings of words do not show these repetition effects. Frequency is another lexical factor that influences the amplitude of the N400, with lower frequency words eliciting smaller N400's than higher ones. Frequency effects can be overruled by repetition effects and sentential context effects, with low frequency words showing higher N400 amplitudes at the beginning of the sentence rather than at the end.(Van Petten and Kutas 1990) Orthographic neighborhood also influences the amplitude of N400, with larger amplitudes for words that have more orthographic neighbors than ones that don't. This means that words that can be transformed in other words by changing certain letters will elicit larger N400 responses if they have the possibility of forming more words than others. N400 effects have also been observed for nonlinguistic stimuli like line drawings, pictures and short films, suggesting that this component is more likely linked to the

processing of meaningful stimuli rather than just a response to any kind of expectancy violation. (reviewed by Kutas et al. 2011)

3.3.2 Higher level processing: Sentence contexts

Language comprehension involves the rapid integration of various information types into an unfolding representation of what is being conveyed in the linguistic stream. Not only do comprehenders need to decode the linguistic stream, they must also combine it with what is known about the world. An important contribution of the N400 component to linguistic research is that it allows linguists to see exactly how the processing of individual words is influenced by the information encoded in the context provided by the sentence as the input unfolds over time. Below I review studies that have used the N400 measure to investigate how language comprehension is achieved during online processing.

The semantic anomaly paradigm often involves presenting sentences that are either semantically congruent "He spread the bread with butter" or incongruent "He spread the bread with socks" and measuring the ERP's for the critical words to observe how the wave is modulated by the experimental manipulation. Most N400 studies investigate the processing of words in sentential contexts and explore how different information provided in the preceding context impacts the processing of upcoming words during online comprehension. Importantly, it has been showed that there is no qualitative difference between the N400 effect observed in priming studies, and semantic-anomaly studies. Kutas et al. (2011) point out that this finding is crucial to understanding how language processing is achieved, and is evidence to the fact that lexical processing and sentence processing are not two separate processes but rather, lexical and sentential information constantly interact to influence processing step by step. (Kutas et al 2011)

Importantly, by studying the effect of context on the processing of upcoming words, Kutas and Hillyard (1984) were the first to demonstrate that the N400 does not only reflect the processing of semantic mismatches, but that it is more likely linked to how word meaning is processed in general and how it is related to a wider context. This study showed that the N400 is modulated by how expected or predictable a word is in a given sentence context. Word predictability is assessed offline through cloze completion tasks. In such a task participants are asked to complete a sentence that has the last word omitted ("Three people were killed in a major

high way _____", from Bloom and Fischler 1980) with a word that comes first to mind when reading the sentence. The cloze probability of a word is computed by calculating the percentage of the responses for a target word.(Block and Baldwin 2010, Bloom and Fischler 1980)

The materials used in the Kutas and Hillyard (1984) study were sentences that were highly, medially or weakly constraining and were given endings with high, medium or low cloze probabilities. Swaab et al. (2011) explain that a sentence's level of constraint depends on the number of continuations that it can have, so the less continuations possible, the higher the degree of constraint. If a sentence is highly constraining then its completion is a word with a high cloze probability, but just as sentences with low constraint, it can also have a low cloze probability word ending, which although fitting in the context is highly unpredictable. Experiments manipulating the constraint and cloze probability of the sentence stimuli are designed to investigate how sentence context impacts word processing, because they disentangle the effects of sentence context from the effect of predictability as indexed by cloze probability.

The stimuli used by Kutas and Hillyard (1984) were thus sets made of seven sentences each: highly constraining and high cloze: "He mailed the letter without a stamp." Highly constraining and low cloze: "The bill was due at the end of the hour." Medium constraint and high cloze: "She locked the valuables in the safe." Medium constraint and medium cloze: "Too many men are out of jobs." Medium constraint and low cloze: "The dog chased our cat up the ladder." Low constraint and high cloze: "There was nothing wrong with the car." Low constraint and low cloze: "He was soothed by the gentle wind." The results show higher N400 amplitudes for low cloze probability words regardless of how constraining the context was. A systematic decline of the N400 effect was seen as the cloze probability increased, irrespective of semantic congruity. Further analysis showed that the N400 was smaller for low cloze words that were semantically related to the best completions than words that were not. This study showed that the N400 and cloze probability are inversely correlated and that semantic mismatches are not necessary for the elicitation of the N400 effect, a fact that has been used in studies ever since. (Kutas and Hilyard 1984)

Fedemeier and Kutas (1999) also investigated the effect of context on upcoming words. The authors start from the idea that the way in which semantic memory[1] is organized is crucial in determining how the contextual information will impact the processing of upcoming words. Thus, in this study, they ask whether context and lexical-semantic associations between words as stored in long term memory impact processing differently during comprehension. The materials consisted in discourses that created a certain expectation for an object in a category. This expectation was then violated so that the sentence final word was either related (from the same category) with the expected continuation or completely unrelated. Thus, the control condition had the last sentence ending with a word with a highly predicted word: "They wanted to make the hotel look more like a tropical resort. So along the driveway they planted rows of palms." In the within category violation condition, the sentence final word was "pines" and in the between category violation condition the last word was "tulips". The results show that the N400 response for within category ("pines") is smaller than for between category ("tulips") violations relative to control non-violation conditions. Within category violations also showed a larger N400 effect when they were present in low constraining sentences than when they were presented in high constraining ones. These results show that sentential context acts immediately to restrict prediction of what words might follow, which can be seen in the fact that within category violations although sharing semantic features with the most expected items, were characterized by a large negative deflection of the wave in comparison with the control condition. At the same time, the fact that between category violations elicited an even larger N400 response is evidence that the N400 is also sensitive to lexical-semantic associations between the words of a sentence. The authors interpret the fact that the N400 effect was larger for low vs. high constraining sentences by suggesting that highly constraining contexts serve to activate semantic features of the expected continuations that also overlap with the unexpected but related word, pointing to the fact that the N400 might be influenced by the way semantic memory is organized. (Federmeier and Kutas 1999)

Van Petten and Kutas (1992) bring evidence that frequency and sentence context can interact to influence processing very rapidly. Participants were asked to read 335 unrelated, semantically congruent sentences appearing word by word on a screen while their brain activity

[1] Kutas et al (2006) describe semantic memory as the store of knowledge that a person has regardless of the time, place or way in which this knowledge was obtained. According to Kutas et al (2006) semantic memory is taken by most linguists to refer to both semantic (linguistic meaning) knowledge and pragmatic (world) knowledge

was recorded. Sentence final words all had a relatively high cloze probability. The results show that word position within a sentence modulates the N400, as a decrease of amplitude was observed, with higher negatives for sentence initial words than for sentence final open class words. It is argued that this is due to a facilitatory effect that the context build up has on the processing of upcoming words. Thus, it appears that sentence level information can affect processing in a fast enough way so that it is reflected in the amplitude of the N400. An interaction between context and frequency was also observed, with more negative N400's observed for infrequent initial words than for infrequent final ones.

Taken together, these studies show that lower level lexical information can be overridden by contextual information during comprehension and that context acts immediately to influence the online processing of upcoming words.

However, investigating the effects of negation during processing, Fischler et al (1983) found that the N400 response is not sensitive to the truth value of a proposition, but instead to the semantic association between the subject and the object noun. Thus, "vehicle" in "A robin is not a vehicle" elicited a similar N400 response as for "A robin is a vehicle", compared to "A robin is a bird" while no N400 effect was observed for "A robin is not a bird." This result has been interpreted by the authors as evidence of a two stage processing of negation, negation being integrated later into the discourse, after the inner supposition is analyzed. This study is important because it shows that semantic anomalies are not enough to elicit an N400 effect and that this component is not necessarily sensitive to the overall truth value of the proposition, but rather, to the lexical-semantic associations between words in a sentence. (Fischler et al 1983)

Another study that points to the fact that the process indexed by the N400 might be more sensitive to category information than context was done by Kounios and Holcomb (1992) who recorded ERP's to quantifier sentences that had either categories ("gems") or exemplars ("rubies") as subjects and predicates, and that manipulated truth value with respect to the relationship between the subject and the predicate: "All/ some/ no gems/ rubies are rubies/ gems." and "All/ some/ no gems/ spruces are spruces/ gems." The results show that the N400 response for the object noun is not sensitive to the truth-value of the sentence as given by the different quantifiers but rather to the associations between the subject and the predicate, prompting the researchers to suggest that the N400 is modulated by the structural relationships between the stored representations in long term memory. Thus, lower amplitudes were observed

for words that were semantically associated with the subject: “rubies” had a lower amplitude in sentences where “gems” was the subject and also “gems” had an equally low amplitude in sentences with “rubies” as subject, vs. sentences containing the word “spruces,” irrespective of truth value. Thus, there was so difference in amplitude or latency in the N400 component for “No rubies are gems” and “All rubies are gems.” The authors interpret the N400 as indexing processes having to do with basic properties of semantic memory and not processes having to do with decision making and truth-value evaluation. (Kounios and Holcomb 1992)

3.3.3 Discourse and world knowledge

In real life sentences are rarely heard in isolation, often being related to a wider context that affects the way in which individual sentences are interpreted. When we listen or read language, we also need to verify the information conveyed against what we know about the world. Kutas et al. (2006) argue that the semantic information encoded into language and pragmatic knowledge about the facts of the world although distinct, goes hand in hand to facilitate comprehension.

The effect of discourse and world knowledge on comprehension can be visible during online processing as many studies have reported N400 modulations as a result of discourse manipulations. These effects had a similar time-course and morphology to the N400 effects seen for isolated words or sentences.

Hagorot and van Berkum (2007) investigated whether the processing of lexical-semantic information and pragmatic information takes place in two separate stages, by looking at the interaction between semantics and pragmatics during online processing. The brain activity of Dutch participants was recorder via EEG while they were reading sentences that were either congruent (“Dutch trains are yellow”) violating world knowledge (“Dutch trains are white”) or violating semantic restrictions (“Dutch trains are sour”). A clear N400 effect was observed for semantic violations as well as for world knowledge violations and both effects were similar in amplitude, latency, onset and topography. This shows that the two types of information are processed in a similar fashion and used at the same time during comprehension. The results are interpreted by the authors as bringing evidence against processing models in which the truth

value of a proposition is evaluated separately from its reference in the real world. (Hagoort and van Berkum 2007)

Van Berkum et al. (2003) also investigated whether meaning is first processed at the local sentential level before information from the discourse can contribute to interpretation, or whether discourse information affects comprehension immediately. Dutch participants were asked to listen to sentences in Dutch ("Jane told her brother that he was exceptionally quick/slow") that were either compatible or incompatible with the wider context in which they were introduced. The advantage of doing a hearing ERP experiment instead of a reading one is that the linguistic input is presented in a more natural way. An example of the short discourses told to the participants is as follows: "As agreed upon, Jane was to wake her sister and her brother at five o'clock in the morning. But the sister had already washed herself, and the brother had already got dressed. Jane told her brother that he was exceptionally quick/slow." A clear difference in N400 amplitude was seen between the two conditions, with a more negative wave elicited for critical words that were incompatible with the preceding context than for congruent words, regardless of whether they were present in the middle or the end of the sentence. The spoken N400 effect had a somewhat different time course than the written one but these differences might be due to the different modalities in which the stimuli were presented. Importantly, the researchers conducted a follow up experiment to test whether the observed N400 effect is really due to context, by having participants listen to the sentences containing the critical words in isolation, as well as new sentences containing an anomalous or a congruent word "Gloomy men stood around the pencil/ grave of the president." The results show a standard N400 effect for the anomalous words in these sentences but no effect was observed for the sentences from the first experiment. (Van Berkum et al. 2003)

This study thus found that the morphology and scalp distribution of the N400 effect was similar for both sentence and discourse anomalies. Words that were anomalous given a certain preceding context, consisting of an additional sentence to which the critical word referred to, elicited a similar N400 response in comparison to anomalous words in isolated sentences. These results show that the lexical-semantic information encoded in incoming words is immediately integrated into the discourse representation and that discourse context has an immediate effect in downstream processing changing the way in which words would be processed in isolated sentences.

Nieuwland et al. (2006) showed that discourse context can even overrule world knowledge information during comprehension. This study also disconfirms the hypothesis according to which local sentential and word associative information is processed before global discourse information, and shows that when contextually appropriate, strong semantic anomalies that violate semantic primitives like animacy can be easily processed. Participants listened to 60 Dutch spoken stories describing two characters one of which was inanimate in nature but was described as animate: "A woman saw a dancing peanut who had a big smile on his face. The peanut was singing about a girl he had just met. And judging from the song, the peanut was totally crazy about her. The woman thought it was really cute to see the peanut singing and dancing like that. The peanut was salted/ in love, and by the sound of it, this was definitely mutual. He was seeing a little almond." What is interesting about the study's design is that it pits discourse context against world knowledge. In one condition the critical word was congruent with respect to the semantic properties of the subject and world knowledge but anomalous in the cartoon-like context, while in the other condition the critical object noun was anomalous with respect to animacy constraints and world knowledge but fit well in the discourse created by the preceding context. Animacy violations when presented in an appropriate context were rendered acceptable by comprehenders, as a larger N400 response was observed for contextually anomalous but semantically congruent critical words than for animacy violating objects.(Nieuwland and Van Berkum 2006)

Taken together, these studies show that online language comprehension is rapid and that the processing system uses all available information to facilitate comprehension, without giving priority to the lexical relations between words.

Although it is clear that previous context influences the processing of upcoming words, it is not quite obvious at which stage in processing this happens. Cloze probability ratings have been seen to modulate the N400 in a graded fashion but there is little known about how the degree of constraint of the context impacts online processing. Fedemeier et al. 2007 design a study that pits contextual constraint against expectancy in an attempt to investigate how sentential constraint and cloze probability impact the processing of upcoming words. Pairs of sentences that were strongly or weakly constraining were given high cloze probability and semantically unrelated endings. "The children went outside to play/look" and weakly "Joy was too frightened to move/look." The aim of the design is to see how, when everything else is held

constant, context constraint influences N400 amplitude. Since "look" had an equally low cloze probability in both highly and weekly constraining sentences, it is expected that any difference in the N400 amplitude will be due to the effect of the context. As expected, the N400 response was modulated gradually by cloze probability but interestingly no effect of constraint was observed. This study thus provides evidence that context effects on word processing unfold over multiple processing stages which are not all necessarily indexed by the N400 component. (Federmeier et al 2007)

Overall, the studies reviewed in this section strengthen the view that the N400 component reflects the processing of words and is influenced by how well an individual word fits with the overall context of the discourse. However it is important to note that this does not necessarily mean that all the information in the previously activated context is processed fast enough to affect activation of downstream words and it is ultimately a matter of how much different kinds of information already present in the context can impact the processes reflected in the N400 for upcoming words.

3.3.4 Quantifiers and negation

The previous sections show a rather contradictory view on the incremental nature of language processing. Studies manipulating a word's fit with discourse context and world knowledge seem to demonstrate that world knowledge and discourse information are integrated immediately and constrain expectations for upcoming words, while studies on negation and quantifiers show evidence for a view in which at least some aspects of the input are not resolved and integrated immediately.

Niewland et al. (2008) investigate the effects of negation on language processing. As mentioned above, Fishler et al. (1983) found a difficulty in processing, evidenced by a larger N400 response, for words inconsistent with what is known about the world, regardless of whether the respective proposition was negated or not. A problem with the design of the Fischler et al. (1983) study might be that the stimuli that had the true truth value were pragmatically infelicitous (they offered information that was of no use to the comprehenders). Niewland et al. (2008) devised a study in which pragmatics and negation are fully crossed, to see if negation is in

fact incrementally processed in pragmatically licensing sentences. The results point towards the incremental processing of negation and towards a view in which the processor takes into account both world knowledge and pragmatic licensing during comprehension. In the pragmatically licensed sentences, a larger N400 was observed for false "With proper equipment, scuba-diving is very dangerous/ isn't very safe and often good fun." vs. true "With proper equipment, scuba-diving is very safe/ isn't very dangerous and often good fun." critical words, showing that negation is processed immediately and affects online processing of downstream words. The unlicensed sentences showed however an interaction between truth value and negation, with a greater N400 for false words "Bulletproof vests are very dangerous and used worldwide for security" vs. true "Bulletproof vests are very safe and used worldwide for security" in affirmative sentences but not in negated ones.("Bulletproof vests aren't very safe and used worldwide for security") The study shows that embedding sentences into pragmatically licensed contexts, results in a modulation of the N400 which is sensitive to both pragmatics, expectation and preceding context. (Nieuwland et al. 2008)

To investigate the processing of quantifiers, Urbach and Kutas (2011) designed a study in which quantifier type ("few" and "most" type quantifiers) is crossed with typicality and world knowledge. The sentences used in the study were simple active sentences containing a bare plural subject noun, a main verb and an object that was either consistent (typical condition) or inconsistent (atypical condition) with the preceding sentential context. To these, sentence quantifiers were added modifying the subject noun and resulting in a full cross between quantifier type and typicality: "Few/Most farmers grow crops/worms."

The first experiment in the study tested the hypothesis that world knowledge and discourse information are processed incrementally and modulate the N400, by recording ERP's at the object noun in the un-quantified sentences "Farmers grow crops/worms." As expected, the results showed larger N400 amplitudes for the atypical noun versus the typical one. The second experiment manipulated sentence level processing by adding quantifiers to the subject nouns of the sentences in Experiment 1.

To assess how the quantifiers are interpreted offline, participants had to rate each sentence for plausibility on a scale from 1 to 5. The analysis of these results confirm the predicted cross-over interaction of quantifier type and typicality, with few-type quantifiers reversing the direction of the plausibility ratings given for most-type quantifiers. As expected,

the information encoded in the quantifier is rapidly integrated with background knowledge about the subject noun during offline comprehension, affecting the interpretation of the critical word. Interestingly, this crossover effect was not observed in the ERP waveform. Although quantifiers modulated the N400 component in the predicted direction, the few-type quantifiers did not reverse the direction of the effect as was observed for the plausibility judgments. The results are summarized in the below figure:

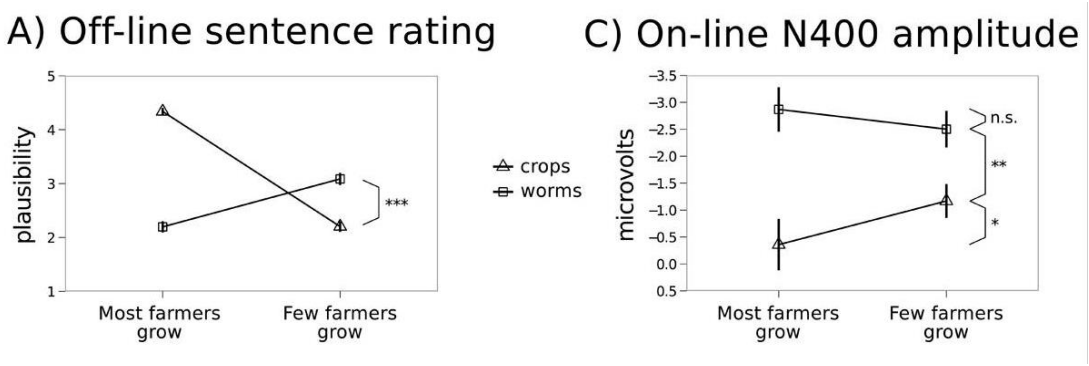

Figure 2. This figure is taken from Urbach and Kutas (2011) and shows the lack of a crossover effect in the N400 response for few vs. most type quantifiers.

A larger N400 wave was observed for most-atypical sentences than for most-typical ones, while few-atypical also elicited a larger negative deflection compared to few-typical. Although compared to the most-type quantifiers, the few-type quantifiers elicited a larger negative wave for the typical noun, and a smaller negative for the atypical one, the crossover interaction was not observed, suggesting that few-type quantifiers are not entirely processed incrementally.(Urbach and Kutas 2011)These results seem to enforce the notion that the N400 response indexes something about how much the preceding context can help predictability of the upcoming words. In isolated, contextually poor sentences, few-type quantifiers don't seem to be able to contribute enough semantic information to the context to facilitate the processing of atypical words, although offline a sentence like "Few farmers grow worms" is interpreted as plausible.

This conclusion was further investigated in a new series of experiments reported in a 2015 paper, where the authors tested whether adding a pragmatically licensing context to the stimuli, would result in a different results.

The experiments tested the effect of pragmatic licensing and task during online comprehension. A total of 4 experiments were conducted, with Experiment 1 containing most/few +typical/atypical sentences preceded by a context and in which participants had to rate

each sentence for plausibility ("In mountainous areas where the terrain is uneven and it's easier to go around obstacles than forge direct routes through them....few roads are curved due to engineering limitations. Are there many winding roads in mountainous areas?"), Experiment 2 presented the stimuli without a plausibility tasks and Experiments 3A and 3B were the control experiments containing the sentences without contexts.

The plausibility and cloze test results for Experiment 1 showed evidence of a full integration of the quantifier semantics into the interpretation of the sentence. A crossover interaction was observed for both cloze and plausibility tests. Unlike Urbach and Kutas (2010) the plausible conditions were symmetrically rated as plausible while the 2 implausible conditions were well-matched in low plausibility ratings. The original study found a mismatch in the ratings for most + typical (plausible) versus few + atypical (implausible), rendering the quantifier effect on the atypical word smaller than the effect on the typical one. The ERP results in Experiment 1 show that most + atypical stimuli showed a larger N400 response than most + typical sentences while few + typical sentences also showed a larger N400 response. This experiment did not show a reversal of the effect for few-type quantifiers and therefore no crossover effect between quantifier type and typicality.

Importantly, Experiment 2 did find the predicted crossover effect. This experiment investigated both pragmatic and task effects on quantifier processing, and found a larger N400 for most + atypical vs most + typical and also for few + typical vs. few + atypical sentences when they were preceded by a discourse context and in the absence of a plausibility task during the experiment.

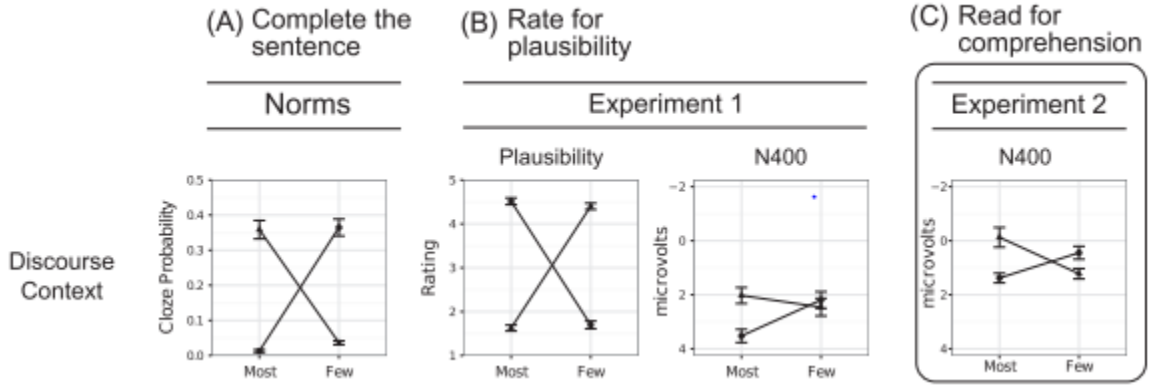

Figure 3. This figure is from Kutas and Urbach (2015) and summarizes the results for Experiment 1 and Experiment 2. A full crossover effect of quantifier type with typicality can be observed in the box on the right for Experiment 2.

Experiments 3A and 3B further investigate whether the observed effect in Experiment 2 is due to the context or the plausibility task, by having participants read sentences with no preceding discourse and rating them for plausibility (Experiment 3A) or just reading them for comprehension (Experiment 3B) Experiment 3A found no evidence of a typicality effect on the N400, with most-type quantifiers eliciting a larger N400 response for the atypical words than for the typical words, but few-type quantifiers eliciting a similar N400 response for both conditions. The N400 effects in Experiment 3B were smaller than in Experiment 2 and critically, there was no effect of typicality observed for few-type quantifiers, where both typical and atypical words elicited similar N400 waves. (Urbach et al. 2015)

Nieuwland (2016) further investigate the processing of quantifiers by having participants read quantifier sentences of the form "Most/few gardeners plant their flowers during the spring/winter for best results" while their EEG was recorded. This study tries to dissociate quantifier type from predictability. The N400 is taken to index the degree to which the meaning for a word is predicted given the preceding context, the question asked by the author is whether positive ("most") and negative ("few") quantifiers influence the prediction of the critical word in a way that can affect online processing differently. For each quantifier the critical word could render the sentence false or true, resulting thus in 4 conditions: True positive: "Most gardeners plant their flowers during the spring for best results. True negative: "Few gardeners plant their flowers during the winter for best results." False positive: "Most gardeners plant their flowers during the winter for best results" and False negative: "Few gardeners plant their flowers during the spring for best results." Two groups were studied, one in which participants rated each sentence for plausibility and another in which they only read the sentences for comprehension. The results show an N400 effect for positive quantifiers but not for negative ones. This effect depended on cloze value and represented an interaction between truth value and quantifier for lower cloze values and only an effect of truth value for higher cloze values. The author takes this as evidence that quantifiers can be interpreted incrementally and can affect the modulation of the N400 when their meaning can be used for predicting the upcoming word. Thus, the lack of effect for the few-type quantifiers can be explained by the fact that these quantifiers cannot aid prediction as they render sentences that are not very highly constraining.(Nieuwland 2016)

As mentioned above the N400 component is sensitive to a complex interaction of various factors showing how different processes of language comprehension interact with each other. Discourse has proven to be a big factor in the modulation of the N400, and studies mentioned above have shown that preceding context can have an immediate impact on the modulation of the N400 response, especially when it is rich enough to facilitate prediction for upcoming words. This context can be made of sentential, wider discourse or world knowledge information. These studies bring further evidence to the incremental and rapid manner in which all these different types of information is processed and integrated into the unfolding representation of the linguistic stream, contributing to the way in which upcoming words are processed.

This data overall also shows that the N400 effect reflects something about how words are related to the meaning conveyed in the context and cannot be explained only in terms of priming and lexical-semantic associations between words. Thus, although world knowledge and lexical semantic associations have been proven to be important factors that modulated the N400, these effects can be overruled by the effects of discourse context, showing that the N400 is sensitive to the degree of fit between words in the context available to the comprehender at a given time.

3.3.5 Counterfactuals and the N400

As described earlier in this thesis, language provides us with the ability to speak counterfactually about situations that contradict the facts of our world and cannot actualize in the factual world. When interpreting counterfactuals, language users need to balance what they know about the world with what can be expressed through language and need to create absurd conceptual combinations and at the same time create the consequences that those new concepts might bring on other events. (Byrne 2005) On this view, counterfactuals could theoretically pose a problem for comprehension as they involve the acceptance of situations that violate what is known about the real world.

Nieuwland et al. (2013) investigate whether the interpretation of counterfactuals is actually problematic for the processing system. Unlike other studies that reported a discourse context effect on the modulation of the N400 (e.g. Nieuwland and van Berkum 2006), Nieuwland et al (2013) investigated whether a single antecedent clause can attenuate the N400 effect for counterfactual sentences. The study reports two EEG experiments, one in which

participants read counterfactual simple sentences “Dobermans would breathe under water/ poison” vs controls “Tuna breathes under water/poison” and another experiment in which different participants read the same sentences preceded by a counterfactual conditional that rendered the subsequent sentence plausible “If dogs had gills, Dobermans would breathe under water/poison without problems”(counterfactual true/counterfactual false) vs. controls “Because fish have gills, tuna breathe under water/poison without problems.”(real world true/real world false) The aim of the first experiment was to test if whether the sentences presented in isolation, with no facilitating counterfactual context, would show a processing difficulty due to semantic incongruity as reflected in the N400. The results in Experiment 1 show larger N400s for counterfactual false and real world false sentences compared with true sentences, showing that truth-value can modulate the N400 irrespective of tense. The results of Experiment 2 show that a counterfactually licensing context can in fact modulate the N400, and effects of propositional truth value were seen in the expected direction. Thus, counterfactually true and real world true sentences had overlapping N400 waves and smaller than counterfactual false and real world false sentences, showing that this component is sensitive to propositional truth value and that given a supporting facilitating context, counterfactuals are processed with no additional difficulty. This study also shows that a wide discourse is not necessarily needed to modulate the N400.(Nieuwland et al. 2013)

Kulakova et al. (2016) explore how the link between social cognition and counterfactual language is maintained during online comprehension. Following Kutas and Fedemeier (2011), they see the N400 as reflecting the facilitation of retrieval of a word from memory, due to prior information available in the context and world knowledge. Thus, it is assumed that the N400 reflects a process of prediction of what word is going to appear next, based on world knowledge, context and pragmatic cues. The more semantic features the upcoming word shares with the prediction, the easier it will be to be retrieved and the smaller the N400 wave will be. In this view, the N400 does not directly reflect the processing of truth value and factual and counterfactual propositions can be equally facilitated, facilitation that relies among other things on pragmatic processing. As reviewed by Kulakova and Niewland (2016) pragmatic skills differ from one individual to another and include the ability to use the available cues in order to pick up on the intention of the speaker of referring to a counterfactual situation.

Unlike the above mentioned study, that looked at the processing of false continuations introduced by counterfactual antecedents, this study aimed at investigating how and if the processing of the actual antecedent is predicted by an individual's pragmatic skills.

Participants read conditional and declarative sentences that were either in subjunctive and indicative mood. ("If/As words/sweets are/were made out of sugar, sentences/candy can/could make people very fat when consumed frequently.") Thus, counterfactual true sentences "If words were made out of sugar" differed from their counterfactual false counterparts in that, although true with respect to word knowledge, violated the expectations created by the pragmatic cue of the subjunctive mood which creates the expectation for a counterfactual continuation. The indicative conditions were used as a comparison while the declarative was the control condition. After the experiment participants were asked to take a questionnaire evaluating their pragmatic skills. The results show that mood can modulate the N400 as larger amplitudes were seen for the critical word "sugar" in counterfactual antecedents than for hypothetical ones ("If sweets were/are made out of sugar"). Thus, it appears that the subjunctive mood makes the critical word less expected. At the same time a relationship was observed between pragmatic skills and the amplitude of the N400, suggesting that the N400 effect might reflect the effects of pragmatic processing during online comprehension. Interestingly, there was no effect of mood observed for atypical words in "If words were/are made out of sugar." This suggests that the N400 is not an index of plausibility of a proposition but rather reflects the degree to which the retrieval of a word is facilitated by the preceding context. As these sentences lacked a rich facilitating context, the critical word "sugar" was not easily predicted by the comprehender. (Kulakova and Nieuwland 2016)

3.4 What processes are indexed by the N400

The studies reviewed in this chapter show that language processing is rapid and complex. Comprehension involves a complex interaction of different processes and the N400 component has provided useful hints about the workings of these processes. In order for language comprehension to be achieved, upcoming words need to be accessed in long term memory and their meaning needs to be integrated into the unfolding context. Word meanings are stored in long term memory, in the brain's neural structures. When a person reads or hears words, these stimuli pass through the brain's neural circuits and activate different parts of it, where the mental lexicon is stored. (Altmann 1998: 2-30) After words are activated and selected from the mental lexicon, they need then to be integrated in the representation of the context built from previous words (Lau et al. 2008) A popular view of language comprehension posits that a series of lower processes take place beforehand, analyzing words as perceptual and then linguistic items at orthographic and phonological levels, and after the word is matched with a representation in the mental lexicon, it is then analyzed semantically and integrated into the preceding context. (reviewed by Kutas and Fedemeier 2011)

Although clearly involved in semantic processing, the sensitivity of the N400 to a wide range of factors, pertaining to both lower and higher information levels, has made it unclear what exactly stage in processing this component indexes. A large body of work identifies the N400 with a process of semantic integration while other studies strongly argue that it indexes a process of access to semantic memory. Congruent words with high cloze probabilities have been seen to elicit smaller N400 responses than unexpected ones. This has given rise to the question of whether the upcoming words are activated before they appear and thus actually predicted or whether because these words are more plausible given the context, they are easier to integrate with the unfolding linguistic representation. Thus, the main debate surrounding the functional interpretation of the N400 has evolved around the question of whether the N400 indexes a post-lexical process of integrating the meaning of accessed words with a representation of the preceding discourse or whether it actually indexes a pre-lexical process of access to long term memory and retrieval of semantic meaning. (reviewed in Nieuwland et al. 2018)

3.4.1 Prediction and lexical access

Kutas et al. (2010) argue in favor of an incremental comprehension system that uses predictive processes to function as efficiently as possible. Because comprehension has only a few hundreds of milliseconds to happen, and because correctly interpreting the input depends on all sorts of information, they argue that assuming that prediction plays a role in comprehension makes it easier to explain the rapid time course of comprehension. Thus, the comprehension system on the basis of previous input can predict upcoming words as their features are already pre-activated. On this view, prediction can be seen as the altering of current processing by upcoming words that have not yet been seen.(Kutas et al. 2010) Evidence for this view comes from studies that show context facilitation for predicted words.

DeLong et al. (2005) tackle this debate in a study which capitalizes on the phonological difference between the indefinite article when it precedes a noun starting with a vowel ("a") and a noun starting with a consonant ("an"). For a sentence like "The day was breezy so the boy went outside to fly a kite/an airplane." The word "airplane" is expected to elicit a larger N400 than "kite" as it is unexpected given the context. As, there is no difference in meaning between the two indefinite articles "a" and "an," by measuring ERP's at the article, the study investigated to what extend the comprehension system forms predictions online. The ERP's to articles that are congruent with the phonological form of the highly predicted word were compared with ERP's to articles with identical meaning that introduced congruent but unexpected nouns. Thus, the violation of expectancy is seen before the noun appears. The results show a separate larger N400 response for incongruent articles and nouns ("an" and "airplane" in "The day was breezy so the boy went outside to fly an airplane"). The results provide evidence that the N400 is modulated as a function of contextual constraint, with increasing negativity for words that were lesser expected (low cloze probability). The fact that the N400 effect is already visible at the indefinite article has been taken as evidence for the fact that the phonological form of certain words was already anticipated according to predictions made on the basis of the context. The authors interpret their results by stating that features of the context pre-activate information in semantic memory, which contains both linguistic and world knowledge information. Thus the information in the context that goes beyond the linguistic input is accessed in semantic memory and leads to a pre-activation of expected words that can be quite specific as has been seen in this study. As

both continuations were semantically congruent and fit well with the rest of the sentence, the N400 effect can be explained by the fact that the system is shaped in advance by information about upcoming words.(Delong et al. 2005) However, it is worth mentioning that an attempt replicate the study by Niewland and colleagues found only an N400 effect on the noun but not on the article.

Van Berkum (2009) reviews a body of work that shows that extended context is able to modulate the amplitude of the N400. At the same time, Van Berkum (2009) argues that some experimental data point against an integration view of the N400, as the N400 effect has been observed for non-linguistic data, like a clip of a man shaving with a rolling pin, masked priming, as well as repetition, frequency and orthographic neighboring. The author supports the view of the N400 as an index for "intensified memory retrieval" facilitated by cues in the preceding context. On this account the N400 reflects the amount of resources needed to retrieve an object's coded meaning. Thus, larger N400's are seen when the expectation generated by the context mismatches the meaning needing to be retrieved. The context, on the basis of which predictions are made, is seen as a "mixed bag" containing associated words, "scenario based knowledge about the world activated by the preceding text" (2009: 305), speaker meaning, pragmatic meaning, mental models of the situation and sensory context. Information encoded in previous words together with other cues "define a less or more helpful interpretative background within which to retrieve (or select a suitable) coded meaning for the critical word."(2009: 307) Under this account the N400 reflects primitive initial sense making processes and it can only indirectly be associated with more advanced processes of semantic composition and integration. (van Berkum 2009)

3.4.2 Integration and plausibility

The integration view is based on the idea of bottom-up processing in which context affects processing of upcoming words only after the meaning of the word has been activated. (Federmeier 2009) According to this view thus, the N400 indexes a process through which activated word meaning is integrated with world knowledge and sentence context. Integration is a compositional process that combines word meaning into the overall meaning of a sentence. Nieuwland et al. (2018) explain that on this view, smaller N400 responses are seen for

predictable words as evaluated through cloze probability because integrating their meaning gives a higher degree of plausibility to the sentence (Nieuwland et al. 2018)

Hagoort et al. (2004) found that the N400 is modulated by world knowledge and plausibility. In this study both anomalies were equally unpredictable but they differed in how plausible they were. The fact that different N400 responses were seen for the different types of violations suggests that the N400 is more sensitive to plausibility than predictability.

Theories of pragmatics postulate the existence of a common ground between the participants to a conversation that contains the knowledge shared between them as well as a representation of the unfolding discourse. (reviewed by Hagoort and van Berkum 2007) Hagoort and van Berkum argue for a view in which the meaning of an upcoming word is unified with what is already present in the common ground and thus it would be irrelevant if the input contained a rich discourse or if it was an isolated sentence for the process reflected by the N400. (Hagoort and van Berkum 2007)

As mentioned above, Niewland and van Berkum's (2006) instrumental study, provides strong evidence for the incremental nature of language processing. By pitting world knowledge and primitive semantic constraints like animacy against discourse level information, the study found that when the preceding discourse is rich enough, it can override local sentential constraints during comprehension. Thus, the attenuated amplitude of the N400 for animacy violations seems to show that this component reflects a process of integration of word meaning into a wider discourse rather than access to long term memory on the basis of lexical-semantic associations.

Testing the impact of pragmatic information on online comprehension, Van Berkum et al. found that the N400 is modulated by a speaker's voice and social class, with greater amplitudes for incompatibilities between what the hearer is lead to assume about the speaker and what the speaker says. (reviewed in van Berkum 2009) Other studies show modulations of the N400 for discourses containing ideas that conflict with the subject's moral values. (reviewed in Hagoort and van Berkum 2007) These studies taken together suggest that language interpretation depends on much more than just the semantic meaning of the linguistic input and that it is closely related to pragmatic meaning as well, and have prompted researchers to state that the N400 reflects a process of semantic composition and of integrating the meaning of upcoming words with the rich context created from all sorts of different information.

3.4.3 Challenges to the debate

On the basis of the conflicting evidence mentioned above, Baggio et al. (2011), propose that the N400 response reflects a dynamic interaction between processes of prediction and integration that take place in different brain areas. They propose that feedback from the frontal cortex (involved in a process of integration) to the temporal regions (involved in a process of lexical access) can explain the N400 effect.

On this account the N400 response reflects both a process of integration and of lexical access. The linguistic input is delivered to the temporal regions, where posterior temporal areas are activated corresponding to the lexical information encoded in the input word. According to the authors, this also results in a spread of activation to neighboring regions containing information about words with similar lexical characteristics. The signal coming from the temporal region is then transmitted to the inferior frontal cortex, where populations of neurons are selectively activated and where the context is maintained activated over time. Signals are then sent from the frontal cortex back to the temporal cortex, more precisely to the same regions from where the signals were first originated. Given that an input sentence is kept activated over time by signals coming from the inferior frontal cortex, the content words of the sentence will cause a spread of activation to regions containing the features of these words. If the upcoming word is highly expected, then some features activated for the preceding context would also be activated for the next one. If the word is incongruous or unexpected, there will be no overlap in activated semantic features and an N400 effect would occur. (Baggio and Hagoort 2011)

Nieuwland et al. (2018) further investigate whether the N400 reflects a process of prediction and ease of access due to pre-activation of the semantic features of predicted words or if whether it much rather indexes a facilitation in integration of words that more plausibly fit with the context. The authors re-analyze data from a large scale 2017 replication study of DeLong et al. Before the EEG was recorded the stimuli were also rated for cloze probability and plausibility. Results point to the fact that the N400 response shows effects of both predictability and plausibility. Thus, the researchers found that the effect of predictability start around 200 ms after stimulus onset, while the effect of predictability was seen around 350 ms after stimulus onset and only after the effect of predictability. Thus, “effects of predictability and plausibility both occurred in the N400 time window, but the former dominated the N400’s rise (i.e., upward

flank), while the latter set in at its fall (i.e., downward flank).”(2018: 17) Importantly, this study shows that the N400 response represents not just one process but at least two related but distinct processes, as initially proposed by Baggio et al. (2011), and questions the validity of the ongoing debate regarding the N400 component. (Nieuwland et al. 2018)

3.5 The N400 in the current study

Although the exact processes indexed by the N400 are still a matter of debate, it is agreed upon in the field that the N400 represents the processing of the meaning of single words as the sentence unfolds over time, and its amplitude is modulated by the overall fit a word has with the preceding context. Thus, whether it represents a process of integration, lexical access/retrieval or both does not affect the conclusions of this study. In this study we used the N400 as a dependent measure because it allows us to see the effect of different modal verbs on the critical words, whose interpretation depends on the meaning encoded in these verbs. As sentential context has been shown repeatedly to modulate the N400 amplitude, by measuring ERP’s in the 200-500 ms (N400) time window, and providing that intensional modal verbs are indeed processed incrementally, any observed difference in the N400 waveform for the critical words can be attributed to the differences in the semantic meaning encoded in each verb.

4. Current study: Hypothesis and predictions

The conclusion taken from the previously reviewed studies is that the N400 component is a reflection of processes of predictability and plausibility and that it most likely reflects an overall fit of the upcoming word with the preceding context, regardless of truth value with respect to the factual world. The N400 is modulated by a complex interaction of factors and both world knowledge and semantic information weigh in on the retrieval and integration of upcoming words into the unfolding representation of the discourse. As seen in the previous sections, some studies show that discourse context can have an immediate effect in incrementally building the interpretation of the linguistic input, facilitating the processing of counterfactual sentences that describe improbable scenarios (e.g. Nieuwland et al. 2013, Nieuwland et al. 2006), while other studies suggest that not all lexical-semantic information is processed immediately as the sentence unfolds in time.(e.g. Fischler et al 1983, Holcomb et al 1992) If context influences processing of downstream words immediately, it is still undermined what would be the minimal amount of context needed for this to happen. While Kutas and Urbach (2011) showed that negative quantifiers in isolated sentences do not contain enough semantically rich information to facilitate processing of upcoming words, Kulakova et al (2016) found that the information provided by the subjunctive mood alone is strong enough to facilitate processing of counterfactuals that violate what is known about the world.

The present study investigates the effect of semantic modality on the N400 by pitting the semantics of modal verbs against world knowledge and typicality. By looking at complex sentences that contain intensional modal verbs quantifying over subordinate clauses consistent or not with world knowledge like “Tora vet at fugler har vinger/gjeller” (“Tora knows that birds have wings/gills.”) this study investigates whether the semantic information encoded in these verbs is processed incrementally and fully during online comprehension and whether it creates a rich enough context that influences the processing of upcoming words as indexed by the N400 ERP. The study therefore aims to see if the process reflected in the N400 component is sensitive to the cues of semantic modality that are encoded in intensional verbs.

Under the null hypothesis the semantic information of the verbs is not processed incrementally and the N400 response will be modulated by expectations regarding lexical-semantic associations between words and world knowledge. Thus, under the null hypothesis we

expect to see higher N400 amplitudes for object nouns in the atypical condition versus the typical condition irrespective of verb.

If semantic modality is processed incrementally and fully, then we predict that the factuality value assigned through each verb to the situation expressed in the subordinate clause will weigh in on the processing of the critical object nouns and modulate the N400. Thus, if the assigned factuality value contradicts typicality and world knowledge about how things should be, we expect to see an N400 effect. For sentences like "Tora vet at fugler har vinger/gjeller" ("Tora knows that birds have wings/gills") a larger N00 is expected for "vinger" vs "gjeller" as the atypical noun contradicts the assigned value "factual" and is false with respect to the factual world. For sentences in the "drømmer" ("dream") condition: "Tora drømmer at fugler har vinger/gjeller" ("Tora dreams that birds have wings/gills") we expect to see no difference in the N400 response of the typical and atypical nouns, as both types of situations have the assigned value "possibly factual" and the verb does not specify whether the following proposition actualizing in a nonfactual world is true or not with respect to the factual world. On the other hand for "Tora innbiller seg at fugler har vinger/gjeller" ("Tora imagines that birds have wings/gills") a reverse pattern than for "vet" ("know") is expected as the worlds accessed by this verb are evaluated as being counterfactual by the speaker. Nieuwland and van Berkum 2006 found a larger N400 effect for words that were compatible with world knowledge than for words that rendered the sentence counterfactual when embedded in an appropriate context, and Nieuwland et al (2013) found that a single anteceded sentence is enough to facilitate the processing of counterfactuals. Thus, if the modal context given by "innbille seg" creates a strong expectation for counterfactuality, we expect a larger N400 response for "wings" than for "gills."

5. Methods

As mentioned in the introduction of this thesis, the construction of the materials and the recruitment of participants as well as data collection were done in close collaboration with fellow student Anna Giskes.

5.1 Materials

5.1.1 Participants

41 right-handed Norwegian native speakers were recruited from Trondheim via flyers and internet posts. Each participant received a movie ticket in value of 120 NOK per participating (mean age 24.21, range [19, 41]). Data from 29 participants were excluded because of excessive EEG artifacts. The mean age of the remaining participants was 25.5 years, rage [21, 41] years, of which 10 participants were male and 2 female. All participants were right-handed native Norwegian speakers and had Bokmål as their native written language, with normal or corrected to normal vision and no self-reported history of neuro-cognitive impairment. The participants also reported that they grew up in monolingual environments with Norwegian as their first language of acquisition. In addition each participant was required to sign a consent form declaring that they are not under any medication that would affect the EEG recording.

5.1.2 Materials

300 Norwegian simple active sentence pairs were created consisting of a subject noun phrase followed by a verb phrase and an object noun which was the critical word ("birds have gills/wings"). Each member of a pair was identical up to the object noun, with one member of the pair containing a predictable object noun that fitted world knowledge and what is known about the subject of the clause, and the other having an object noun that did not fit expectations and was considered atypical with respect to the preceding context. 13 verbs in these sentences appeared in the past tense, describing agents that are no longer alive ("Louis Armstrong played the tuba/handball"), and the rest were all present tense. The subject nouns were either proper names of individuals or companies or plural bare nouns. The object describing this property in the typical condition was replaced by a highly atypical, implausible object noun with respect of

what is typically known about the subject. Although the atypical object noun contradicted expectations dictated by pragmatics and world knowledge, the sentences were all grammatically well formed and correct, making sure that the lexical-semantic restrictions of the verb were not violated. In total, we created 600 simple active sentences, 300 of each type. Since the N400 is measured at the object noun at the end of the sentence, 20% of the stimuli were given short continuations of 2 to 6 words and no full stops were added at the end of each sentence, to avoid any potential wrap up effects. Thus, we also minimize the risk of participants developing certain processing strategies for the sentence final words.

Each member of this pair was embedded into a main clause containing a subject noun in the form of a proper name followed by an intensional modal verb in the present tense "tro", "tvile på", "drømme", "innbille seg" ("believe", "doubt", "dream", "imagine") in the experimental condition and the factive verb "vet" ("know") in the control condition. All main verbs were in the present tense. To make sure that the meaning of these verbs is as expected from what we know from their translation in English, we consulted Norwegian speakers with regards to the everyday use of these verbs. Our conclusion is that there is a close mapping between the meaning of these verbs in Norwegian and their translation in English. The only difference is that "doubt" in Norwegian is a particle verb and is always followed by "på" and "imagine" is a reflexive verb in Norwegian and will always be followed by the reflexive pronoun "seg". Also, the verb "innbille seg" in Norwegian has a stronger counterfactual meaning than the English verb "imagine" and is always interpreted as counterfactual. In this thesis only the results for verbs "drømme" and "inlbille seg" are reported. The data for verbs "tro" and "tvile på" is reported by Anna Giskes in her master's thesis. The table below shows an example set of stimuli for all conditions together with their English translations:

Main verb	Typicality	Sentence	English translation	Condition
vet	typical	Tora vet at fugler har vinger	Tora knows that birds have wings	Control
vet	atypical	Tora vet at fugler har gjeller	Tora knows that birds have gills	Control
drømmer	typical	Tora drømmer at fugler har vinger	Tora dreams that birds have wings	Experimental
drømmer	atypical	Tora drømmer at fugler har gjeller	Tora dreams that birds have gills	Experimental
innbiller seg	typical	Tora innbiller seg at fugler har vinger	Tora imagines that birds have wings	Experimental
innbiller seg	atypical	Tora innbiller seg at fugler har gjeller	Tora imagines that birds have gills	Experimental
tror	typical	Tora tror at fugler har vinger	Tora believes that birds have wings	Experimental
tror	atypical	Tora tror at fugler har gjeller	Tora believes that birds have gills	Experimental
tviler på	typical	Tora tviler på at fugler har vinger	Tora doubts that birds have wings	Experimental
tviler på	atypical	Tora tviler på at fugler har gjeller	Tora doubts that birds have gills	Experimental

Table 1. Example of stimuli for all conditions and all verbs. The entire set of stimuli can be seen in the Apendix of this thesis

The stimuli were designed to fully cross typicality with the 5 different main verbs mentioned above. Thus, each main verb appeared in a main clause, embedding all sentences with both typical and atypical objects. The result was a total of 2400 experimental sentences (600 x 4) plus 600 control sentences.

The Norwegian simple sentences were all checked 4 times by 5 different volunteers for grammaticality and naturalness. The volunteers were native Norwegian speakers and were instructed to check each sentence and make sure that they are grammatical and that this is how they would say the sentence. Their feedback was taken into account and corrections were made accordingly. The final version of the stimuli was double checked again by one of the volunteers to make sure that there were no remaining mistakes that would affect the results of the experiment.

Sentences were truncated before the critical word and a cloze probability test was conducted in order to assess the predictability of the critical words. In an online cloze test, participants were asked to complete the last word of the sentence with the first continuation that comes to mind. The preliminary results for the cloze test for the typical words are presented

below for sentences that have at least 10 completions in total per sentence. (mean cloze probabilities: “vet” M= 0.34, “drømme” M= 0.22, “innbille seg” M= 0,27)

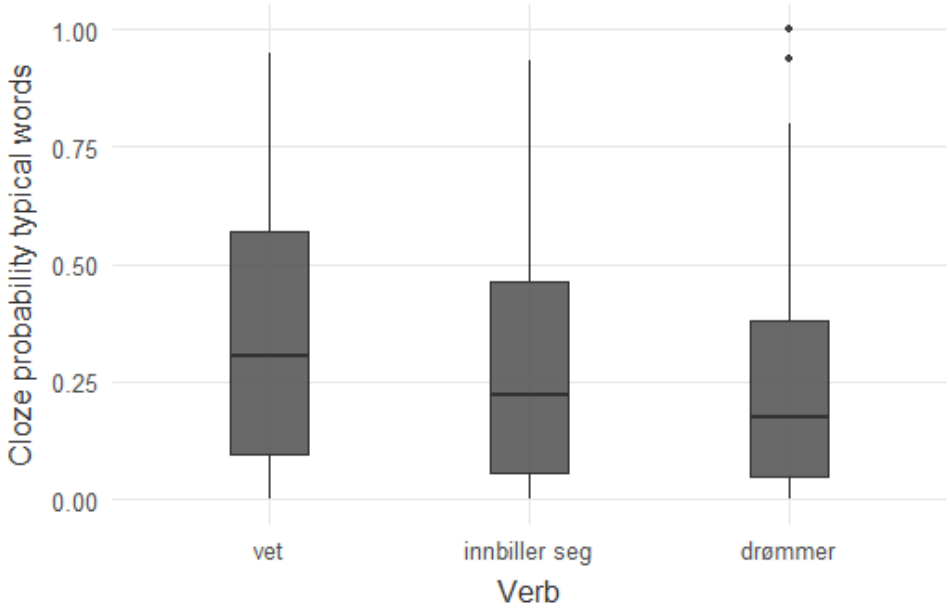

Figure 4. This figure shows mean cloze probabilities for the typical words for the verbs vet, innbiller seg and drømmer

5.1.3 Critical words

Special attention was given to the critical typical and atypical words and several variables known to modulate the N400 component were carefully controlled for. The critical words were all unmarked nouns, referring to general things, characterizing the subject nouns. Phonological competitors were avoided within the pair as well as with the preceding verb for both members of the critical pair. We also made sure that there are no close lexical-semantic associations between the subject of the complement clause and atypical words that would make them seem less atypical.

None of the critical words were repeated more than once across condition in either experimental or filler sentences and did not exceed 12 characters in length. The average length of the typical words was M=6.5 with SD = 2.1 and range [2, 12]. The average length of the atypical words is M=6.8 with SD = 2.1 and range [3, 12].

The frequency of the critical words was assessed using the NoWaC (Norwegian Web as Corpus). The advantage of using this corpus is that it is a very large web based corpus, containing 700 million tokens and reflects contemporary use of everyday Norwegian language well. However, the corpus is not very well cleaned and, although meant to be representative of Bokmål, it still contains many instances of Nynorsk, Norway's other writing standard, as well as English texts or texts occurring multiple times. (Guevara 2010) Also, a close inspection of the corpus has revealed that its tagger is not entirely accurate and that there are many misclassified occurrences. This was a problem especially for homonymous words as the word count for the target noun would in many cases contain the occurrences of its homonymous forms from different syntactic categories (adjectives, verbs). For example, the form "gift" in Norwegian means both "poison" and "married" which are two separate lemmas. At the same time the plural form of the noun is "gifter" which coincides with the present tense form of the verb "to get married": "gifter seg". The lemma count for our word of interest "poison" would include not only the adjective form but also all the occurrences of the present tense verb. Thus, the lemma count would not only include counts for words with identical lemmas but also any other word forms that would match any inflected form of the word of interest.

To avoid these confounds and to get a word count that as much as possible mirrors the actual frequency of the lemmas of the critical words, we used the following self devised method of assessing frequency for homonymous words: For each target word we needed the frequency of its lemma. First we would search the target word form tagged as "noun" and take a sample of 100 hits from that search result. Then in that sample we counted the number of occurrences that were misclassified and we subtracted this number as a percentage from the total frequency. Then, we searched each homonymous form separately tagged according to their syntactic category and took again a random sample of 100 occurrences from each search result. Out of the 100 sample we counted the number of times our target word appeared in any inflection, and added the percentage to the total frequency. This method was applied to every homonymous form of the target words.

A Wilcoxon signed-rank test was performed on the resulting frequency data to test whether there is a significant difference between the frequency of the typical and atypical words. The results of the test $W = 43678$, p-value = 0.5337 show that there is no significant difference between the two groups.

Typicality was assessed by the experimenters, using preliminary cloze probability ratings as a guideline and the intuitions of volunteer Norwegian speakers. Thus, the five volunteers mentioned earlier were also asked to check for typicality and make sure that the two conditions of typical and atypical are truly met. Both typical and atypical nouns were of the same syntactic form within each pair. Atypical nouns were taken to be highly unexpected words that contradicted what is generally known about the subject noun. They ranged from describing counterfactual situations that violate natural laws ("birds have gills"), to situations that although consistent with natural laws were still highly atypical and violated what is knows about the subject ("veterinarians treat infants in the clinic").

5.1.4 Fillers

In addition, 250 filler sentences were created, 28 of which contained a syntactic violation in the form of word order and phrase structure. This was to maintain a high degree of variability among the sentences in the study. The fillers varied in length and typicality, with some containing highly plausible scenarios while others contained violations of pragmatic expectations. The structure of the fillers mimicked the structure of the experimental sentences (proper name subject noun + predicate + subordinate clause) in order to make sure that there are no obvious differences between stimuli and fillers, but at the same time making sure that there's enough syntactic variability in the fillers to not draw too much attention on the experimental sentences. 45% of the filler sentences were about non-general truths and contained non-verifiable information about the subject: "Randi assumes her girlfriend remembers her phone number", while others referred to general things in their subordinate clause: "Liam forgot that English is a compulsory subject."

The 3000 sentences were each randomly assigned to one of 10 lists to make sure that the same sentence in different conditions is not repeated in an experimental session. Thus each list contains a sentence with one of the main verbs and in one of the two conditions: typical and atypical and each participant saw 550 sentences (experimental + filler). To each list the 250 filler sentences were added and the order of the sentences in a list was randomized.

5.2 Procedure

Participants were seated in a comfortable chair in an electrically proof, sound attenuating room. Stimuli were presented on a monitor in white font on black background using Presentation® (by Neurobehavioral Systems). The monitor was placed 82 cm in front of the participants. Sentences were presented one word at a time, with 300 ms word duration and 600 ms SOA. After each sentence a fixation cross appeared which lasted for 2000 ms before the next sentence was presented. Sentences were presented in blocks of 15 sentences each. After each block the word BRREAK would appear on the screen. Each break would last as long as the participant wished. There were 37 blocks in total. Participants were instructed to minimize muscle and eye movement as much as possible during the experiment. The experiment lasted 1:06 hours without breaks but on average participants spent 1:30 hours during the experiment.

5.3 Data recording and analysis

The EEG data was recorded from 32 electrodes, placed according to the Extended 10/20-System in the Easycap 32 Channel Standard EEG Recording Cap. The montage used is shown in the figure below:

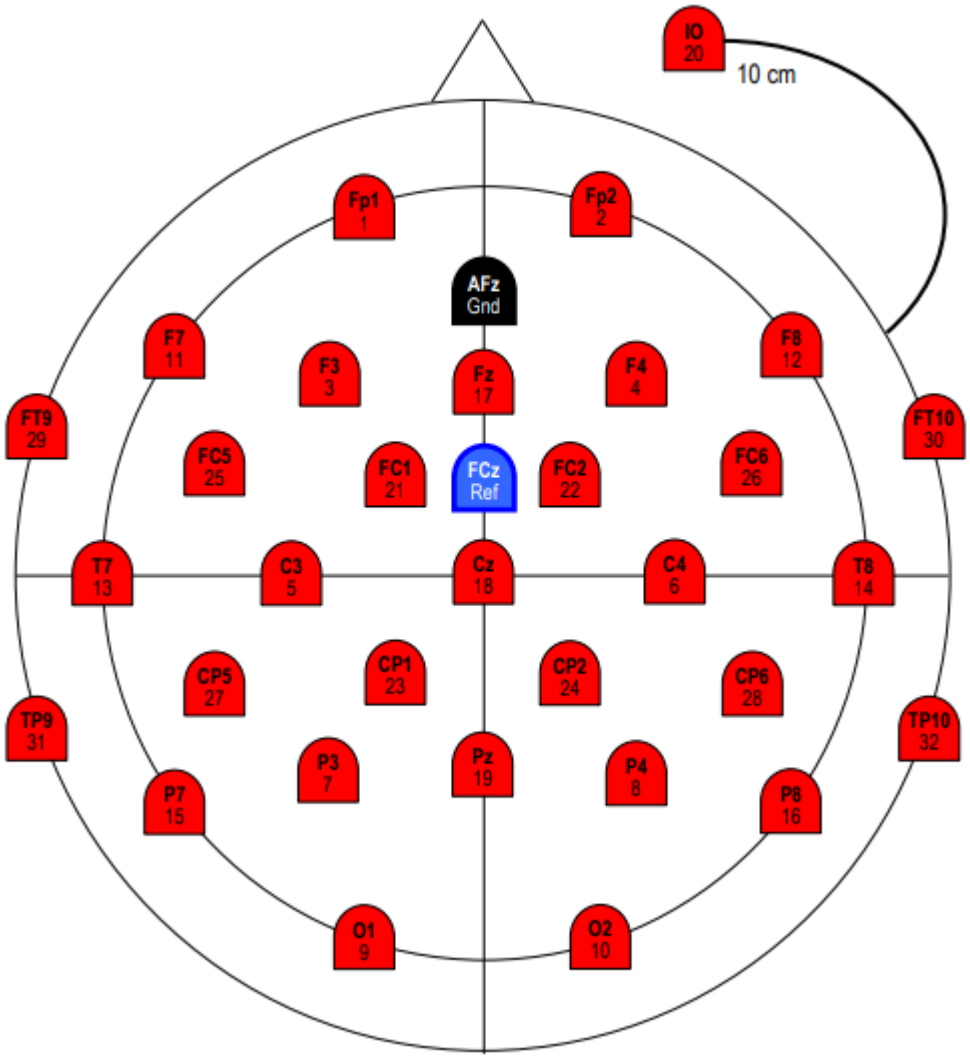

Figure 5. This figure shows the montage of the EEG cap used in the experiment.

The observed ERP is not the activity seen at one electrode site, but rather the potential of the current to move between two locations (the active electrode and the reference electrode). (Luck 2005) Each electrode was therefore referenced to the common FCz reference electrode. In the pre-processing stage subject specific EEG segments time locked to the critical object noun were extracted for each condition in each trial. The length of these segments was defined between -200 and 800 ms relative to word onset. In order to measure the amplitude of the component of interest, a baseline correction was applied that established the baseline against which the amplitude is computed. For each participant the waveform in the -200-0 ms time

window was averaged across conditions to result in a 0 muV pre stimulus mean wave. This resulting average waveform in the -200-0 time-window is used to correct the pre-stimulus voltage for each trial. It is important to choose a larger time window for the baseline as baselines in shorter time windows are generally sensitive to voltage fluctuations which influence the measured amplitude of the ERP component. Any noise in the baseline adds noise in the measurement. (Luck 2005)

As EEG data is very noisy, in order to process it some of the noise must be filtered and artifacts must be rejected. Two FeltTrip functions were used. For the first one a threshold of ±150 microV was used. Thus, only trials with activity within the ±150 microV frequency range was kept. The second function used an algorithm that searches for certain shapes and properties in the waveform that are characteristic of wave movements for the frontal channels Fp1 and Fp2. The data in these channels was preprocessed using a band-pass filter of 1–15 Hz. A low-pass filter of 30-Hz was applied to the segmented, artifact free data. Because of the artifact rejection criteria adopted, the data from only 12 participants was used in the analysis.

A nonparametric randomization test was performed on the data that resulted from the pre-processing stage.(see Eric Maris and Oostenveld 2007) The grand averages for the two conditions are computed for each verb over all participants per channel, for which a t-test is computed. Electrodes with significant p-values are then clustered on the basis of spatial adjacency. After that, a randomization procedure is applied, in which for each verb and each electrode location the data points are randomized and new t-tests are computed for the new partitions. A Monte-Carlo p value estimate is then computed as “the proportion of random partitions that resulted in a larger test statistic than the observed one.” (Eric Maris and Oostenveld 2007: 179)

6. Results

The waveforms resulted from the data analysis are characterized by the N1 and P2 components, followed by the N400 component.

For the "vite" ("know") condition the atypical words elicited on average larger N400 amplitudes than the typical ones. The N400 waveforms elicited by the typical and atypical nouns start diverging at about 200 ms post word onset, with the average wave elicited by atypical words having a larger negative amplitude than the one elicited by typical nouns, and peaking at about 400ms post stimulus. This N400 effect was reliable at 2 midline electrodes. No effect of typicality was seen in the 500-800 ms time window. The figure below shows the grand average waveforms for the critical words across 12 participants for the typical and atypical conditions for 9 electrodes for the verb "know" in the control condition:

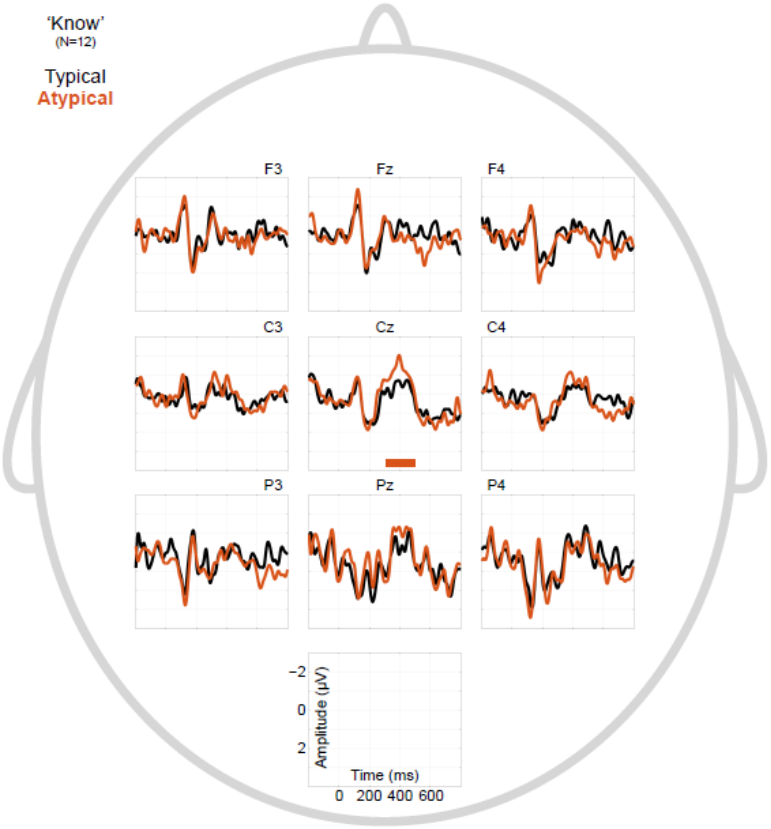

Figure 6. Grand average waveforms across all participants for 9 electrodes for the "know" ("vet") control condition. The N400 effect is visible at the Cz electrode in this figure.

A t-test was computed for each electrode location, comparing the mean amplitudes of the ERP wave segments in the 300-500 ms and 500-800 ms time windows for the two conditions: typical and atypical. For the resulting p-values smaller than a significance level of 0.05, the corresponding electrode-time pairs were clustered together on the basis of space adjacency. For the "know" condition in the N400 (300-500 ms) time window, the midline channels Cz and Cp1 were taken to form a cluster. For the clustered sample the sum of the t-values was computed (sumstat: -4.7313) and taken as the test statistic and a p-value was computed with a Monte-Carlo simulation (p= 0.0650) as the proportion of clusters with a larger test statistic than the observed one. As expected, the results show a significant effect as a result of experimental manipulation of typicality in the 300-500 ms time window for the control "know" condition.

For the verbs "å drømme" ("to dream") and "å innbille seg" ("to imagine") in the experimental conditions no effect of typicality was observed on the amplitude of the waveform in the 300-500 ms and 500-800 ms time windows. This means that for both "å drømme" and "å innbille seg" the t-tests computed for each electrode location failed to reject the null hypothesizes. The figures below show the grand average waveforms across 12 participants for the typical and atypical conditions for 9 electrodes for the verbs "dream" and "imagine":

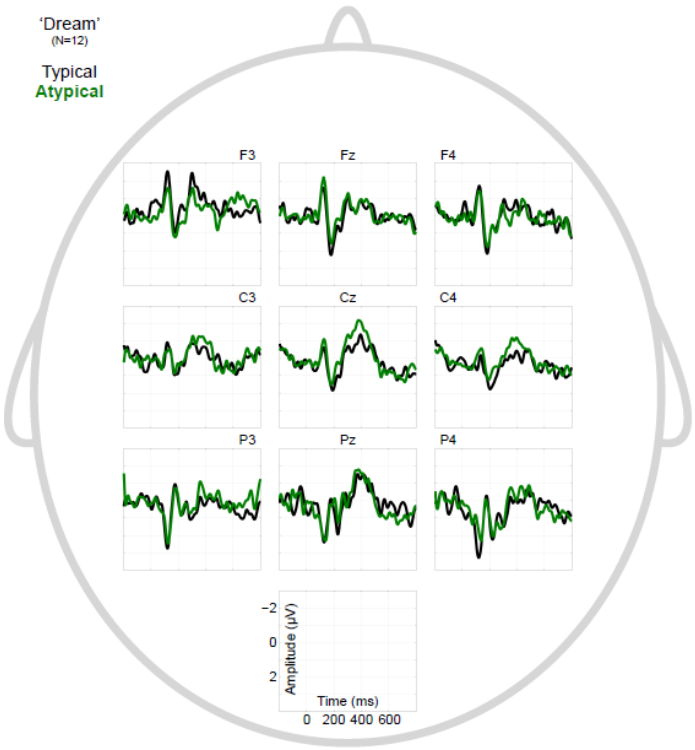

Figure 7. Grand averages across 12 participants for 9 electrode locations for the verb "drømme" ("dream")

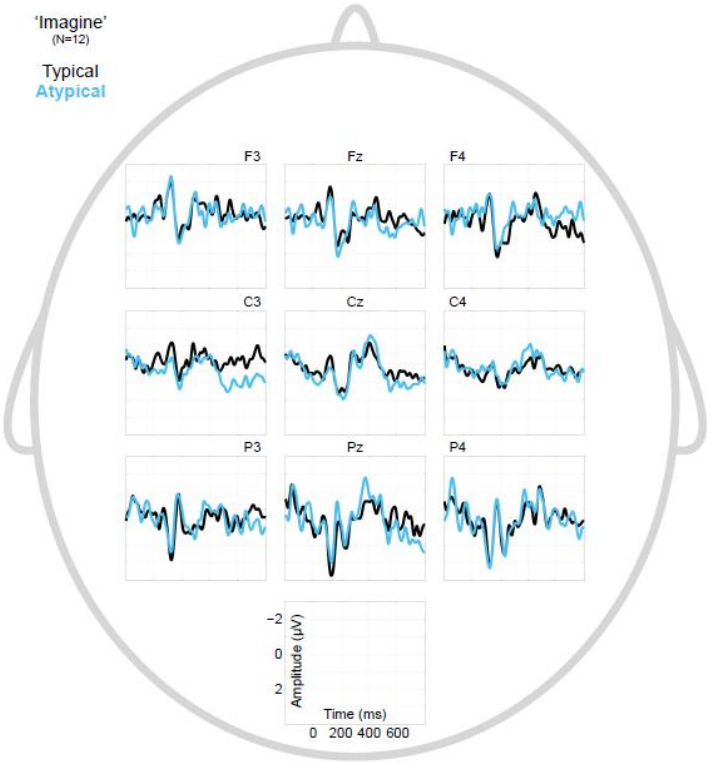

Figure 8. Grand averages across 12 participants for 9 electrode locations for the verb "innbille seg" ("imagine")

A 2 x 5 x 32 repeated measures ANOVA was conducted with the mean amplitudes for all electrodes in the 300-500 ms time interval with factors of typicality x verb x electrode to test if there's an interaction between verb type, typicality and electrode location in the N400 time window. The ANOVA analysis showed that there is no interaction between typicality and verb but that there is an interaction between typicality and electrode location. (F= 5.148, p=3.74e-15)

The figure below shows the average waveforms at electrode location Cz for all verbs at the critical noun in the typical and atypical conditions. As can be seen, there is no significant interaction effect between verb and typicality.

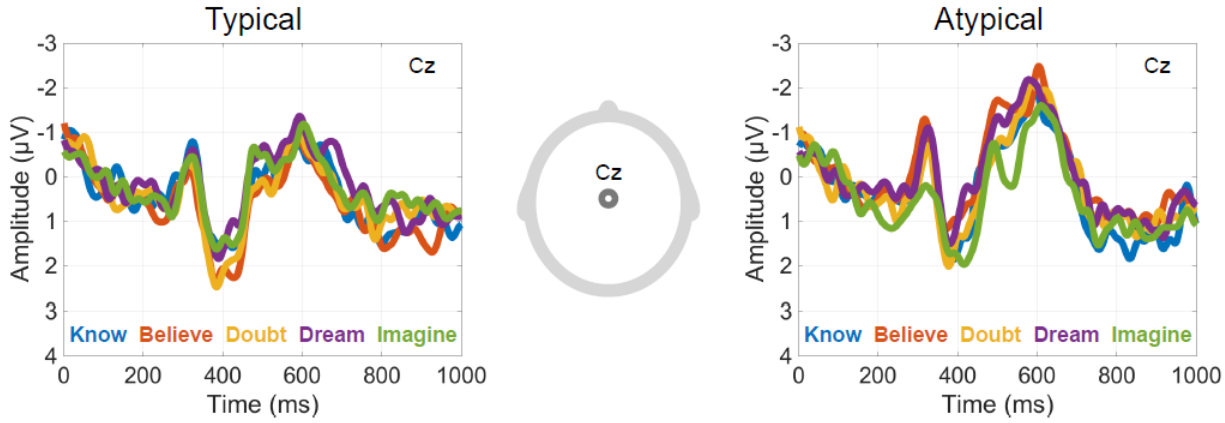

Figure 9. Average waveforms at electrode location Cz for all verbs at the critical noun in the typical and atypical conditions

7. Discussion

The current study has investigated the online processing of Norwegian intensional verbs like "vet" ("know"), "drømme" ("dream") and "innbille seg" ("imagine"). Because of the small sample size of participants used in the data analysis we take the observed results as indications of what the brain might be doing when processing these verbs and cannot be taken as conclusive evidence.

The verbs researched in this study establish accessibility relations between the factual world and nonfactual worlds and quantify the thinking individual's degree of certainty about a situation having chances to actualize in the factual world. (Declerck 2011) Some verbs establish accessibility relations with worlds that are more likely to coincide with the factual world than others. The thinking individual's degree of confidence that the set of accessed worlds coincides with the factual world takes different factuality values that can be placed according to Declerck on a scale. Below is a replication of Declerck's (2011) epistemic scale, ordered from left to right, with the epistemic values being separated in two groups: non-modal and modal. Explanations about what is assumed for each value are also provided:

Non-modal= factual	Modal = non-factual		
Absolute factuality value. Here the accessed world is evaluated as being the factual world. e.g. *know*	Purely theoretical= relative factuality value The accessed world is evaluated as may or may not coincide with the factual world. e.g. *dream*	Not-yet-factual= relative factuality value The accessed world does not coincide with the factual world but is expected to do so at a future time e.g. *will*	Counterfactual= absolute factuality value The accessed world definitely does not coincide with the factual world. e.g. *imagine*

Table 2. This table is a replication of Declerck's epistemic scale ranging from complete compatibility with the factual world given by the value "factual" all the way to incompatibility with the factual world as given by the extreme value on the right "counterfactual."

With this in mind, what follows is a detailed discussion and interpretation of our preliminary results. Because of differences in the lexical-semantic properties of each verb, the ERP results for each verb will be first discussed separately, followed by an overall discussion of the processing of semantic modality as indexed by the N400.

7.1 ERP results for the verb "å vite"

The ERP results observed for the control condition "å vite" ("to know") indicate that this Norwegian verb is processed online as predicted. Thus, sentences in the "vite"-atypical condition "Tora vet at fugler har vinger" ("Tora knows that birds have gills") elicited reliably larger N400 amplitudes on average than sentences in the typical condition "Tora vet at fugler har gjeller" ("Tora knows that birds have wings.") The verb "know" in Norwegian as in English is a non modal factive verb and it is placed on one extreme of the epistemic scale. This means that the world accessed by "know" is the factual world and there's nothing in the semantics of the verb to create expectations for a world that does not match everything that the knowing subject (the argument subject Tora) knows about the factual world. This is reflected in the ERP results.

7.2 ERP results for "å drømme"

No N400 effect was observed for the "å drømme" ("dream") condition which is according to our expectations. This means that there was no statistical difference between the average N400 amplitude for sentences in the typical condition "Tora drømmer at fugler har vinger" ("Tora dreams that birds have wings.") and in the atypical condition "Tora drømmer at fugler har gjeller" ("Tora dreams that birds have gills.") The factuality value expressed through this verb is "possibly factual" therefore the situation expressed in the following complement clause actualizes in a world that might coincide with the factual world or not. No exact expectation for factuality or coutnerfactuality is expressed. The results seem to indicate that the modal meaning of the verb is processed fully and incrementally as both typical and atypical situations are processed with no evident processing cost. The verb "å drømme" refers to a

process rather than an actual state of mind like “vet” (“know”) and does not evidently encode the subject’s evaluation of the nonfactual world saying nothing about what the knowing individual takes to be true or not. However, following Declerk (2011), I take “å drømme” to encode an epistemic value of the subject’s uncertainty that the non modal world coincides with the factual world. This is because through the verb “dream” the subject accesses a set of possible worlds of which he is not certain to coincide with the factual world. The epistemic value of “possibly factual” is therefore known by the knowing individual Tora.

7.3 ERP results for “å innbille seg”

Unexpectedly, no N400 effect was observed for the “å innbille seg” (“to imagine”) condition. According to our predictions based on the lexical-semantic properties of the verb, we expected that the “innbiller seg”-typical condition “Tora innbiller seg at fugler har vinger” (“Tora imagines that birds have wings”) will elicit a statistically larger N400 response than sentences in the “innbiller seg” -atypical condition “Tora innbiller seg at fugler har gjeller” “John imagines that birds have gills.” This is because the set of worlds accessed by the verb “innbiller seg” are evaluated as counterfactual and have no chance of coinciding with the factual world. The fact that no processing difficulty was observed for the sentences in the typical condition seems to suggest that the full meaning and implications of the verb are not processed entirely by the time the critical object noun “vinger” (“wings”) is encountered. It appears thus that expectations for factuality are not lowered fast enough to influence the N400 response. The fact that no difference between the two conditions was observed, suggests however that “innbille seg” is processed incrementally to create expectations for counterfactual continuations and to facilitate processing of atypical nouns during online comprehension.

However, it is worth mentioning here that there are two meanings attributed to the verb “innbille seg”. The most common and salient one is used to refer to the fact that someone is under the illusion that something is true when everybody else knows that it isn’t. Thus, in a sentence like “Tora innbille seg at fugler har gjeller” (“Tora imagines that birds have gills”) what is said is that Tora falsely believes that birds have gills but the speaker knows that in the factual world birds don’t have gills. Thus, under this reading “innbille seg” is strongly counterfactual as the situation actualized in the modal world “birds have gills” is evaluated as actualizing in a

counterfactual world with no chances of actualizing in the factual world. Thus, saying "Tora innbiller seg at fugler har vinger" would be implausible as it means that Tora is under the false impression that that birds have wings as evaluated by the speaker which contradicts what is known about the factual world, that birds do have wings. There is also an element of deceit in the meaning of "innbille seg" which means that the subject is fooling himself/herself to believe something that everybody knows is not true.

At the same time, "innbille seg" in Norwegian can also mean that Tora does not know that birds have gills but believes that they do without knowing for sure if this is true or false. Under this reading it would make sense to say that "Tora innbiller seg at fugler har vinger" assuming that Tora doesn't know for sure that birds have wings but she imagines that they do. Under this reading "innbille seg" is not strictly counterfactual as the situation actualized in the modal world is evaluated as may or may not coincide with the factual world by the thinking individual. Thus, Tora doesn't know for a fact that birds have wings but she imagines that they do.

An informal plausibility rating test was performed in order to investigate which of the two meanings of the verb are attributed to the sentences in our stimuli. The results of the test show that people generally take "innbille seg" to have the counterfactual meaning and that sentences in the typical condition are generally ranked less plausible than sentences in the atypical condition. When asked about their intuitions regarding the meaning of the verb our informants confirmed that usually they take the verb to mean that the subject imagines something that isn't true or real but also that the different uses of the verb depend on the context. Therefore without evidence to the contrary, we assume that the verb "innbille seg" is interpreted as counterfactual by the participants in our experiment.

It is worth mentioning however that opinions can be divided about the interpretation of this verb and more data needs to be collected in order to establish what meaning of "innbille seg" is given to the sentences in our experiment.

7.4 General discussion

The question asked in this study is whether the modal meaning of intensional verbs is processed immediately and fully during online comprehension in a way that can modulate the amplitude of the N400 response.

According to Stalkner (1999) communication between different individuals involves a mutual understanding of the presuppositions that stand behind the propositions actually being uttered. In order for communication to be successful all participants must share the same set of presuppositions which is available in the common ground. (Stalnaker 1999: 47-63) Under this view, epistemic modality can be seen as the presupposition of the speaker that what is said is either true, false or possible with regard to the factual world. If a verb like "innbille seg" is interpreted counterfactually, it would come with an extra presupposition from the speaker's part that what the subject of the sentence imagines is definitely not factual, not just that it has the potential to be counterfactual like in the case of the verb "drømme". Thus, when a strongly counterfactual cue like "innbille seg" is encountered, the hearer should form the expectation that what will follow in the complement clause will be false of the factual world and also that the speaker is aware of that, presumption which must be part of the common ground by the time the critical word is encountered. Hagoort and van Berkum (2007) see the N400 as reflecting a process through which the meaning of an upcoming word is rapidly unified with the information already present in the common ground which contains a representation of the unfolding discourse as well as background knowledge that the two speakers share, and which is always updated as new words are introduced in the discourse. The N400 thus does not represent higher level processes of sense making but rather the degree to which upcoming words match the semantic features already activated by the discourse context. The amplitude of the N400 depends thus on our ability to use information about word meaning, world knowledge and also speaker meaning to create expectations.

In our study we found that during online comprehension intensional modal verbs are processed fast enough so that their impact is seen at the critical object word in the N400 amplitude. The fact that for the "å vite" condition the effect was in the expected direction shows that our stimuli on average were equally compatible with world knowledge in the typical condition and equally incompatible with world knowledge in the atypical condition. It also

shows that the effect of the matrix verb on its complement clause can be seen immediately at the critical object noun. The amplitude of the N400 is also inversely correlated with cloze probability and how well a word fits in the overall preceding discourse. The fact that for both "drømme" and "innbille seg*"* between the typical and atypical conditions no difference in the amplitude of the N400 was observed, suggests that both types of critical words are interpreted as equally fitting with the unfolding representation of the linguistic input. In the typical condition there is a strong lexical-semantic association between the content words of the complement clause, which is a factor known to influence the amplitude of the N400 response. No difference is seen in the amplitude for atypical words because the modal context of "drømme" and "innbille seg" is rich enough to facilitate integration of atypical words into the unfolding representation of the linguistic input. The fact that the effect of lexical-semantic associations is not overturned by the impact of a strongly counterfactual modal verb like "innbille seg" suggests that by the time the critical word is encountered the preceding context activated in the common ground is not rich enough to cause the expectation for a strictly counterfactual continuation and to make the retrieval and integration of typical words more difficult. Similarly, Urbach and Kutas (2011) found a lack of a crossover effect in the N400 response for "few" vs. "most" type quantifiers. The crossover interaction was observed in a 2015 follow up study, only when the quantifier sentences were embedded in pragmatically licensing discourses. The fact that without a rich discourse "few"-type quantifiers do not reliably modulate the amplitude of the N400 means that this type of quantifiers cannot influence sufficiently the forming of predictions of what is to come next in simple declarative sentences.

The fact that for "drømme" and "innbille seg" no N400 effect was observed can be explained by the fact that the amplitude of the component is modulated by both the ease with which words are accessed on the basis of their pre-activated features in long term memory and the ease with which they are integrated with the activated overall context in the common ground. Based on lexical-semantic associations the typical words were easily accessed and retrieved as some of their features were already activated by the information provided by the context (e.g. the subject noun "birds" would also activate information about what is typically associated with birds and what they look like e.g."wings). The atypical words were also easy to integrate into the unfolding representation of the discourse as the context created expectations of both factual and counterfactual continuations in the case of "å drømme". The fact that for the typical words in the

"innbille seg" condition no difficulty of integration is observed could suggest that the presupposition of strict counterfactuality is not integrated in the common ground by the time the critical word appears. It appears thus that in our study the modal context did not lower the expectation of factuality enough.

In line with our results, Niewland et al (2013) found that counterfactual sentences are processed without delay or additional effort if made plausible by appropriate counterfactual antecedents. They found that counterfactually true and real world true sentences "If dogs had gills, Dobermans would breathe under water" and "Because fish have gills, tuna breathe under water." had overlapping N400 waves and smaller than counterfactual false "If dogs had gills, Dobermans would breathe under poison" and real world false sentences "Because fish have gills tuba breathe under poison," showing that this component is sensitive to propositional truth value and that given a supporting facilitating context, counterfactuals are processed with no additional difficulty, as the expectation for counterfactuality is quickly integrated in the common ground. This study however did not directly investigate if counterfactual cues can actually lower expectations for factual continuations. Both sentence types in the counterfactual conditions refer to situations not true of the factual world and it is the truth value with respect to those counterfactual antecedents that is manipulated.

Searle (1975) refers to the rules involved in communication as vertical rules that connect reality with language. These rules state that the speaker is committed to the truth of the uttered proposition, must be able to prove and account for the truth of the proposition and that the speaker believes that the proposition is true. In speaking counterfactually on the other hand, these rules are broken by what Searle calls "a set of extra linguistic, non-semantic conventions" which act horizontally in disrupting the connection between words and the world. (Searle1975: 326)

According to Byrne (2005) counterfactuals represent people's attempt to alter current state of affairs. People often try to create alternatives to reality but in a rational way and with as little alteration of the factual world as possible. In sentences in the atypical conditions the object nouns rendered the clause very unusual and incompatible with the factual world. The lack of a difference in amplitude between typical and atypical words for both "drømme" and "innbille seg" suggests that given the modal meaning of the preceding context, these very unusual situations given by the atypical words are computed very fast and integrated with the preceding discourse and all the necessary alterations to the representations of the linguistic input are made.

However, without enough reasons for completely changing the facts of the world, typical words in the "innbille seg" condition would still have their features activated by the preceding discourse. In understanding the strong counterfactual meaning of "innbille seg", comprehenders need to completely suspend the vertical rules of language, rules that by default are always present in our day to day interactions.

As modal meanings are placed on a scale, it would appear thus that the position on this scale influences how specific modalizers are processed during online comprehension. The closer a verb is to the counterfactual value, the more alterations to what is expected by default need to be made. Under a strong counterfactual reading, what is expressed through "innbille seg" is the speaker's presupposition that what is being uttered is not true of the factual world. This presupposition needs to be integrated by the comprehender in the common ground fast enough and the common ground needs to be updated with the new information. No N400 effect was seen for "innbille seg" as it seems that the strictly counterfactual meaning is not yet fully integrated in the common ground at the time the critical word is presented and the context created by adding this modal verb to the common ground is not rich enough to restrict predictions for the typical words. The lack of N400 effect for the verb "innbille seg" could imply that people don't easily give up the bias for factuality, as in our everyday lives we deal with the factual world much too often to forget it so easily. This of course doesn't mean that the full counterfactual meaning of "innbille seg" is not eventually processed; it just suggests that the modal context created by the verb by the time the object noun is encountered is not strong enough to reverse the N400 effect.

7.5 Further research

The conclusions drawn from this study are only preliminary and need further investigation. What is clear however is that the stimuli behave as expected and that the meaning of the matrix verb is processed incrementally to influence the amplitude of the N400 at the critical object noun. A larger sample of participants needs to be recruited in order to achieve a higher degree of certainty that the observed effects are statistically significant. What has been presented here are just indications of the direction of the effect that the processing of intensional verbs has on the N400.

Sperber and Wilson (2002) argue that comprehension is guided by the assumption of relevance that is built in every new utterance in a conversation. According to them, guided by the assumption of relevance, the comprehender takes the path of least effort in testing hypotheses about how an utterance should be interpreted, and stops the first instance the principle of relevance is satisfied, accepting the most relevant hypothesis compatible with speaker knowledge and world knowledge. (Sperber and Wilson 2002) It is therefore possible that without any supporting discourse, participants guided by the assumption of relevance took into consideration the less counterfactual meaning of "innbille seg". Whereas our sentences in the typical condition were meant to refer to trivially true situations known as general knowledge to everyone (e.g."Trees have leaves"), it is possible that some of the typical sentences in the context of "innbille seg" could have been interpreted as a plausible thing for the subject not to know. This is because typicality is not an absolute value and some aspects about the world are more salient to some people than others. For example it would be possible to assume that John doesn't know for sure that wasps like sugar but assumes that they do. Thus, on this reading both sentences in the typical and atypical condition ("wasps like sugar/cabbage) would have been interpreted as plausible, which would result in the observed N400 pattern. In order to disentangle the two meanings of "innbille seg" further analyses need to be made and the stimuli need to be further classified into different groups according to their degree of typicality.

Another issue that needs further investigation is the effect of cloze probability and plausibility of the stimuli on the N400 response. It would be informative to classify the stimuli according to cloze probability and plausibility ratings and to observe the N400 effects for different groups, in order to disentangle the effects of lexical-semantic association from the

effects of the intensional verbs under investigation. Conducting an additional plausibility rating test for the stimuli would also show how the different sentences are interpreted offline.

As mentioned above, processing counterfactual language depends heavily on the comprehender's ability to suspend the conventions of communication, mind reading abilities, and ability to quickly infer speaker meaning and add the presuppositions implied by a proposition in the communicative common ground. These abilities are crucial to understanding the social dimension of language which is the object of pragmatics. Niewland et al. (2010) and Kulakova et al (2016) found that an individual's pragmatic skills have a great impact on how fast and successfully sentences are processed. Niewland et al. (2010) tested whether the N400 is modulated by pragmatic felicity and found no difference in processing between under-informative and informative sentences "Some people have lungs/pets." However, looking at the individual scores on tests assessing pragmatic skills, an interesting effect was found. Participants with high pragmatic skills did show an N400 effect for uninformative vs. informative sentences, with uninformative sentences eliciting larger N400 responses. On the other hand, for participants with low pragmatic skills, the reverse response was found. Informative sentences showed a larger N400 wave compared to uninformative ones because of the lack of lexical-semantic associations between the content words in the informative sentences (no association between "people" and "pets"). (Nieuwland et al. 2011) Although the N400 is not a direct reflection of pragmatic and inferential processes, it can show indirectly the effects that such processes have on the processing of upcoming words. Although the N400 strictly reflects the processing of upcoming words, the way in which these are processed is influences by what has been already computed and added in the common ground by the time a word is encountered. It remains therefore to be shown if the processing of intensional modal verbs is also correlated with individual pragmatic skills and if for highly skilled participants the expectation of factuality is lowered fast enough for strongly intensional verbs like "imagine."

8. Conclusion

This study has shown that Norwegian intensional modal verbs are processed incrementally and that the modal context created through their meaning can influence the amplitude of the N400. Our results represent evidence that points to the fact that the lexical-semantic properties of modal verbs are processed immediately and affect the processing of upcoming words as indexed by the N400. Whereas for the "vite" condition we have found that words in the typical condition elicit smaller N400 response on average than words in the atypical condition, no effect was seen for the "drømme" and "innbille seg" condition, with no significant difference in N400 amplitude between the typical and atypical words for either verb. The results of this study therefore suggest that the semantic meaning of intensional modal verbs is processed incrementally in a way that modulates the amplitude of the N400. These results serve to reinforce the idea that the processes reflected in the N400 are sensitive to all sorts of information from the preceding context which has an impact on the downstream processing of words. This shows thus, that during online comprehension complex semantic information is rapidly processed and incrementally added to the common ground so that it rapidly reshapes patterns of activation of lexical semantic features. The fact that no N400 effect was seen for "drømme" and "innbiller seg," suggests thus that the modal information encoded in these verbs is processed incrementally and reshapes the representation of the discourse context in the common ground and expectations about what is to come next. However, the lack of N400 effect for "innbille seg" may suggest that the semantic information provided by the verb to the common ground is not strong enough to inhibit prediction of typical semantically associated words by the time the critical word is encountered. Thus, it would appear that fully interpreting a strongly counterfactual verb like "innbille seg" in simple sentences with no context discourse requires later processes that are not reflected in the N400. This conclusion however depends on the assumption that the verb "innbille seg" is taken by participants to have a strongly counterfactual meaning and needs further investigation.

What has been presented in this thesis are only preliminary results taken from a sample size of 12 participants and represents only an indication of the impact of intensional modal verbs on the processing of downstream words. It remains thus to be seen if these conclusions still hold with a larger sample size.

Bibliography

Altmann, Gerry T. M. *The Ascent of BabelAn Exploration of Language, Mind, and Understanding*. Oxford University Press, 1998.

Baggio, Giosuè, and Peter Hagoort. "The Balance between Memory and Unification in Semantics: A Dynamic Account of the N400." *Language and Cognitive Processes*, vol. 26, no. 9, 2011, pp. 1338–67.

Block, Cady K., and Carryl L. Baldwin. "Cloze Probability and Completion Norms for 498 Sentences: Behavioral and Neural Validation Using Event-Related Potentials." *Behavior Research Methods*, vol. 42, no. 3, 2010, pp. 665–70.

Bloom, Paul A., and Ira Fischler. "Completion Norms for 329 Sentence Contexts." *Memory & Cognition*, vol. 8, no. 6, 1980, pp. 631–42.

Byrne, Ruth M. J. *The Rational Imagination : How People Create Alternatives to Reality: EBSCOhost*. 2005.

Declerck, Renaat. "The Definition of Modality." *Cognitive Approaches to Tense, Aspect, and Epistemic Modality*, edited by Frank Brisard and Adeline Patard, vol. 29, John Benjamins Publishing Company, 2011.

Delong, Katherine A., et al. *Probabilistic Word Pre-Activation during Language Comprehension Inferred from Electrical Brain Activity*.

Eric Maris, and Robert Oostenveld. "Nonparametric Statistical Testing of EEG-and MEG-Data." *Journal of Neuroscience Methods*, vol. 164, 2007, pp. 177–90.

Federmeier, Kara D. "Comprehension." *Psychophysiology*, vol. 44, no. October 2006, 2009, pp. 491–505.

Federmeier, Kara D., and Marta Kutas. *A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing*.

Fischler, Ira. *Brain Potentials Related to Stages of Sentence Verification.: EBSCOhost*.

Forbes, Graeme. *Attitude Problems : An Essay on Linguistic Intensionality*. Clarendon, 2006.

Guevara, Emiliano Raul. "NoWaC: A Large Web-Based Corpus for Norwegian." *Proceedings of the NAACL HLT 2010 Sixth Web as Corpus Workshop*, no. June, 2010, pp. 1–7.

Hagoort, P., and J. van Berkum. "Beyond the Sentence Given." *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 362, no. 1481, 2007, pp. 801–11.

Hilyard, Kutas and. *N400 Corelated with Cloze Probability*. 1984.

Hilyard, and Marta Kutas. *Reading Sensless Sentences: Brain Potentials Reflect Semantic Incogruity*. 1980.

Kappenman, Emily S., and Steven J. Luck. "ERP Components: The Ups and Downs of Brainwave Recordings." *The Oxford Handbook of Event-Related Potential Components*, edited by Emily S. Kappenman and Steven J. Luck, Oxford University Press, 2011, doi:10.1093/oxfordhb/9780195374148.001.0001.

Kounios, John, and Phillip J. Holcomb. "Structure and Process in Semantic Memory: Evidence From Event-Related Brain Potentials and Reaction Times." *Journal of Experimental Psychology: General*, vol. 121, no. 4, 1992, pp. 459–79.

Kulakova, Eugenia, and Mante S. Nieuwland. *Pragmatic Skills Predict Online Counterfactual*

Comprehension: Evidence from the N400. 2016.

Kutas, Marta, Katherine A. Delong, et al. *CHAPTER 15 A Look around at What Lies Ahead: Prediction and Predictability in Language Processing*.

Kutas, Marta, Cyma K. Van Petten, et al. "Psycholinguistics Electrified II (1994-2005)." *Handbook of Psycholinguistics*, 2006, pp. 659–724.

Kutas, Marta, and Kara D. Federmeier. *Thirty Years and Counting: Finding Meaning in the N400 Component of the Event Related Brain Potential (ERP)*. 2011.

Larreya, Paul. "Towards a Typology of Modality in Language." *Modality in English : Theory and Description*, edited by Raphael Salkie et al., De Gruyter Mouton, 2009.

Lau, Ellen F., et al. "A Cortical Network for Semantics: (De)Constructing the N400." *Nature Reviews Neuroscience*, vol. 9, no. 12, 2008, pp. 920–33.

Lewis, David K. *On the Plurality of Worlds*. 1986.

Luck, Steven J. *An Introduction to the Event-Related Potential Technique*. MIT Press, 2005.

Nieuwland, Mante S., et al. *Dissociable Effects of Prediction and Integration during Language Comprehension: Evidence from a Large-Scale Study Using Brain Potentials*. 2018, doi: http://dx.doi.org/10.1101/267815.

Nieuwland, Mante S. "'If a Lion Could Speak ...': Online Sensitivity to Propositional Truth-Value of Unrealistic Counterfactual Sentences." *Journal of Memory and Language*, vol. 68, no. 1, Elsevier Inc., 2013, pp. 54–67.

Nieuwland, Mante S. *Quantification, Prediction, and the Online Impact of Sentence Truth-Value: Evidence From Event-Related Potentials*.

Nieuwland, Mante S., and Jos J. A. Van Berkum. "When Peanuts Fall in Love: N400 Evidence for the Power of Discourse." *Journal of Cognitive Neuroscience*, vol. 18, no. 7, July 2006, pp. 1098–111.

Nuyts, Jan. "Surveying Modality and Mood: An Introduction." *The Oxford Handbook of Modality and Mood*, edited by Jan Nuyts and Johan Van Der Auwera, vol. 1, Oxford University Press, 2016, doi:10.1093/oxfordhb/9780199591435.001.0001.

Portner, Paul. "Introduction." *Mood*, Oxfrd Surv, Oxford University Press, 2018, p. 282.

Portner, Paul *Modality*. 2009 New York: Oxford University Press

Searle, John R. "The Logical Status of Fictional Discourse." *New Literary History*, vol. 6, no. 2, 1975, p. 319.

Sperber, Dan, and Deirdre Wilson. "Pragmatics, Modularity and Mind-Reading." *Mind and Language*, vol. 17, no. 1&2, 2002, pp. 3–23.

Squartini, Mario. "Interactions between Modality and Other Semantic Categories." *The Oxford Handbook of Modality and Mood*, edited by Jan Nuyts and Johan van der Auwera, Oxford University Press, 2016, p. 667.

Stalnaker, Robert. *Context and Content : Essays on Intentionality in Speech and Thought*. Clarendon Press. 1999, 1999.

Swaab, Tamara Y., et al. "Language-Related ERP Components." *The Oxford Handbook of Event-Related Potential Components*, edited by Emily S. Kappenman and Steven J. Luck, The Oxford, Oxford University Press, 2011.

Urbach, Thomas P., et al. *Quantifiers Are Incrementally Interpreted in Context, More than Less*. 2015, pp. 1922–2013.

Urbach, Thomas P., and Marta Kutas. *Partial Incremental Interpretation*. Vol. 63, no. 2, 2011, pp. 158–79.

van Berkum, Jos J. A. "The Neuropragmatics of 'simple' Utterance Comprehension: An ERP Review." *Semantics and Pragmatics: From Experiment to Theory*, 2009, pp. 276–316.

Van Berkum, Jos J. A., et al. "When and How Do Listeners Relate a Sentence to the Wider Discourse? Evidence from the N400 Effect." *Cognitive Brain Research*, vol. 17, no. 3, 2003, pp. 701–18.

Van Petten, Cyma, and Marta Kutas. "Interactions between Sentence Context and Word Frequencyinevent-Related Brainpotentials." *Memory & Cognition*, vol. 18, no. 4, 1990, pp. 380–93.

von Fintel, Kai. "Modality and Language." *Encyclopedia of Philosophy – Second Edition*, edited by Donald M. Borchert, MacMillan, 2006.

von Fintel, Kai, and Irene Heim. "Intensional Semantics." *Technology*, 2011, p. 139.

Federmeier, Kara D; Wlotko, Edward W; De Ochoa-Dewald, Esmeralda; Kutas, Marta "Multiple Effects of Sentential Constraint on Word Processing." *Brain Res.*, no. May 18; 1146: 75–84.

Nieuwland, Mante S.; Tali, Ditman; Gina R., Kuperberg *Investigation of Informativeness and Pragmatic Abilities*. Vol. 63, no. 3, 2011, pp. 324–46, doi:10.1016/j.jml.2010.06.005.On.

Appendix

Appendix A. Informed conset form

Informed consent sheet

Subject code: _____

Project title

Processing of semantic information during online comprehension: An ERP study

Respond to all the questions listed below and sign if you agree, and if you understood everything, thus giving his consent to participate in the study. Do not sign the agreement if something is not clear.

Name: _____

Date of Birth: ____ / ____ / _____

Gender: M / F

Years of education: _____

Maximum qualification obtained: _____

Please answer these questions:

1) Do you have pacemakers cardiac and / or bio-stimulators, hearing aids, metal implants or metallic foreign bodies in the head or shoulders? □ Yes □ No

If so, what?

_____

2) Do you have a personal history of seizures or absences? □ Yes □ No

3) Have you undergone surgery to the head or the back? □ Yes □ No

If so, what and when?

_____

4) Have you got any hearing problems? □ Yes □ No

If so, what?

_____

How is your hearing corrected (eg. Hearing aid)? _____

5) Do you suffer or have suffered from any other medical, psychiatric or neurological disorder? □ Yes □ No

If so, which one?

_____

6) Do you use medications with effects on cognitive function? □ Yes □ No

If so, what?

_____

7) How many hours did you sleep last night? ____

8) Have you taken alcohol or other psychoactive substances in the last 24 hours? □ Yes □ No

9) Have you read the information sheet about this study? □ Yes □ No

10) Have you asked any questions you considered necessary? □ Yes □ No

11) Have you received satisfactory answers to your questions? □ Yes □ No

12) Have you understood that you are free to leave the experiment at any time? □ Yes □ No

13) Do you agree to participate in this study? □ Yes □ No

Date _____

Signature of participant _____
Signature of experimenters _____

Appendix B Backround information questionnaire

Processing of semantic information during online comprehension: An ERP study

Participant number: _____

Please fill in this brief questionnaire with information about yourself.

Gender: M / F

Age: _____

Are you right handed, left handed or ambidextrous?

_____

Do you wear glasses or contact lenses? If so, is your sight normal when wearing them?

_____

Do you have any other vision problems?

_____

Is Norwegian your only native language?

_____

Are you primarily a bokmål or nynorsk user?

_____

What isyour native dialect/region?

_____

What is your parent's native language?

_____

Were there any other languages in your family or direct environment while growing up?

_____

Other comments:

_____

Appendix C List of the entire set of stimuli in Norwegian

Ingrid vet/ tror/ tviler på/ drømmer/ innbiller seg at:

1. rullebrett har hjul /gir
2. prinsesser går med kjoler /smoking på gallaer
3. geiter spiser gress /yoghurt for å overleve
4. terapeuter tar seg av pasienter /kaniner
5. planter danner oksygen /tid
6. frisører klipper hår /billetter
7. rørleggere reparerer toalett /motorer
8. pyramider har gravkammer /kontorer
9. murere setter opp vegger /feller
10. vann løser opp salt /metall
11. snekkere jobber med tre /krem
12. sjåfører kjører bil /slalom
13. lungene trenger luft /røyk for å puste
14. ørene oppfatter lyd /smak
15. pianoer har tangenter /sjel av elfenben
16. fioliner har strenger /rør
17. briter snakker engelsk /latin med hverandre
18. bønder dyrker hvete /meitemark på åkere
19. gallerier stiller ut malerier /dører
20. speidere sover i telt /reir
21. orkaner forårsaker ødeleggelser /hepatitt
22. bakerier selger boller /hav
23. dyrleger behandler katter /spedbarn i klinikken
24. konditorer baker kaker /fliser
25. bryggerier produserer øl /smør
26. mygg lever av blod /vodka
27. dirigenter leder orkester /diskusjoner med en taktstokk
28. munker bor i kloster /dyreparker for å føle seg nær
29. meglere planlegger visninger /farer for å selge boliger
30. plastposer skader miljøet /kvelder

31. geologer studerer jordlag /litteratur
32. briller korrigerer synsfeil /holdning
33. appelsiner inneholder vitaminer /kull
34. vepser elsker sukker /kål
35. tog går på skinner /olivenolje
36. forfattere skriver romaner /bøter
37. maur bygger tuer /kjøpesentre for å lagre forsyninger
38. tolker assisterer døve /hvaler
39. biologer dissekerer frosker /studenter for å studere anatomi
40. eskimoer bygger igloer /skyskrapere av is
41. pingviner spiser fisk /grøt i naturen
42. inuitter jakter etter seler /pensjonister
43. patologer undersøker lik /svindel for å bestemme dødsårsaken
44. trær har grener /nebb
45. katter fanger mus /leger
46. elger er pattedyr /insekt
47. bøker har sider /negler med tekst
48. rever har pels /rulleblad
49. sykler har bremser /sønner
50. spinat inneholder jern /helium
51. jordbær er frukt /leker
52. roser har torner /planer
53. aviser publiserer artikler /sanger
54. politifolk arresterer kriminelle /prester
55. dommere dømmer forbrytere /hjerter i rettssalen
56. komikere underholder publikum /babyer på scenen
57. lærere vurderer elever /foreldre
58. detektiver forhører mistenkte /gjenferd
59. foreldre oppdrar barn /uteliggere med kjærlighet og omsorg
60. selskaper ansetter revisorer /ministre til å håndtere budsjettet
61. barn vil ha godteri /press hele tiden
62. syklister drikker vann /maling

63. klovner kaster paier /spyd
64. biler trenger drivstoff /syltetøy
65. nygifte mottar presanger /trusler ved brylluppet sitt
66. rådgivere gir veiledning /immunitet
67. advokater hjelper klienter /elskere
68. ingeniører planlegger byggverk /fester
69. bakere skjærer opp brød /skinke
70. atleter løfter vekter /peanøtter på idrettssenteret
71. psykologer bruker hypnose /vold
72. astronomer observerer stjerner /kulturer med teleskop
73. pirater kaprer skip /banker
74. ansatte får lønn /plommer hver måned
75. verter inviterer gjester /kritikere til middag
76. kirurger bruker skalpell /gafler under operasjoner
77. sjimpanser skreller bananer /epler
78. lover gjelder for alle borgere /spøkelser
79. hunder gnager på kjøttbein /selleri
80. spioner har falske indentiteter /kunstverk
81. slanger sluker egg /dinosaurer
82. Sherlock Holmes finner ledetråder /tyggegummi
83. familier planlegger ferier /rettssaker
84. fastleger stiller diagnoser /klokka
85. badevakter redder druknende /klatrere
86. tannleger borer i tenner /fingre
87. leietakere leier hus /stiger
88. skippere bruker kompass /ordbøker for å navigere
89. soldater bekjemper fiender /allierte på slagmarken
90. leger redder liv /skudd
91. sekretærer tar notater /kokain
92. monarker leder nasjoner /foreninger
93. puber serverer fatøl /hyller
94. bier samler pollen /diamanter

95. slaktere selger kjøtt /parfyme i slakterbutikken
96. akrobater opptrer på sirkus /høyskoler
97. søvnløse teller sauer /kyllinger
98. surfere leter etter bølger /måker
99. reisende oppsøker turiststeder /hevn på reisene sine
100. melk kommer fra kua /elver
101. mus spiser ost /elefanter
102. røyk signaliserer brann /jordskjelv
103. kjendiser skriver autografer /tall for fans
104. diabetikere trenger insulin /morfin
105. banker tilbyr lån /suppe
106. griser ruller seg i gjørme /mel
107. musikere memorerer noter /rabatter
108. kinoer selger popcorn /firma
109. setninger består av ord /sanger
110. ekorn gjemmer nøtter /muffins
111. servitører bærer mat /terninger
112. pandaer tygger bambus /sko
113. fektere duellerer med sverd /teskjeer
114. jordmødre jobber på sykehus /loftet
115. apotek selger medisin /brettspill ved disken
116. torden kommer etter lyn /valgkampen
117. fotografer tar bilder /lydopptak
118. hester hopper over hinder /fjelltopper i konkurranser
119. jobbsøkere forbereder seg til intervju /ballspill
120. veganere spiser grønnsaker /larver
121. pistoler skyter kuler /rosiner
122. grunnloven garanterer frihet /nedbør for alle
123. selgere prøver å overtale kjøpere /søsken
124. fiskere bruker agn /sitater
125. firkløver betyr lykke /tragedie
126. gjetere beskytter saueflokker /data

127. diktatorer straffer opprørere /fugler
128. massører masserer rygger /deig
129. iskrem ligger i fryseren /badstuen
130. vinnere får medaljer /straff
131. gartnere sår frø /piller om våren
132. bevere bygger demninger /hotell
133. kameler bor i ørkenen /jungelen
134. skihoppere bruker hjelm /slips
135. generaler gir ordre /vafler til underordnede
136. anklagere anklager tiltalte /nonner
137. groupier følger etter artister /forskere på turné
138. trenere veileder utøvere /filosofer
139. boksere kjemper i ringen /cockpiten
140. arkeologer leter etter fossiler /blåbær
141. blinde går med stokk /flagg i byen
142. løver jager gaseller /professorer
143. band spiller inn plater /dialoger i studioet
144. kattunger klorer på møbler /tavler
145. vaktmestere skifter lyspærer /bleier på jobb
146. jegere skyter vilt /tulipaner
147. lommetyver stjeler mobiler /fjernsyn
148. piloter lander fly /hauker
149. lektorer underviser klasser /dyr
150. smuglere smugler narkotika /parasoller over grensen
151. turister besøker museer /faresoner
152. talere snakker i mikrofoner /kopper
153. arkitekter designer bygninger /klær
154. vitner beskriver ranere /grammatikk
155. postmenn leverer pakker /organer
156. investorer investerer i aksjer /sokker
157. cowboyer rir på hester /ulver
158. lagre oppbevarer produkter /hensikter

159. fugler har vinger /gjeller
160. Disney lager barnefilmer /nyheter
161. spedbarn drikker morsmelk /brus
162. rømlinger flykter fra politiet /barnehagen
163. lamper henger fra taket /himmelen
164. aper klatrer i trær /kraner
165. småbarn leker med dukker /gevær
166. oppvaskere skyller glass /truser i kafeer
167. gutter spanderer på jenter /lærere på date
168. intervjuere spør om meninger /sigaretter
169. huseiere betaler avgifter /leie
170. brudepar gifter seg i kirken /lesesaler
171. bommer stenger veier /forhold
172. paraplyer beskytter mot regn /ansvar
173. raketter reiser til månen /øyer
174. baristaer brygger kaffe /svette
175. bjørner sover i hi /senger
176. riddere har rustninger /bikinier på
177. innsatte rømmer til utlandet /fengsler
178. diagrammer viser statistikk /følelser
179. skomakere jobber med lær /papir
180. aktivister planlegger aksjoner /salg
181. ektepar feirer bryllupsdag /skilsmisser hvert tiår
182. borgere velger politikere /rektorer hvert fjerde år
183. gribber spiser åtsler /agurker
184. svamper absorberer væske /risikoer
185. skilpadder har skall /briller
186. møll spiser ull /betong
187. bandasjer dekker sår /bark
188. grantrær har nåler /spiker
189. spåkoner leser i kaffegrut /føtter
190. skulptører hogger ut statuer /desserter

191. huskyer trekker sleder /radiatorer
192. kobraer spruter gift /hvitvin
193. undulater sitter i bur /kameraer
194. kameleoner skifter farge /navn
195. tannkrem inneholder fluor /støv
196. duer leverer brev /tips
197. kidnappere krever løsepenger /nettsteder
198. såpe fjerner skitt /minner fra klær
199. gardiner dekker vinduer /graver
200. sakser har blader /venner
201. muldvarper graver tunneler /badekar under jorden
202. sjørøvere graver ned skatter /hytter
203. fabrikker avgir gasser /regnbuer
204. romerne bygde murer /roboter
205. egypterne skrev hieroglyfer /bokstaver på papyrus
206. gjær består av sopp /gips
207. hackere lager virus /ebøker
208. huggorm har skinn /bein
209. flaggermus genererer ultralyd /inntekt
210. müsli inneholder korn /nikotin
211. smeder lager hestesko /flasker av jern
212. sjøforsvaret eier ubåter /kommuner
213. glasskår punkterer dekk /kajakker
214. haier angriper svømmere /løpere
215. vakthunder skremmer bort fremmede /dykkere
216. kaktuser tåler ekstrem tørke /kritikk og varme
217. krokodiller bor i sumper /rådhus
218. låsesmeder kopierer nøkler /skjermer
219. ugler har nattsyn /mareritt
220. sebraer har striper /prikker
221. frosker spiser fluer /ordfører
222. fyrtårn veileder båter /delfiner om natten

223. østers lager perler /mynter
224. turgåere bærer ryggsekker /kjøleskap
225. revolusjoner feller regimer /kuratorer
226. Stephen Hawking sitter i rullestol /arresten
227. vaksiner forebygger sykdommer /mord
228. hvelv sikrer verdisaker /kvinner
229. magikere gjemmer kort /brunost i ermene
230. turbiner genererer strøm /universer
231. skreddere syr plagg /kutt
232. strateger danner allianser /poteter
233. barberere trimmer skjegg /busker
234. annonsører finner på slagord /nekrologer
235. foreldre ansetter barnepiker /trenere
236. oppfinnere tar patent /makten for oppfinnelsene sine
237. gitarister bruker plekter /hammere
238. vinbønder høster inn druer /erter
239. gamblere spiller på kasino /sosialister
240. skatere øver på triks /flyging på ramper
241. pikkoloer bærer kofferter /laks
242. dagbøker har lås /tær for beskyttelse
243. ordstyrere leder debatter /fotturer
244. spisevaner påvirker helse /lufttrykk
245. skiløpere går opp bakker /fosser
246. bilulykker forårsaker dødsfall /sult
247. studenter pugger fakta /adresser
248. peiser avgir varme /kulde i stua
249. rengjørere vasker gulv /ører
250. røykere kjøper tobakk /sagflis
251. bartendere blander drinker /lim
252. kjøpmenn selger varer /bestemødre
253. diplomater forhandler om fred /menyer
254. designere ansetter modeller /leiemordere

255. forlag gir ut bøker /steiner
256. yoga forbedrer balansen /synet
257. pianister spiller konserter /biljard
258. fysikere studerer naturlover /økonomi
259. seilbåter trenger vind /oppmuntring for å bevege seg
260. russetida foregår før eksamenstida /jul
261. kenguruer er pungdyr /muslimer
262. Mozart komponerte symfonier /lister
263. Van Gogh malte selvportrett /elektroder
264. Louis Armstrong spilte trompet /håndball
265. Beyoncé fikk priser /influensa for musikken sin
266. MacDonalds selger burgere /tapeter og pommes frites
267. kokker arbeider på restauranter /likhus
268. keisere erobrer land /postkontor
269. bueskyttere skyter piler /blyanter
270. esler bærer sekker /puter
271. falsknere kopierer penger /mennesker
272. birøktere selger honning /kondomer
273. Shakespeare skrev drama /kalendere
274. Lord Byron skrev dikt /blogger
275. sukkertøy forårsaker hull /kompetanse i tennene
276. Jimi Hendrix spilte gitar /Tetris
277. dansere lærer koreografi /algebra
278. yogier lærer meditasjon /historie
279. aspirin kurerer hodepine /demens
280. blomster trenger sollys /perspektiver
281. kardemomme er krydder /pølser
282. Cristiano Ronaldo spiller fotball /bordtennis
283. ambulanser har blålys /lidelser
284. geishaer har på kimono /romdrakt
285. toreadorer vifter med kapper /undertøy
286. Trump skriver mange meldinger på /på 00;Twitter

287. vikingene plyndret landsbyer /drivhus
288. Copernicus studerte astronomi /ballett
289. Marie Curie oppdaget radium /fløte
290. salt dreper snegler /hummere
291. bestemødre strikker gensere /regnbukser
292. vloggere legger ut videoer på /på 00;YouTube
293. korker tetter vinflasker /porer
294. påfugler sprer sine fjær /doktriner
295. brannbiler har sirener /plener
296. kontrakter stadfester avtaler /fantasier
297. desertører flykter fra krig /internett
298. dietter foreskriver helsekost /potetgull
299. edderkopper spinner nett /tepper
300. svenner utdanner lærlinger /senatorer