Master's thesis

NTNU
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Investigating Morphological Decomposition of Established and Novel Compound Nouns in L1 English Speakers and Norwegian L2 English Speakers

A masked Lexical Decision Task study

Master's thesis in English psycholinguistics as part of the English Lektor program at NTNU. Supervised by Dave Kush and Andrew Weir

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Thanks

My mother and father. You have given me a life of safety and support - by proxy, this thesis is as much your work as it is mine.

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0 Contents 2

External addenda:

0.1 Abstract

Through a masked Lexical Decision Task experiment, the current thesis finds evidence for a sublexical morphological decomposition of established orthographically contiguous compound nouns (such as |toothbrush|) in Norwegian L2 English speakers, but not in native English speakers. Furthermore, this difference between the subject groups is not present with novel orthographically contiguous compound nouns (such as |groundlord|), where both subject groups showed sublexical morphological decomposition. The data indicates that Norwegian L2 English speakers morphologically decompose as their first mechanism - while native English speakers employ a whole word look-up as their first mechanism in visual word recognition and lexical access of compound nouns. It is suggested this distinction is rooted in the differing productive and orthographic norms Norwegian and English portray in compound nouns, and that Norwegian L2 English speakers carry over their L1 decompositional behaviors to their L2 processing.

1 Introduction

When a literate human contacts familiar orthography, one can observe an instinctual and subconscious effort to identify it as a word. This process is an automatic attempt at recognizing and cross referencing the visual stimuli with a corresponding entry in our stored lexical memories - the Mental Lexicon. Researching and understanding this process of visual word recognition and access to these lexicon entries is one of the chief undertakings of psycholinguistics as a field.

Traditionally, the field as a whole has been open to two possible explanations for how visual parsing and lexical access take place - by whole word listing or by morphological decomposition. In recent years, our understanding of these phenomena has been evidently advanced to the point where both are known to be possible mechanisms of recognition and lexical access, and the contemporary debate revolves around specifics, and questions of the relationship between these two mechanisms for access. Is decomposition initiated before whole word activation or after? Do whole word look-up and decomposition operate serially or in parallel? And if they are serial; which process is the first resort, which is the second?

These questions have mostly been investigated in a monolingual native speaking environment with the assumption that whatever the nature of the relationship between these processes looks like, it would likely be employed in a similar manner in second language speakers of that given language. Human languages do, however, portray a wide range of differing orthographic, creative and productive norms - and it is not given that visual word recognition and lexical access should behave uniformly across this entire range of differences.

An example of such differences is the way English and Norwegian orthographically present compound nouns (CNs): English presents novel CNs as orthographically split (e.g. |church color|) while established and frequent CNs are often presented as contiguous orthographic strings (e.g. |toothbrush|). Norwegian orthography adheres to a norm of all CNs being contiguous regardless of their degree of establishment and frequency; e.g. the novel |kirkefarge| (translated; church color) and the established |tannbørste| (translated; toothbrush).

The distinction between the orthographies might be a product of the differing frequency with which these two languages tend to produce novel compounds. We know that there are differing word formation rules in different languages (Dressler, 2007:159-160), both pertaining to morphological derivation and compounding. Based on statistical analyses (Baayen & Lieber, 1991; Baayen, 1992; Baayen & Renouf, 1996; Baayen, 2011), it is clear that the word formation rules affect the degrees and kinds of productivity a language portrays. While Norwegian and other North Germanic languages tend to construct contiguous orthographic strings with novel combinatorial semantic values with regularity, English has a tendency to phrase many of these as "[noun] of [noun]" constructions instead. Compounding words is a more productive and permitted productive process in Norwegian than in English, and as a consequence the natural use of Norwegian, like other typical Germanic languages, ends up consisting of more novel compound words than English (Dressler, 2007). There is research to suggest that different languages and orthographies lead its speakers to parse and process words in different manners (Kim, Wang, Taft, 2015), but whether these differences are carried over to their L2 processing is still a largely undecided matter.

The fundamental idea the current thesis investigates can be stated as; Do the orthographic and productive norms of our first language (L1) affect the way we parse and access words in our second language (L2)? Stated in terms of research questions, we ask;

(1) Do native English speakers and Norwegian L2 English speakers automatically decompose orthographically contiguous *established* CNs like |toothbrush|?

(2) Do native English speakers and Norwegian L2 English speakers automatically and sublexically decompose orthographically contiguous *novel* CNs like |groundlord|? What might the similarities and/or differences between the groups across the categories illuminate regarding visual word recognition and lexical access?

1.1 A primer on prerequisite concepts

Lexical access, the Mental Lexicon and the Lexical Decision Task (LDT) are concepts that are necessary to be familiar with before the deeper theoretical substance can be discussed. Therefore, this subchapter has been dedicated to function as a primer on these key concepts.

1.1.1 The Mental Lexicon

We know that words that we have the potential to comprehend and produce are stored cognitively as lexical memories. We also know that the retrieval of these memories seems efficient, and that must mean that the memories are not only stored - but are organized (Chomsky, 1965; 2012). So, if we carry with us something in which words are stored in an organized way, we arrive at a conceptualization not far from a dictionary of the mind - a Mental Lexicon.

Due to the tip of the tongue-phenomenon - where one can know the sense of what one wishes to express, but is in lack of the formal information to utter it - we have reason to believe that the organized storage of lexical items has to be divided into at least two sub-parts (Schwartz, Metcalfe, 2011; Coughlan, Beattie 1999); the formal information on what a word looks and sounds like (lemma), and the semantico-syntactic information that corresponds to the form (the lexeme). One of the most subscribed to neuro-linguistic models, the Memory, Unification and Control model (MUC Model, Hagoort, 2016) explains based on neuroimagery and LDT data how different lexical representations of an ambiguous single word are likely stored as two or more separate lexeme memories that correspond to an identical lemma level:

"Choke"

Lexeme

Syntax; Verb: Intransitive - slots into verb in template without object.

Semantics; Involuntary loss of ability to breathe, happens to experiencer. Semantically derivative form; inability to do what one is expected to

Lexeme

Syntax; Verb: Transitive - slots into verb in template when done by subject to object of sentence

Semantics; Voluntary violent / martial infliction of loss of ability to breathe by agent to patient

Lexeme

Syntax; Noun, common: Slots into noun in template

Semantics; Violent / martial grip, the act of involuntary inability to breathe, the act of inability to do what is expected

Lemma

Phonological form; /t͡ʃoʊk/

Orthographic form: CHOKE / choke / Choke

Morphology; [-ing] / [-ed] / [-s] / [-er]

1.1.2 Lexical access

The process of retrieving elements or items from our Mental Lexicon is what is referred to as achieving lexical access, and this process can happen in at least two ways; by phonological input or orthographic input (or when selecting output). On its face, these two ways of comprehending and producing language seem distinct, but they may not be as different as one might intuit. First of all, visual word recognition is much more than just reading. It is one of the fundamental mechanisms of the human brain - the ability to retrieve information (and construct new information) from visual stimuli - be it a letter or a picture (Jerema, Libben 2007:31). Second of all, it is not obvious that audible word recognition should use a different mechanism to construct meanings from input. They are both ways of absorbing stimulus from one's environment, and accessing the memories they are recognized as, to finally be unified to a collective sense (Hagoort, 2016). It is also the case, especially in alphabetic orthographies like Norwegian and English, that the orthographic stimuli contains some encoded phonological information by virtue of the alphabet used. One would for example know from orthography that |choke| likely involves the voiceless postalveolar affricate [t͡ʃ] based on what audible lemmas are often colocated with orthographic lemmas that involve |ch-| in their onsets. The only known distinction between audible and visual word recognition is the modality of the input which is matched with a memory; the lexical memory seems to remain the same whether we hear a word or read a word, the unification process seems to remain the same whether we hear a sentence or read a sentence (Carmazza & Hillis, 1991).

In other words, there is a practical division to make here between the recognition process and the process of lexical access. The modality of the input seems to only affect the way recognition is done, while the process of retrieving the memory likely remains the same.

Lexical access of |choke| and /t͡ʃoʊk/

Visual word recognition

I. Read |choke|
II. Look for memory with lemma level which corresponds with |choke| in orthography
III. If no match; terminate search
IV. If match; retrieve lexeme with highest probability match for context (Hagoort, 2016)
   A. If semantically or syntactically incompatible; retrieve lexeme next on probability list
      1. If no other lexeme exists; terminate search

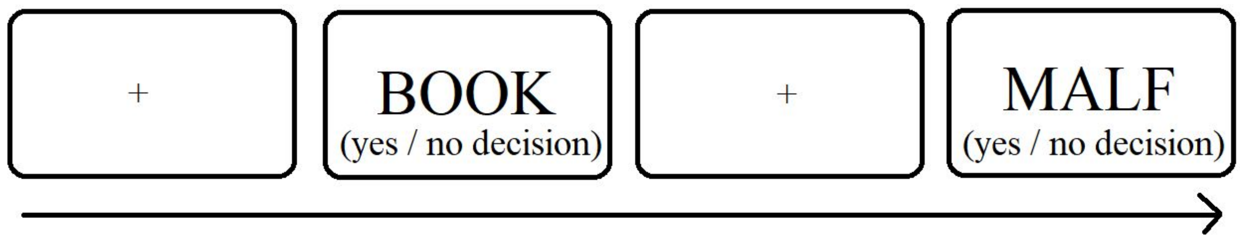
Auditory word recognition

I. Hear /t͡ʃoʊk/
II. Look for memory with lemma level corresponding with /t͡ʃoʊk/ in phonology
III. If no match; terminate search
IV. If match; retrieve lexeme with highest probability match for context (Hagoort, 2016)
   A. If semantically or syntactically incompatible; retrieve lexeme next on probability list
      1. If no other lexeme exists; terminate search

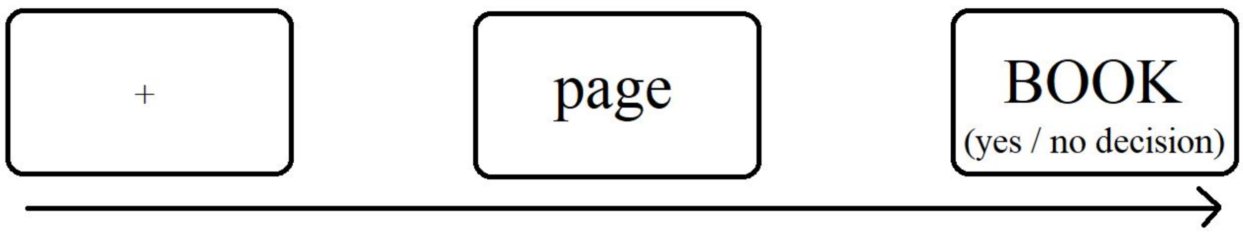
1.1.3 The Lexical Decision Task

Most of the theory and research that will be represented in the following subchapters will have the Lexical Decision Task (LDT) as a central methodology. The method will be explained and justified for my experiment in the methodology chapters (3.0 - 4.2).

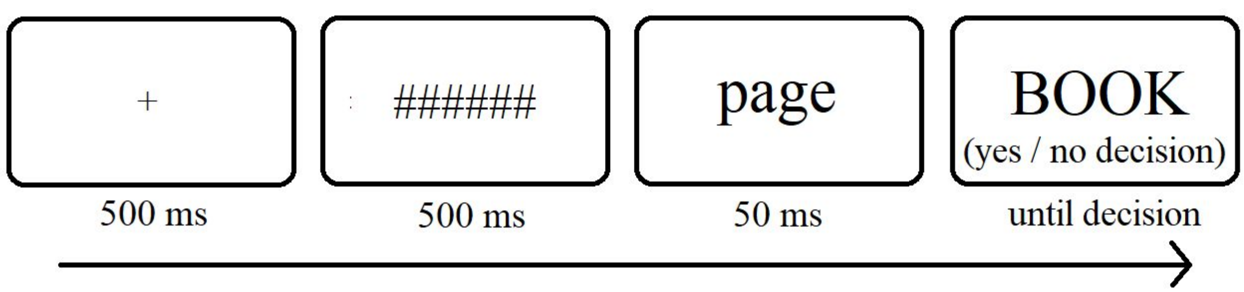
In short; a Lexical Decision Task is an experimental design which asks a participant to decide whether a target stimulus is a word or not and records the time it takes them to do so. The founding principle of the LDT is that the response times (RTs) are able to reflect the degree of difficulty experienced by the participant in making the decision:



An added aspect that many LDT designs utilize is the addition of a prime word before the target stimulus. In making this addition, there is not only the raw RT to a word to look at, but also the degree to which the word preceding it eases the process (whether or not, and by how much the preceding word reduces the RT) - which is referred to as a "priming effect" (PE).



These prime-target LDTs then add the possibility to manipulate relationships between the prime and the target words, and thus are able to provide insight into whether or not, and to which degree the prime is processed along similar cognitive routings as the target. The method was traditionally carried out with an unmasked prime where both prime and target are consciously readable. In recent years the masked priming LDT, where the prime is flashed for 50-60ms, thereby not being consciously readable, has gained popularity.



2 Theoretical background

2.1 Theoretical background: Processing complex words

"Morphologically complex words" is a very broad linguistic category which contains everything from derived simple word forms such as |chok-ed| to compound nouns like |water-fall| and |back-break-er|. Psycholinguistically, these words are of particular interest as they can indicate what the atomic units of lexical access are; morphemes or words. Are multi-morphemic words listed as individual entries, or are they decomposed in their constituent morphemes?

Much research has been done on morphologically complex words and how they are stored in and retrieved from the Mental Lexicon in native speakers. There is a consensus that morphology plays a significant role in lexical access and visual word recognition in L1 (Marslen-Wilson et al. 1994; Libben 1998; Zwitserlood 1994), but there is some discussion regarding the specifics of how morphology plays that role. Some do not grant morphology an importance as an independent factor in word recognition, and propose that the morphological effects we observe in word recognition are byproducts of semantic and orthographic processing (Butterworth 1983; Plaut & Gonnerman et al. 2000). Others agree that morphology is a crucial part of lexical access, but disagree on exactly when the decomposition takes place. In this section of the thesis, we will look closer at these theories, their claims and their evidentiary reasons for stating what they state.

2.1.1 Morphological decomposition theory; sublexical and supralexical

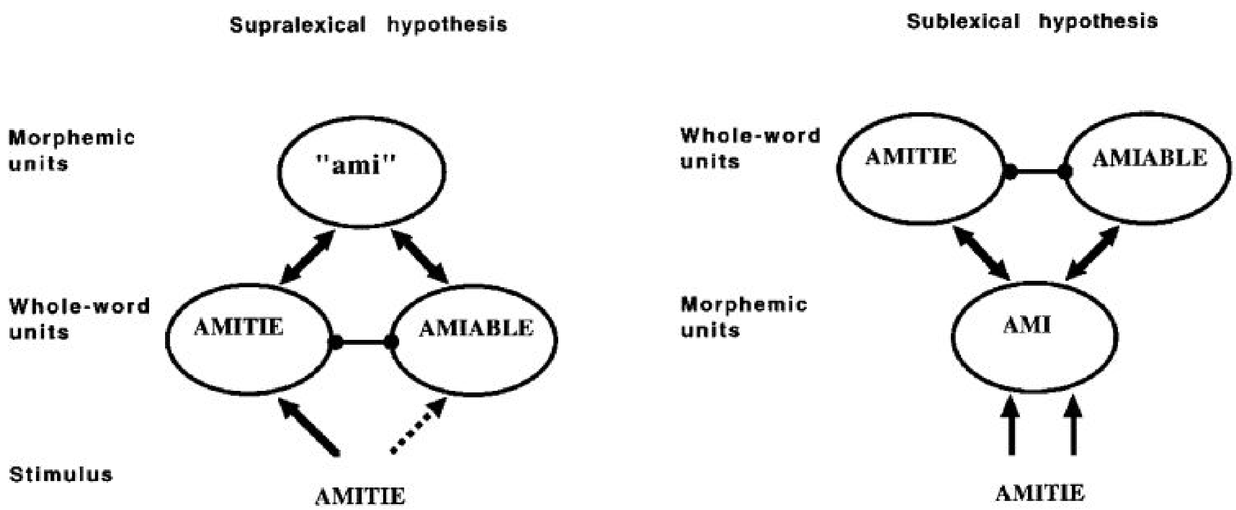
One pioneering research paper on the topic was Taft & Forster's (1975) experiments which produced evidence to support that we store stems and affixes as separate Mental Lexicon units. They found that real stems (which they defined as that to which a semantically significant affix, where |re-| means *again* etc., can be added) such as |-juvenate| took longer to classify as non-words than pseudo-stems, such as |pertoire| (to which |re-| can be added, but without the semantic implications of the real affix |re-| being *again*). Taft & Forster took this as meaning that real stems that can have real affixes attached to them are, in fact, represented in the Mental Lexicon and are thus harder to recognize as non-words in

LDTs than fake stems which cannot have affix attachments. Morphemes that can appear as both bound and free in form (like |-vent| and |vent|) are easier to recognize as a valid word when their free form (vent) is more frequent than their bound form (|-vent|, like in |circum-vent|), and significantly harder to recognize when their bound form is more frequent than their free form. From this, they concluded that *"[…] The results of the preceding experiments are all consistent with the assumption that a morphological analysis of words is attempted prior to lexical search"* (Taft & Forster 1975:645).

This solidified another more controversial claim as well; namely the idea that a morphological decomposition is attempted before the whole-word lexicality is considered or recognized - it is an automatic and subconscious search for morphemes. Taft & Forster's theory on morphological decomposition has come to be known as *the early decomposition theory*, the *morphology first theory* or *full-parsing theory* - suggesting a full, sublexical decomposition by morphemes. The sublexical approach is one of two main takes on the way our cognition decomposes the morphological constituents in visual word recognition, and argues that the decomposition happens before whole word recognition and activation. This single route full decomposition theory has been reinforced by both MEG neuroimaging (Stockall, 2006) and further LDT research (Rastle, Davis, New, 2004).

Taft & Forster (1976) went on to look at compounds and polysyllabic words. In their 1976 study consisting of five experiments, Taft & Forster found that the first syllable of polysyllabic words is the pivotal point at which lexical access processing begins. Non-words where the first syllable was a real word (such as |dustworth| and |footmilge|) took significantly longer to classify as non-words for participants than words where the first syllable was not (such as |trowflak| and |mowdflisk|). They also found that whether or not the last constituent of a polysyllabic compound non-word was a word had no relevance at all in RT. |footmilge| took long for the participants to classify as a non-word, while |trowbreak| was as easy to classify as a non-word as |mowdflisk|, even though |trowbreak| includes a real morpheme. This seemed to suggest that the decomposition of compound words is entirely contingent on whether or not the first constituent is lexically accessible or not, and that the decomposition of these words happens serially from the first to the last constituent. The idea that only the first constituent and the first syllable of a polysyllabic compound word is used in activation has since been revised in light of more research on the topic, although there is still a clear empirical tendency of the first constituent of a compound word being more focal to the decomposition process than the second (Taft, 1991). When comparing reversed compound nouns such as |berryblack| to novel compound nouns such as |brieftax|, they found that the former types took longer to classify as non-words. This suggested that the last constituent of a compound word does indeed activate in their lexical processing. Finally, and perhaps most crucially, by using the same paradigms as in their earlier studies (Taft & Forster 1975), they found that subjects attempted to decompose non-word compounds before a whole word recognition and potential lexical access. This reinforced the credibility of their sublexical assertions, and gave reasons to believe that the same mechanisms lie behind processing and accessing compound words as lie behind processing and accessing derived multimorphemic word forms.

The opponents of the sublexical morphological decomposition theory usually argue for a *supralexical morphological decomposition*. The crux of the supralexical arguments is that the early decomposition theory is misaligned with certain empirical findings, such as pseudo-complex words not being decomposed (|rest| not priming |restaurant|). If decomposition did in fact happen before whole word recognition and before any lexical information is extracted from a word, one would predict that any word consisting of a morpheme would be decomposed regardless of it being a pseudo-compound (like |restaurant|) or a real compound (like |restless|). If one has not recognized the whole word representation and lexicality yet, then how can one know that the form |rest-| in |restaurant| is irrelevant, but the form |rest-| in |restless| is relevant? The supralexical approach explains this by saying that the parsing process that is at play in visual word recognition does not actively parse for stems and affixes, but seeks a whole word recognition upfront (Giraudo, Montermini, 2014). After this whole word recognition is carried out, possible morpho-semantic candidates are activated as the stimuli is decomposed further into its constituent morphemes to unify them semantically. All effects morphology would have on visual word recognition would have to be spillover effects from the activation of the morphemes involved: In other words, a supralexical approach would be to say that the Mental Lexicon is organized after a whole word principle in automatic look-up, but morphemes are its atomic units in further processing. The whole word is recognized first, and the computing of the morpho-semantic information contained within the word is prompted subsequent to that (Giraudo & Grainger, 2000; 2001):



(Fig. 1: Two possible conceptualizations of visual word recognition, Giraudo & Grainger, 2000:423)

While the supralexical approach offers a remedy for a problem the sublexical early decomposition model faces, it fails to align with all the empirical data. The idea that whole word recognition and/or lexical access happens before decomposition is challenged by a lot of research done by masked priming, which is a priming paradigm that targets the very early and subconscious visual recognition of words (more on this in chapter 3.3). Especially masked priming LDT research done on pseudo-morphologically-complex words such as |turnip| and |corner| has made it reasonable to doubt the supralexical explanations.

It is shown with consistent replicability (Longtin et al., 2003; Rastle et al., 2004) that |corner| does facilitate its pseudo-morpheme |corn| but |turnip| does not facilitate its pseudo-morpheme |turn|. It is stipulated that this is because the remainder of the word |corner|, |-er| is also a valid morpheme, while the remainder of |turnip|, |-ip| is not. In other words; in an LDT which uses masked priming and shows the participant the word |corner| as a prime, and |CORN| as target stimulus (henceforth denoted as "prime-TARGET") - this significantly decreases the time it takes the participant to decide that the target word |corn|

is a word. Both pseudo-morphemes of |corn-er| are incapable of adding any semantic information on the word |corner|, but subjects attempted to decompose the word nonetheless - which was not true for |turn-ip| even though both |turn-| and |-ip| are similarly incapable of adding any semantic value to the word they compose. The only difference between these two instances - and therefore the only factor we can chalk this difference in participant behavior up to - is that both of the pseudo-morphemes in |corner| exist as valid morphemes in other multimorphemic instances.

The implication of this is that the morphemes of |corn-er| are recognized as being potentially semantically relevant based purely on form, before any semantic processing or information retrieval has happened - a process that is not instantiated when the word cannot be split into two morphemes that are both recognized as being potentially semantically valuable such as |turn-ip|. This suggests that the reason for this is that morphological decomposition had started on the prime, even before any semantic information had been gathered on its constituent parts - supporting the sublexical decomposition theory.

2.1.2 Non-decompositional approaches

Although the evidence to support morphemes as the atomic unit of the Mental Lexicon is impressive, and largely informs the big picture consensus of the field, some are also arguing the non-decompositional case.

One of the earliest versions of this theoretical approach to lexical access and storage came in the form of the *full-listing theory* (Butterworth 1983). In this model, it is argued that all words are listed as whole, atomic units, and that there is no individual level or step of processing which decomposes a word by its morphemes. According to this theory, Taft & Forster's early decompositional model cannot account for the way we recognize opaque multimorphemic words (for example |hogwash| or |honeymoon|). At the very least, Butterworth argues, fully opaque compound words like |hogwash| necessitate another mechanism of word storage and access than a decompositional one, due to the morphological information of the word not being sufficient to construct the wholesale semantic meaning of the compound. Therefore multimorphemic words are listed in whole, just as monomorphemic words are. If we really do morphologically decompose every word we hear, how can it then be that we know what |honeymoon| means? On its face, this seems a banal and oversimplified objection, as one could simply posit that all these types of opaque compound words are listed as whole entities in our lexicon, but it cannot be handwaved away that easily. After all, both words in |honeymoon| are valid, free morphemes, and the CN |honeymoon| is not a pseudo-compound like |restaurant|. It is clear that we see the word |honeymoon| as consisting of two nouns, and that it is not comprised of the semantic properties of them.

This problem, at a minimum, challenges the idea that all words can be morphologically decomposed. If a morphologically complex word exists that cannot be morphologically decomposed, but can be understood all the same - then that must mean that words are listed as whole in our Mental Lexicon, at least as an emergency backup option (or as a preferential first option). In hindsight, it is fair to characterize the Butterworth version of the full-listing argument as too extreme, in the sense that "we either store words as full listings, or we decompose and recompose all words on the spot" is far too binary, and presented as a false choice.

2.1.3 Mixed models and parallel processing

Most current models of lexical access are mixed. The extreme full-listing theory is considered computationally implausible by most (Dominguez et al. 2000), and a more connectionist variant is considered (Plaut & Gonnerman 2000; Seidenberg & McClelland 1989). These models say that the evidence for the morphological effects in LDTs are not individually carried forth by a morphological step in recognition, but is a composite of orthographic, phonological and semantic representations - which is to say that morphemes, as a basic unit, only seems to be affecting reaction times in LDTs, where the real influencers of the decrease in RTs would be a multivariable of orthographic form priming, semantic and associative priming.

Other modifications of the full listing theory suggest that words are the atomic lexical units in the lexicon, but that morphological features can contribute in ease of access

(Carmazza et al. 1998; Rueckl & Raveh, 1999). This approach suggests that even though whole words are what is searched for, there is still room to allow morphology to play an indirect role in access, as the networking between words with similar morphemes is physically or semantically proximal. This proximal networking leads morphemes to “aid” the retrieval of whole words while not being the atomic units of the lexicon. As such, morphemes are best conceptualized as sub-features under the whole word entries that are searched for. On its face, this theoretical explanation resembles a supralexical decomposition approach, but differs in one crucial respect: The supralexical decomposition theory regards morphemes (not words) as the atomic unit of the Mental Lexicon.

In light of evidence, an extreme full decompositional model is also implausible. The partial parsing proposed by Marslen-Wilson et al. (1994) accounts for the fact that whole word look-up simply has to take place under certain conditions by suggesting that; full decomposition is preferred, but lexical items are only stored as morphemes as far as semantic transparency allows for it - accounting for the issues with semantically opaque words and affixes such as |honeymoon| and |-mit|.

While most of the mixed models presuppose that access to a given word has to happen by one of the processes as a first resort, it is not necessarily the case that either of these two routes of access has to be preferred over the other. Some argue that whole word look-up and decomposition are not in exclusive competition; both processes can be computed simultaneously, a proposition that has been supported by computer modelled processing, as well as some lexical decision tasks (McQueen & Cutler, 1998; Frauenfelder & Schreuder, 1992). The more modern discussion regarding lexical access is, in other words, not one of “either full listing or full parsing”, but rather; Is one process attempted serially before the other? If so, which process is attempted first, and in which situations is which mechanism employed first?

2.1.4 Two models of decomposition and access

Even though there are many competing models on lexical access (TRACE, COHORT, Logogen Model), all with their own explanatory strengths and weaknesses, there are two that are of particular interest to the current paper. One is a model of lexical access - the Autonomous Search Model, and the other is a complementary model on the mechanics of morphological decomposition - the APPLE model.

2.1.4.1 The Autonomous Search Model

The Autonomous Search Model (ASM) (Taft & Forster, 1976; Taft, 1979; 1981; 1985) posits that wordsearch happens according to certain stimulus features; phonological, orthographic and semantico-syntactic - and that we do not search for words, but *stems and affixes*. It proposes that stems and affixes are stored in "bins" along these feature paths, and the most frequent stems are on top, with the least frequent ones at the bottom. Words are searched for in these bins until an exact match has been found, and is a serial process rather than a parallel one. The main idea contained in this model is that even single words are searched for by their stem to exactly match a portion of the word, and is then given an affix attachment afterwards (if needed) to fine tune the exact matching. This is to say; as long as a word is morphologically complex it will be decomposed into its constituents, and accessed piecemeal by its stem and affixes to produce an exact match. The onset of the stimulus (both phonological and orthographic) is stated as having an especially important role in the ASM. It accounts for known priming effects as follows; frequency priming effects are explained by general bin organization, repetition priming effects by a temporary reordering of bin organization due to recent encounters, semantic priming effects by cross reference in Mental Lexicon and considers context effects to be post-access.

The most controversial claim in the ASM is that morphological decomposition is applied in all words that can be decomposed; in other words it is the preferred method of achieving lexical access, and this process happens sublexically, in that this is an automatic process that is immediately begun before any semantic information on the individual morphemes has been retrieved, and before whole word lexicality is considered.

The short list approach is not possible in compound words. According to the ASM, the parsing of words such as |henchman| (and any other established compound word) should start by looking for a legal and lexical possible candidate for a first constituent, and then look for at least a legal second constituent.

The Decomposition of HENCHMAN, TRUCERIN and LATCHMUN According to the "First Legal Parse Hypothesis"

	Parse		*Constituent 1*		*Constituent 2*	
	C1	*C2*	*Legal*	*Lexical*	*Legal*	*Lexical*
1.	h	enchman	×	×	×	×
2.	he	nchman	√	√	×	×
3.	hen	chman	√	√	×	×
4.	henc	hman	×	×	×	×
5.	hench	man	√	√	√	√
1.	t	rucerin	×	×	√	×
2.	tr	ucerin	×	×	√	×
3.	tru	cerin	√	×	√	×
4.	truc	erin	√	×	√	×
5.	truce	rin	√	√	√	×
1.	l	atchmun	×	×	√	×
2.	la	tchmun	√	√	×	×
3.	lat	chmun	√	×	×	×
4.	latc	hmun	×	×	×	×
5.	latch	mun	√	√	√	×

(Fig. 2: An algorithmic representation of Taft & Forster's "first legal parse" hypothesis, cf. Libben 1994:373)

So, in the schema represented above, the Automatic Search Model hypothesizes that the first parsed variant of "h-e-n-c-h-m-a-n" that yields three checks in a row is how the word will be decomposed and accessed through its morphemic parts.

2.1.4.2 The APPLE model of decomposition

In the case of established, non-novel compounds such as |henchman|, Taft & Forster's model largely holds up (Libben, 1994). However, one aspect of compound words the ASM does not explain is the possible novelty of compound word formation - and more problematically; compound nouns that are both novel and ambiguous. These are the problems the Automatic Parsing and Lexical Excitation (APPLE) model of morphological decomposition wishes to explain. This particular model confines itself to the parsing process involved when reading morphologically complex words, and should be seen more as a complementary addendum to the ASM than as a detractor of it.

Decomposition Possibilities for Ambiguous Novel Compounds

	Parse		*Constituent 1*		*Constituent 2*	
	C1	*C2*	*Legal*	*Lexical*	*Legal*	*Lexical*
1.	f	eedraft	×	×	√	×
2.	fe	edraft	√	×	√	×
3.	fee	draft	√	√	√	√
4.	feed	raft	√	√	√	√
5.	feedr	aft	×	×	√	×
6.	feedra	ft	√	×	×	×
7.	feedraf	t	√	×	√	√
1.	b	usheater	×	×	√	×
2.	bu	sheater	√	×	√	×
3.	bus	heater	√	√	√	√
4.	bush	eater	√	√	√	√
5.	bushe	ater	√	×	√	×
6.	bushea	ter	√	×	√	×
7.	busheat	er	√	×	√	√
8.	busheate	r	√	×	×	×
1.	s	eathorn	×	×	√	×
2.	se	athorn	√	×	√	×
3.	sea	thorn	√	√	√	√
4.	seat	horn	√	√	√	√
5.	seath	orn	√	×	√	×
6.	seatho	rn	√	×	×	×
7.	seathor	n	√	×	√	√

(Fig. 3: An algorithmic representation of Taft & Forster's "first legal parse" hypothesis extended to novel, ambiguous compound nouns, cf. Libben 1994:373)

In an experiment where participants were asked to pronounce novel ambiguous CNs (like |busheater|, which can be |bus-heater| and |bush-eater|) as they first deem fit, Libben found that there was not a pattern of the first legal parse being the chosen pronunciation. For example, 30 out of 30 participants pronounced |busheater| as /bʊʃˈiːtə/, even though that is according to the ASM algorithm the second legal parse, where /bʌs ˈhiːtə/ should be the first. The second legal parse of ambiguous novel CNs were often accessed first, and thus it had to be concluded that the first legal parse hypothesis was not valid in novel CNs. Furthermore, it also had to be concluded that whichever mechanism parses visual word recognition must do it in a way where all possible morphemes can potentially reach the excitation stage (the stage where a word or morpheme is recognized as being that).

The parsing mechanism in APPLE is described as being “goalless” (Libben, 1994: 383) in that it essentially just scans, rather than searching the input string from left to right. If a morpheme is revealed, that morpheme is used as an excitation of the corresponding mental representation of that morpheme. The recursivity of APPLE enables it to explain how |seathorn| was pronounced /siː θɔːn/ half the time, and /siːthɔːn/ the other half of the time.

```
Procedure APPLE
          Repeat      until all letters of the StimulusString have been used
          Begin
                   Add the next letter of the StimulusString to the TargetString;
                   Allow lexical excitation of the TargetString;
                   If TargetString is lexical then
                      Begin
                             Take the remainder of the StimulusString;
                             If it is legal make it the new StimulusString;
                             Do APPLE;
                      End;
          End.
```

(Fig. 4: the APPLE model of recursive parsing, Libben 1994: 384)

A recursive process ensures that, once decomposition is initiated, all viable morphemes reach excitation. From the lexical and legal excitations, the most viable candidate is accessed (rather than the first legal parse).

> “The basic operation of this procedure is to scan a string from left to right. Thus the word TRUCK would be parsed as T, TR, TRU, TRUC, _TRUCK_. Lexical excitation (indicated here by an underlined string) only occurs on the fifth step of the process. The algorithm performs morphological segmentation through a recursive call to the APPLE procedure. Thus FOOTBALL would be parsed as F, FO, FOO, _FOOT_. At this point, it is assumed that excitation of the representation for FOOT occurs and triggers the recursive call. Now the remainder of the string (BALL) becomes the stimulus string and the APPLE parser starts from that point (e.g. B, BA, BAL, _BALL_). Because of the recursive nature of the algorithm, after the excitation of BALL the parser will

> pop back to continue its original parse and result in the excitation of the whole-word representation for FOOTBALL." (Libben, 1994: 384-385)

The same parsing process is hypothesized by APPLE to be in place when decomposing novel compound words, e.g. B, BU, _BUS_ - H, HE (although valid, APPLE leaves out function words from decomposition), HEA, _HEAT_ - E, _ER_ - pops back to B, BU, BUS, _BUSH_ - E, EA, _EAT_ - E, _ER_. It should be noted that the APPLE model does not account for which of the two |seathorn|s is accessed and why, it simply explains by mechanics how it is possible that one participant accessed |sea-thorn| and another accessed |seat-horn| from the same stimuli. Being a mechanistic model of how morphological decomposition is possible, the APPLE model does not claim to explain when morphological decomposition is instantiated before a whole word look-up or vice versa, and whether the processes are serial or parallel.

2.1.5 Summary and the questions at hand

Historically, two main camps have formed around the question of whether decomposition happens; those that grant decomposition an independent stage in lexical access (i.e viewing morphemes as the atomic unit of the Mental Lexicon), and those that do not. The former of these camps has also split in two, divided between the sublexical and supralexical theories. The sublexical theory posits that parsing of visual stimuli happens with morpheme recognition as a goal in early automatic processing, while the supralexical theory regards whole word recognition and activation to happen before further decomposition is pursued.

The evidence produced has largely shown that morphology is a vital factor in the processing of morphologically complex words - an assumption that is reinforced by neuroimagery, Lexical Decision Task data (both masked and unmasked) as well as meta-analyses (Taft & Forster 1976; Li et al. 2015; Ko, 2011; Goral et al. 2008; Alonso et al., 2016; Cheng, Wang, Perfetti 2011 and Ko, Wang, Kim 2011), and the APPLE model is a comprehensive and plausible explanation for how such a parsing process might occur.

Still, the perspective gained from the non-decompositional vantage point is also instructive, as it highlights that even morphologically complex words will have to be processed like simplex words when they are completely opaque. |Hogwash| seemingly consists of two morphemes, but the evidence shows that we do not treat it like it does. Consciously, we can (after the fact of lexical access) deduce that it is multimorphemic, based on some metaphorical derivation, but we cannot simply look up its constituents and derive its meaning through a full parsing process.

Because of this dual possibility, both of these camps (decomposition vs. non-decomposition) have morphed into mixed models as they have both been forced to accept each other's proposals as possible mechanisms - but the jury is still out regarding which of them (if any) happens before the other:

Whether morphological decomposition happens or not is not the question we currently need to answer; the evidence firmly suggests that it does, and there are plausible mechanistic explanations as to how it happens. What we want to answer is if it is a first resort, which is backed up by a whole listing in case the compound words are too opaque, a second option, one which is only consulted after having tried to look the word up as a whole listing first - or a third option; in parallel with each other in a "first past the post" manner. Furthermore - when decomposition happens, does this morphological decomposition happen sublexically or supralexically?

2.2 Recent research

Given that the current thesis aims to investigate the visual word processing of CNs in L1 and L2 speakers of English through an LDT, it is necessary that we familiarize with what the recent and contemporary data suggests.

2.2.1 Recent research: CN processing in native English speakers

Native processing of complex words has garnered a lot of attention since Taft & Forster (1975) first proposed their findings and models. The most recent science suggests that transparency plays a big role in whether or not a word is morphologically decomposed by native English speakers. Linguistically, the idea of whether or not a compound word is transparent deals with the degree to which a word's semantic value can be directly derived from the compound word's constituents. Typically, one can distinguish between four different degrees or types of transparency (Libben et al. 2001); transparent-transparent; |toothbrush| (TT), transparent-opaque; |shoehorn| (TO), opaque-transparent; |strawberry| (OT) and fully opaque-opaque; |hogwash| (OO). Sandra (1990) conducted a traditional priming LDT with semantically related and unrelated primes matched with full compound nouns as targets, where he compared the RTs of semantically transparent constituents to semantically opaque constituents (i.e. TT death-BIRTHDAY and moon-SUNDAY). Sandra proposed that if recognition of CNs happened through morphological parsing that first activated a compound's constituents, one should be able to observe a semantic priming effect in his experiment. The experiment showed that only transparent CNs resulted in a consistent and significant priming effect. Due to the design of Sandra's experiment (only having TT and OO words), the semantic priming effect seemed to be an all or nothing phenomenon, but many more recent lines of research have shown that a word can be partially transparent (TO / OT) as well (Libben et al. 2001).

The transparency of the heads of the CNs has been thought of as being the most important factor of the degree of morphological decomposition one observes in visual word recognition of CNs (Libben et al. 2001; Jarema et al. 1999). The fact that heads seem to have a larger impact on semantic PEs than other constituents indicates that there is an automatic attempt to locate the head noun, and hinge onto them the sub-constituent nouns. In other words, much of the recent research done on the topic of compound words (and compound nouns in particular) further indicates that there is a morphological component to processing compound nouns. Even if there is clear evidence to suggest that morphological decomposition happens, there would still be doubt regarding the temporal locus of the process. There is recent evidence pointing to that there is a sublexical morphological component to visual word recognition (Li et al., 2015).

2.2.2 Recent research: CN processing in L2 English speakers

What the current paper is concerned with, is what the differences are (if any) between the way a native English speaker would process CNs, and the way in which an L2 English speaker would. We have already looked at the evidence suggesting that L1 speakers of English employ morphological decomposition in visual word recognition, and the evidence to that effect is convincing for derived word forms and transparent CNs, but largely inconclusive with regards to opaque and novel CNs. However, the issue regarding whether or not L2 English speakers behave similarly is unclear. This subchapter will represent some recent research which might suggest what the present paper might find. We begin by looking at a general backdrop of studies, and continue by going in-depth with two studies that are the most similar to the experimental design this thesis conducts.

2.2.2.1 General backdrop

Ko (2011) conducted two within-language prime-target pairs (not cross-linguistic) in a masked LDT, using native Korean-English bilinguals - Korean being their L1. One of the experiments used Korean compound words as targets, with its constituents as primes. The other used English compound words as targets, with its constituents as primes. What was suggested by these experiments was that the subjects showed clear tendencies of morphologically decomposing their L1 with both constituents of the CN activating the CN itself, but no tendency to decompose their L2.

Goral et al. (2008) found similar results when doing the same experimental design on Hebrew-English bilinguals (who had never lived in an English speaking country) in an unmasked LDT. Their processing of L1 compound words showed consistent signs of morphological decomposition, independent of form-priming, while their L2 processing showed none.

Although these papers have recorded no significant morphological decomposition in L2 speakers of English, there is evidence to suggest that the degree of proficiency in their L2 English can affect this. Several studies have shown that morphological decomposition can be observed to increase proportionally with the proficiency of the L2 English speaker (Wang

2010, cf. Uygen & Gürel 2017:93; Alonso 2016a). Moreover, there is considerable empirical data indicating that the frequency of the languages a bilingual or trilingual speaks heavily affects their degree of morphological decomposition in their L2 and L3 (Alonso et al. 2016a). This indicates that the morphological properties of one's L1 can affect the way by which your L2 is processed in visual word recognition.

A relatively restricted amount of research has also been done on the issue by utilizing cross-linguistic experimental designs. Such studies have by and large produced empirical data to the effect of showing that L2 English speakers decomposed CNs into constituent parts (Cheng, Wang & Perfetti, 2011 using Chinese-English bilingual children; Ko, Wang & Kim, 2011 using adult Korean-English bilinguals, cf. Li et al. 2015:4).

2.2.2.2 Ugyun & Gürel (2017)

Uygen & Gürel (2017) conducted a masked LDT experiment on L2 English speakers with an aim to investigate the degree to which they morphologically decompose compound words, as well as the impact of headedness on lexical processing. Along with all other papers mentioned thus far in this subchapter, Uygen & Gürel used the compound words as targets, and their constituents as primes (tooth-TOOTHBRUSH), and included a transparent-transparent (TT) category, as well as a "partially opaque" (PO) category (which combines TO and OT CNs into a single category), the latter being designed to investigate the headedness issue. A pseudo-compound category was also included, which investigated words such as |restaurant| primed by its pseudo-morpheme |rest| to see how much of an effect the pure form-priming of seeing the orthographic string |rest| twice affected RTs. Additionally, there was a category dedicated entirely to monomorphemic words such as |crocodile|.

The paper hypothesized that compound words would be subject to morphological parsing, suggested by the decompositional theoretical perspective. They also predicted that polysyllabic monomorphemic words would be more difficult to recognize and access than TT compound nouns would, which is suggested by the APPLE model (Libben 1998). Further, the paper predicts that only morphemic constituents would be effective as primes to increase the overall processing speed of a compound (and not pseudo-morphemes like |rest-| in |restaurant|), and that semantic transparency (TT vs. PO) along with headedness would not affect these decompositional processing routes. With regards to the differences between L1 Turkish L2 English speakers and native English speakers, they predicted that the orthographic and grammatical similarities between Turkish and English to work in the L1 Turkish L2 English speakers' favor. Because of this, they predicted differences (Ugyin & Gürel, 2017:94) between the groups, but that an approximation of native-like decomposition route would likely be observed in the advanced proficiency group of the Turkish L1 English L2 subjects.

In analysis they found that their hypothesis regarding the APPLE model prediction held water. All participants showed clear tendencies to process CNs of all types (both PO and TT) significantly faster than monomorphemic words. Native speakers, in accord with predictions, were faster in all categories than the L2 English speakers. Furthermore, they found that all participants processed partially opaque compound words significantly faster than they processed fully semantically transparent words. All participants processed the compounds through morphological decomposition regardless of semantic transparency, signified by there not being a significant interaction between word type and prime type (Uygun & Gürel, 2017:97: Table 5). Finally, by comparing monomorphemic words to pseudo-compounds, they found reason to suggest that intermediate L2 English speakers attempted to process both of these word types in a decompositional fashion, but that advanced L2 English speakers showed similar tendencies to those of native English speakers. Native speakers recognized compounds much faster than non-compounds, and in recognition of CNs both constituents were activated, which reinforces what earlier studies on native English speakers suggested (Fiorentino & Poeppel, 2007; Ji et al., 2011; Fiorentino et al. 2014, cf. Uygun & Gürel, 2017).

There were, however, marked differences between low-proficiency L2 English speakers and native English speakers in that native speakers showed that both constituents of the CN were activated as primes, while intermediate L2 English speakers only showed activation of one. This difference disappeared as the proficiency level of the L2 English speaker increased. The advanced L2 English speakers and the native speakers did not show a significant difference in processing behavior. Because of this, they posited that a native-like morphological decomposition is attainable in L2 English speakers with increasing proficiency, as the most advanced L2 English speakers did demonstrate native-like decompositional behaviors. What was not clear by virtue of the experimental design (the CNs being targets and not primes) was whether the decomposition effect they recorded was sublexical or supralexical.

2.2.2.3 Li, Gor, Jiang. (2015)

The most relevant piece of experimental research done in relation to the present study is a masked LDT conducted by Li et al. (2015). In their study, the prime-target design was a variant where the full CN was the prime, while its constituents were used as targets, in order to target the early automatic processing of the CNs. Their subjects were L1 Mandarin Chinese speakers and L2 English speakers. The materials of the study included established CNs like |toothbrush| along with their constituents as targets with unrelated controls, along with a pseudo-compound control category which would control for orthographic form priming. The CNs were distributed into transparency levels; TT, TO, OT, OO. The experiment was conducted on Mandarin Chinese L1 English L2 speakers as well as native English speakers.

In the word-initial category for native English speakers (experiment 1a), there was a significant and statistically equivalent facilitative masked priming effect in both semantically transparent and opaque words - and no priming effect was observed in the pseudo-compound category, with stimuli like |restaurant-REST| (Li et al., 2015:9: Table 5). The role of semantic transparency with regards to the magnitude of the priming effect was investigated (interfacing Prime Type OO/TT and Prime Relatedness), and it failed to reach significance. The correlation between Prime Type-Accuracy and Relatedness-Accuracy was also shown to be insignificant. The category investigating the priming of the word-final position in native speakers (experiment 1b) showed robust and significant priming effects of the word-final position, much like what had been shown regarding the word-initial position in 1a. Again, the orthographic control of the pseudo-compounds showed no significant priming effect, and there was no correlation between semantic transparency of the prime and the magnitude of the PE (Li et al. 2015:10: Table 6). Experiments 1a and 1b replicated the findings of Fiorentino & Fund-Reznicek (2009), and were aligned with the hypothesis of the experiment. This, according to the researchers, provided "*converging evidence for a fast automatic sublexical morpho-orthographic decomposition mechanism independent of semantic transparency in native processing of compounds.*" (Li et al. 2015:10).

Experiments 2a and 2b conducted the same experiments on Chinese L1 English L2 speakers. What they found in the word-initial experiment (2a) was that once more, by relating Prime Type and Relatedness, there was no significant PE magnitude difference between transparent and opaque CNs. In contrast to NSs, there was a significant effect shown in Prime Type-Accuracy and Relatedness-Accuracy (in Chinese L2 English speakers. Also in contrast to native English speakers, Chinese L2 English speakers showed a significant priming effect in orthographic control items, the pseudo-compound category (i.e. there was a priming effect in manipulations like |restaurant-REST| where there were none in experiments 1a and 1b). Experiment 2b showed no significant relationship between Prime Type and Relatedness as it pertained to semantic transparency. However, the accuracy results showed a significant main effect of Relatedness, with accuracy increasing when the target words were preceded by a related prime - while Prime Type showed no significance. 2b elicited "*significant and statistically equivalent masked priming in the transparent and opaque compound conditions and no priming in the orthographic overlap condition*" (Li et al. 2015:12). The findings of experiment 2a and 2b aligned with the hypothetical presumptions based on Fiorentino & Fund-Reznicek (2009), and supported the idea that the same automatic mechanism that underlies native processing also underlies the processing of advanced L2 speakers of English:

> "The present results provide new evidence from compound processing that fast and automatic segmentation of compound words that is entirely driven by the analysis of orthography operates not only in L1 processing, but also in L2 processing in advanced learners. The findings lend support to the sublexical

> morpho-orthographic decomposition model of complex word processing, run counter to the supra-lexical morpho-semantic model, and do not provide support for the hybrid model in which both sublexical and supralexical representation and processing are assumed." (Li et al. 2015:15)

2.2.3 Summary

All of the previous and recent research represented in this chapter shows that the hypothesis of morphological decomposition consistently holds up in studies of native English speakers, but show varying degrees of decomposition in L2 English speakers - a degree that seems to gain intensity the more proficient the L2 English speaker is, and in concordance with how frequently the L2 English is in use. This implies that the same mechanism of visual word recognition and processing applies in L2 speakers as in L1 speakers, and that this mechanism can be learned with proficiency and frequency. The Li et al. experimental design (CNs as primes and constituents as targets) lends itself to suggest that morphological decomposition is in fact a sublexical process and not a supralexical one.

It is interesting to note that none of these studies have compared Germanic L1 speakers' L2 processing. In Li et al. (2015) it is Chinese L1 and English L2, in Uygen & Gürel (2017) it is Turkish L1 and English L2, in Ko (2011) it is Korean L1 and English L2, in Alonso (2011) it is Spanish L1 and English L2 / Spanish L1, Basque L2 and English L3, and in Goral et al (2008) it is Hebrew L1 and English L2.

Another curious convergence of the data is that L2 decomposition seems to be a more expressed behavioral tendency in participants who speak languages that typically portray a transparent morphology - isolating, analytic or agglutinative - like Turkish, Korean and Mandarin as L1s, but is not found to the same degree in participants that speak more morphologically opaque, fusional languages like Hebrew (Zuckermann, Ghil'ad, 2009). While the combinatory nature of more transparent languages inherently propose novel word formations with high degrees of syntactic transparency - where the morphemes of the word formation are obvious in their functions - modern Hebrew is much less transparent in its constructions (Bauer, 2005:329).

In the context of the current thesis, this distinction is possibly relevant, and certainly very interesting; a language's morphological nature affects its word formation rules (Dressler, 2007:171), and it stands to reason that languages with a morphology which is more combinatory and transparent would make its readers more prone to using decomposition processing - and it seems the data suggests that your L1 productivity and morphology characteristics influence the way you process compound nouns in your L2 English.

2.3 Research questions

Based on the theory and research presented throughout chapter 2, the current thesis will address two research questions. 2.3.1 and 2.3.2 are basic descriptors of the inquiries the current thesis attempts to further. They will be revisited in 4.1.6, after the methodology chapters, to explain how my specific experimental design and methodological choices answer them.

2.3.1 Research question 1

Part of research question 1 is a contribution to an already existing literature and ongoing discussion on whether morphological decomposition is an observable phenomenon in the first place. Put simply; to what extent does my experimental data provide evidence that Norwegian L2 English speakers and/or native English speakers morphologically decompose orthographically contiguous and established CNs like |toothbrush| in early automatic processing of established CNs?

Is there a difference in the degree to which they morphologically decompose, and if so - does this difference imply a difference in automatic expectation in response to an orthographically contiguous CN between the subject groups?

2.3.2 Research question 2

The second research question is a more novel inquiry of this thesis; do Norwegian L2 English speakers and/or native English speakers display a difference in the way they respond when stimulated with a completely novel, first-encounter orthographically contiguous CN like |groundlord| compared to the way they respond to established CNs? And is there a "difference in the difference" between my two subject groups? Is there a decomposition in novel, first encounter CNs to imply that the decomposition is a sublexical phenomenon?

If there are differences between the categories, and "differences in the differences" between my subject groups, what does that imply regarding when and how morphological decomposition occurs versus when a whole listing-approach occurs? Is morphological decomposition the first mechanism to be employed or is a whole word-lookup the first - or are both of them active in parallel? Most interestingly; is there a difference between my subject groups in this regard?

3 Methodological theory

3.1 The Lexical Decision Task and priming

The main assumption underlying this experimental method is that the prime can affect the speed at which the target decision is made, and that this increase in decision speed can imply something regarding word storage, word recognition and semantic memory, or the relationship between prime and target on at least one level of representation. If the prime is related to the target in semantic proximity; |hard-DIFFICULT|, categorical proximity; |dog-CAT| or form; |cat-CAT|, the RTs of the decisions decrease relative to the same words in an unprimed context. The researcher can then manipulate the relationships between primes and targets and see how RTs behave in comparison to the manipulations made. The decrease or increase in RTs can then give us valuable data to help determine how our Mental Lexicon functions.

The RT of any given decision or entry in the experiment is the time it takes from the moment the word appears on the participant's screen to the decision of whether or not it is a word has been made. The PE is the effect at the center of the prime-target LDT experimental methodology, and is defined as the difference in RT between a unprimed response to a word, and a primed response to that same word. If one is interested in looking at how much of a priming effect we will produce with |toothbrush-TOOTH|, one also needs the data on the RT to deciding on |TOOTH| when it is not preceded by a prime that is thought to reduce it. After having both of those numbers (in means across as many participants as possible) one can contrast the two and see how much quicker one responds to |TOOTH| when it is preceded by |toothbrush| than when it is preceded by an unrelated word like |waterfall| - this is the PE.

In its original incarnations (Meyer, Schvaneveldt, 1971; Schvaneveldt, Meyer, 1973; Meyer, Schvaneveldt, Ruddy, 1975), the LDT showed the prime word for an extensive enough span of time for the subject to fully read and comprehend the prime in a conscious manner, followed by the target word. The source of this unmasked paradigm's strengths and weaknesses lies in that subjects gain conscious lexical access to the prime before the target is presented. When full lexical access has been achieved to the prime word, the reduction in RT in deciding on the target word will have implications on how the Mental Lexicon is organized. If the decision on |DOG| is significantly faster after having been primed by a prolonged showing of |cat| (compared to an unrelated prime), then that will imply that the routing to access |DOG| either follows along similar cognitive paths as |cat|, or that they are stored proximally to a degree where spreading activation occurs. This traditional Lexical Decision Task priming paradigm is often referred to as “unmasked priming”. This paradigm has done a lot for our understanding of the cognitive processes behind visual word recognition and lexical access, but when one speaks of sublexical and supralexical decomposition, the unmasked paradigm is uninstructive in distinguishing between the two. Furthermore, there are many criticisms of the unmasked paradigm regarding potential strategy effects, both conscious and subconscious, having a marked effect on the participant responses (more on this in 3.2). The alternative to the traditional paradigm of priming comes from the masked priming paradigm.

3.2 On the masked priming paradigm

My experiment utilizes a masked priming method, where the prime word is masked behind hash symbols, which is then very rapidly followed by a target word (######### - toothbrush - TOOTH). The prime is shown for such a short span of time that the participants do not gain conscious lexical access to it (Forster & Davis, 1984:683), which is largely seen to limit the effects from a potential supralexical whole word recognition dependent decomposition. In this chapter, I lay forth an argument to motivate the use of a masked paradigm over an unmasked one.

One of the surprising findings during the early research done with masked priming was that overlapping orthography (mother-brother) did not facilitate priming in unmasked experiments, but did so in masked variants (Colombo, 1986; Martin & Jensen, 1988 cf. Kinoshita & Lupker 2003). This suggests that masked priming taps into a very early portion of word recognition that does not linger in visible unmasked priming. While some have argued that masked priming only facilitates pure formal, orthographic and sublexical priming between the prime and the target, there is strong evidence to suggest that there is a ortho-morphological and semantic effect involved as well. When a clear priming effect is shown between non-cognate translation-equivalent words of languages with different scripts, like Hebrew and English (Gollan, Forster, Frost, 1997 cf. Forster 1998), or Mandarin and English (Jiang, 1997, cf. Forster 1998), one cannot assert that priming is a purely formal effect between prime and target.

As shown by Posner and Snyder (1975), if the prime in an unmasked experiment leads to a strong expectancy for the target, that is bound to lead to a facilitation of expected targets and an inhibition of unexpected targets. Experimental evidence suggests that a masked paradigm eliminates at least some of the unwanted effects that come as a consequence of expectancy (Forster, 1998).

In an unmasked experiment, one is at risk of producing unwanted priming effects as a consequence of letter repetition and/or onset likeness in primes and targets throughout the experiment. Relying on the law of large numbers to even out the mean values to the point of insignificance is one way to deal with this. However, the masked paradigm seems to deal with this issue more reliably: Over the span of 6 experiments on repetition priming with masked primes, Forster & Davis (1984; Experiment 1, 2, 4 & 5) discovered that graphemic overlap had little impact on decision times, and frequency attenuation (how long the possibility of a repetition priming effect lingers) was lower in masked priming than in unmasked priming. They argue that masked priming is less likely to cause data distortion by repetition priming, as masked primes are not cognitively represented as episodic memories (i.e cannot be consciously remembered).

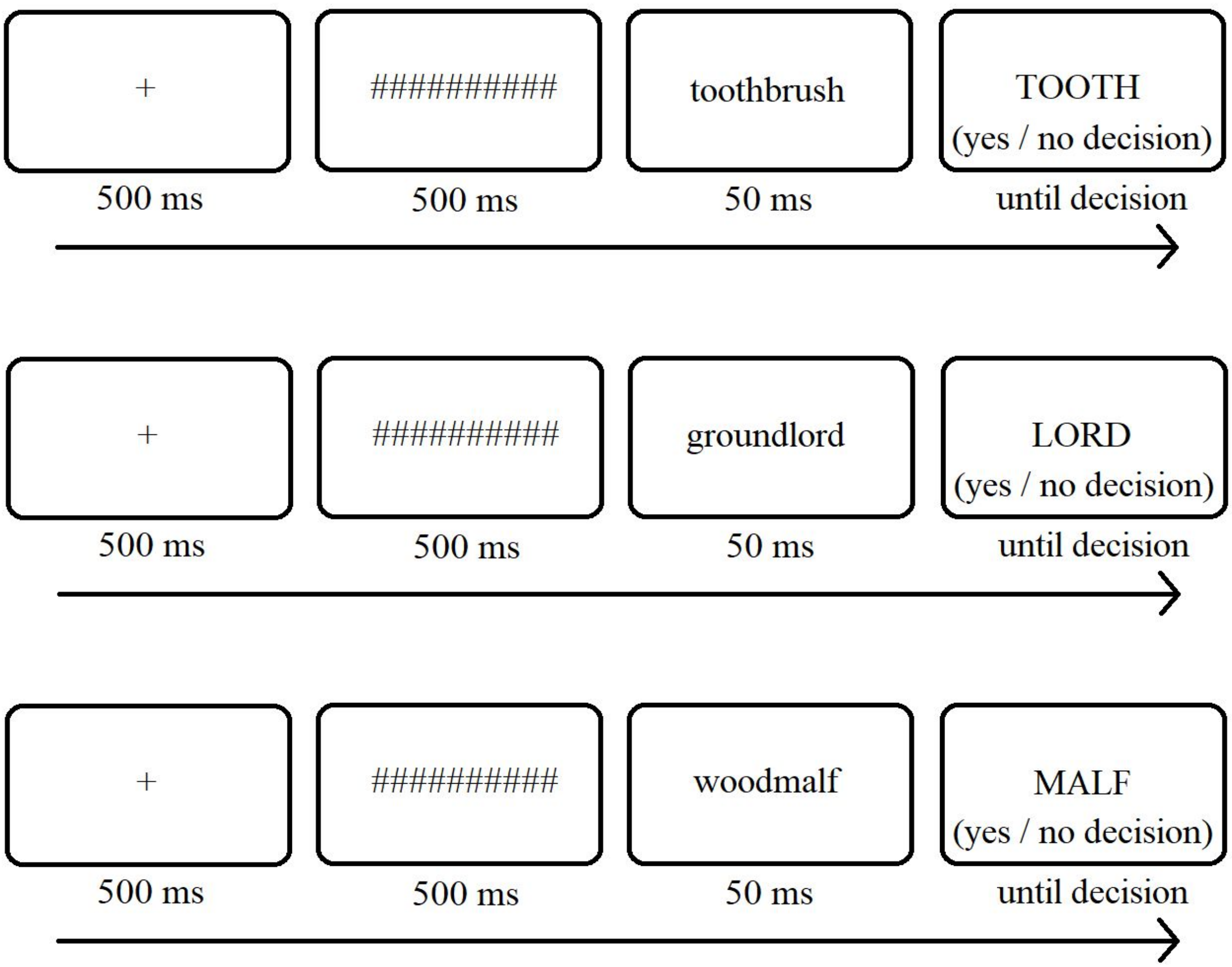
An unmasked paradigm runs the risk of unwanted semantic priming happening between primes and targets from different entries of the experiment. While participant 1 does not have any associative connection between |rain| and |cabin|, participant 2 might. If participant 1 encounters |rain-CLOUD| and |cabin-WOOD| right after each other, there could be a lingering and unforeseen semantic priming effect between the primes of two different entries of the experiment - which is typically only corrected for by flattening the data with as many randomly sequenced observations as possible. A masked paradigm offers a partial solution to this by effectively halving the amount of words that can semantically prime each other. Masked priming achieves this in that the masked primes are not accessed, in addition to there not being an episodic memory stored on the encounter of any given primes in a masked paradigm (Forster, Davis, 1984). This halving is important; if there is an experiment with only four words |cat-ANIMAL|, |dog-FRIEND|, there is a total of 6 unique possible interactions. If we double the amount of words to eight, there is a total of 28 possible interactions. The relationship between words in the experiment (n) and possible unwanted priming effects (y) is therefore quadratic (y=n(n-1)/2), meaning that a halving in total number of words is much more than a halving in total number of possible unwanted semantic interactions.

The idea behind the masking paradigm is: When the human cognition is stimulated with a written word, a recognition process begins. When the process of lexical processing is aborted after 50 ms and interrupted with a new word to recognize and gain access to, you never finish accessing the first word - but only reach the sublexical “entry opening” stage (Forster, 1998). If, however, there is an overlap in the cognitive activity required to access the first word, and the word that interrupts the accessing process of that word, one would expect there to be a decrease in RT for the second word - simply because there is a spillover effect between the sublexical cognitive activity required to access the prime and the target. In other words; the masked priming paradigm targets a subconscious, automatic recognition process with morpho-orthographic and morpho-semantic facilitation, rather than the post-lexical access process the unmasked paradigm targets.

4 Methodological application and hypotheses

4.1 Experimental design

Before the test begins, the L2 participants were asked to confirm Norwegian as their L1, and report proficiency in English as their L2. The native English speakers were asked to confirm that English was their native language. Following the questionnaire, there is an introductory text describing that their task is to decide on whether or not what they see on their screen is a real English word, and that they should aim to do this *as fast and as accurately as possible*. The task involves the subject being presented with a fixation cross for 500 ms to fixate one's vision on, followed by a masking for 500 ms, then the masking is unmasked for 50 ms revealing a prime, followed by the instance where the subject is asked to answer "yes" or "no" to whether a target word is a real word or not. An example:



The primes and targets are divided into two general categories (will be discussed in 4.0), along with a control category. In total, the test consists of 400 decisions, where half are controls with non-word targets which demand a “no” answer, and the other half are decisions with real word targets. “Yes” answers are given with the participant’s left hand, and “no” answers are answered with their right hand. A list containing all of the stimuli used in the experiment is added as an addendum (addendum 1).

Most LDTs use the word that they are interested in researching as their target word. So, in most LDTs that have been done on the topic of CNs, the primes have been constituents of the CN, and the target has been the CN itself, for example: |tooth-TOOTHBRUSH|, making the participant decide yes/no to the CN. By doing this, they could measure the PE of the first and second constituents had on the target, and by that merit say something about the way the processing of |TOOTHBRUSH| happens (Ko 2011, Goral et al. 2008, and Ugyin & Gürel 2017 are all examples of this).

This method would severely limit me, in at least two ways: First of all, there is a finite number of established, orthographically contiguous CNs in the English (written) language, and some of them are very low in frequency. A Norwegian participant contacting the word “paperback” would not be guaranteed to recognize it as an established CN at all, and the same would be the case with many of the CNs in the test. Second, having the CN itself be the target of the LDT was ruled out, since a Norwegian asked to respond to a novel compound in English (such as |lordcolor|) would be confused. On the one hand, novel CNs are usually not orthographically contiguous in English - and by that logic, one might be tempted to answer; no, it is not a word. On the other hand, the noun as a word class is open and infinitely productive, so there is every reason to see the word |lordcolor| and think that it is a completely valid word, say, in a fantasy setting where dressing in purple was referred to as being “dressed in lordcolor”. In Norwegian, “herskapsfarge”, “adelsfarge” or “herrefarge” would be valid novel CNs, but in English these novel CNs need to be split to accord with the orthographic norms of the language - or they run the risk of not being recognized as a compound noun at all.

With my research questions being what they are, it became clear that the CNs could not be the targets of the LDT, but they could be the primes, as in Li et al. (2015). If the CNs are the primes and its constituents are the targets, the participant does not have to take a stance on the validity of the CN itself, but only inadvertently reveal to us how they look at CNs by deciding on its two constituent nouns. Another benefit from this design is that it isolates and targets the early automatic processing of a CN in a more direct way than if one would use the full CNs as targets. When the CN is represented in a masked prime, one ensures that the subject does not consciously process it, and thus one can guarantee that any data one gathers on the processing of these primes are all in the early, prelexical stages of access (Li et al. 2011:5).

Seeing as the frequency of a word has a significant effect on the RT of its decision, all of the materials described have been run through the SubtLex corpus in search of statistical outliers in terms of frequency. A frequency index is added as an addendum (addendum 2)

4.1.1 Materials

The research questions asked requires the investigation and manipulation of three factors, and therefore the materials used are the product of a 2x2x2 factorial design, with compound type (+/-Establishment), constituent (Constituent 1 / 2) and Priming (+/-Priming) as the manipulated factors. Both subject groups were subjected to the same materials. All CN materials were semantically transparent-transparent. The following table (table 1) illustrates my factorial setup for the experiment:

2x2x2 Factorial design of the experiment

CompoundType	+/- Priming	Constituent1/2	**Prime Word**	**Target Word**
established	*primed*	*C1*	toothbrush	TOOTH
established	*primed*	*C2*	toothbrush	BRUSH
established	*unprimed*	*C1*	waterfall	TOOTH
established	*unprimed*	*C2*	waterfall	BRUSH
novel	*primed*	*C1*	groundlord	GROUND
novel	*primed*	*C2*	groundlord	LORD
novel	*unprimed*	*C1*	lakegate	GROUND
novel	*unprimed*	*C2*	lakegate	LORD

(Table 1; Factorial design of the experiment)

The “CompoundType” variable manipulates for whether or not the CN shown as the prime word is an established CN or a novel one. The “+/- Priming” variable manipulated whether the target word is preceded by a related or an unrelated CN (i.e. whether the target word is a constituent of the prime or not). “Constituent1/2” manipulates which constituent of the related CN primes (here; |toothbrush| and |groundlord|) the target is. In addition to these variables, the control category includes compoundlike nonwords as primes and their non-word constituents as targets (i.e |rifsnar-SNAR| and |woodmalf-MALF|). Half of the decisions made were on the control category, and half of them were on the conditions of interest. The materials consist of 100 established compound type items, 100 novel compound type items and 200 nonword control items. In other words, each subject reports on 25 instances of each possible condition.

This factorial design allows us to look at binary manipulations of all the relevant factors involved to answer the research questions; if there is a PE in both constituents C1/C2 (a lower RT in primed targets than unprimed targets) in both compound types established/novel, then this indicates that an automatic parsing is instantiated when contacting a CN. The degree to which and the significance with which this PE occurs, to which constituent it happens, along with the type(s) of compounds it happens to will grant evidentiary grounds to say whether or not a morphological decomposition happens in the subject groups.

The main division of these materials regards compound type, and it is this variable that constitutes the main comparison of interest across the two subject groups. Therefore the rest of the thesis will refer to the materials as being divided into an “established CN category” and a “novel CN category”.

4.1.2 The form priming issue

Originally, my experiment was set to include a fourth category of pseudo-compound primes and their free morphemes as targets; |restaurant-REST|. The fact that seeing a word twice will reduce the RT of the decision is a well documented psychological effect, often referred to as form priming. While a control for how much of the priming effect is formal would have been interesting, it would add unnecessary fatigue in participants (increasing decisions from 400 to 500). Having piloted the experiment on friends and family members, it was obvious that 400 decisions was already approaching their fatigue thresholds. This category was therefore cut, and here is why that cut could be made without affecting the evidentiary quality of my observations:

Even if we record a repetition priming effect along with a semantico-syntactic decomposition effect, we are still gaining information on whether or not the word is morpho-orthographically parsed into distinct forms. A repetition priming effect of a constituent of a CN the participant has flashed on a screen in front of them for 50 ms is indication that decomposition is in process. If a participant seeing the prime word |waterfall| expresses a priming effect when deciding on |WATER| - it is not the case that this priming effect’s usefulness is dependent on whether it is semantic or formal: If |waterfall| primes |WATER| on a formal level, that still implies that the prime |waterfall| has been decomposed to the effect that |water| was separated from |fall| and not |wat| from |erfall|.

The difference between semantic priming and formal repetition priming, in this instance, would rather be; are the CNs decomposed into separate semantic morphemes or separate orthographic morphemes? No matter which of these it is, we can use the priming effect to show that a decomposition process has begun in early automatic processing - on either a formal level or a semantic level - both of which being necessary elements in decomposing a word to unify its constituents after (Rastle, Davis 2008). Even if we assume the "worst" case scenario of the entire effect recorded being solely formal repetition priming, it would still imply a morpho-orthographic or semantic recognition of the morpheme that is repeated.

If we use CNs as primes, and constituents as targets (which the current experiment does) and |waterfall| primes |WATER|, this implies that a certain attention has been given to the exact morpho-orthographic item |water| in the prime, showing decomposition. However, if |water| primes |WATERFALL|, we could not say the same - seeing as in the latter example the prime is fully a part of the target stimulus, while in my experiment only parts of the prime is in the target stimulus. Let us look at meaning and unification of in a non-linguistic domain to fully explain this distinction: If you subconsciously start processing an image of a garden, and respond quicker to an image of a flower that was in that garden, you simply must have been able to "see the garden for the flowers". However, in a flipped instance, subconsciously seeing a flower and responding faster to an image of a garden does not guarantee the same *de*compositional process. A benefit of my experimental design is that the numbers are meaningful regardless of how much of the PE is repetition priming or semantic.

4.1.3 How does the design answer the research questions?

The established CN category will indicate how the subject groups behave as a default when contacting a CN, while the novel CN category will show how their automatic responses change or persist when the CN is a first encounter, and will imply whether the decomposition is sublexical or supralexical.

The magnitude of the change in Priming Effect from the established CN category to the novel CN category will indicate to which degree morphological decomposition is the first or the second process to begin in automatic processing. As shown in 2.2, one expects an L2 speaker of any language to decompose less intensely than a native speaker of that given language (Li et al. 2015; Wang 2010, cf. Uygen & Gürel 2017:93; Alonso 2016a). Therefore one has to look at the consistency of the decomposition (i.e. the consistency of the PE) between the categories. If the PE is consistent between the categories in Norwegian L2 English speakers, but a change is more drastic between the categories in native English speakers (meaning they show a greater PE of constituents when prompted with |groundlord| than with |waterfall|), that indicates that native English speakers' automatic response to an orthographically contiguous CN is to look for it as a whole listing first, and decompose it if whole word-lookup fails. If the PE is consistent and similar between the categories (meaning they show the same response to |waterfall| as to |groundlord|) in Norwegian L2 English speakers, that implies that their automatic response to an orthographically contiguous CN is to forego whole word-lookup and automatically respond to orthographically contiguous CNs as needing decomposition regardless of novelty.

If one subject group's RTs increase more between the categories than the other group, that implies that the group with the most drastic increase spends more time trying to look up the novel CN as a whole listing before resorting to morphological decomposition. One important clarification here is that the time spent looking for the novel CN as a whole listing is bottlenecked by both subject groups being stimulated by the CN for identical 50ms priming windows, but the presumption is that more computation spent decomposing in that window equals a more noticeable PE.

If one subject group's PE is consistent from the established category to the novel category, that indicates that group responding with the same automatic process regardless of a CNs novelty. If a group's PE is drastically increased between the categories, that gives reason to believe that the subject group can process established CNs like |waterfall| without morphological decomposition, but that it resorts to decomposition when whole listing lookup cannot be achieved. If the mechanisms of whole word-lookup and morphological decomposition are happening in parallel, one would expect the PE to be consistent across categories (as decomposition would always be in process for the same amount of time), while if they happen serially we would see a PE in cases where morphological decomposition is employed, and a lack of PE in situations where a whole listing-lookup is employed.

4.2 Hypotheses

First of all, I predict that the experiment is able to yield an observable and significant PE in some or all categories. This prediction, should it hold, would add converging evidence that morphological decomposition is a real and observable phenomenon.

Regarding the first research question; I hypothesize that Norwegian L2 English speakers will show a larger PE than native English speakers due to there being a difference in subconscious expectation between the groups when stimulated with longer strings of letters like CNs. One might see that native English speakers who subconsciously start the process of accessing CNs expect a contiguous orthographic entity to be accessible through a whole listing in the Mental Lexicon, seeing as established CNs are marked by contiguous orthography in English (and thus have been conditioned to expect the ability to shortcut the process of access without decomposing the word). This expectation is reversed in native speakers of Norwegian, due to a longer string of contiguous orthography in Norwegian often being a marker of a first encounter - or at least not being a marker of an established CN. This hypothesis is based on the anecdotally obvious and statistically proven differences between the two languages' word formation rules, and norms regarding productivity in compound nouns (Baayen & Lieber, 1991; Baayen, 1992; Baayen & Renouf, 1996; Baayen, 2011), the fact that different languages seem to ready its users for different processing methods (Kim, Wang, Taft, 2015) and previous research indicating that L1 characteristics might influence L2 processing (Uygen & Gürel 2017).

If we expect native English speakers to respond to CNs by attempting to access them as whole listings, we must also expect that they automatically focalize one of the constituents/one part of the orthography as their access reference. The reason I expect the focalized CN constituent to be constituent 1 is that empirical data suggests that first constituents of morphologically complex words are utilized more in lexical access in native speakers than second constituents are (Taft & Forster 1975; Taft, 1991), and because most parsing models propose a left-to-right scan or search of the stimuli (including ASM and APPLE, Libben, 1994, Taft & Forster, 1976; Taft, 1979; 1981; 1985).

Regarding the second research question; I hypothesize that a PE will be observed in the novel CN category in one or both groups. This prediction is founded in recent empirical research on the topic (Li et al., 2015). If this novel CN PE is found, it implies that the decomposition phenomenon happens sublexically by morpho-orthographic parsing prior to whole word recognition.

Further, I expect a more consistent decomposition effect (i.e. more consistent PE) between the categories in Norwegians due to an automatic response of recording a CN's contiguous orthography and expecting the need to decompose it. Inversely, I hypothesize a more dramatically increased decomposition effect between the categories (i.e. an increase in PE from established to novel) in native speakers of English. These expectations are again founded in the statistical novel word formation rules, and productivity differences the two languages possess (Dressler, 2007; Baayen & Lieber, 1991; Baayen, 1992; Baayen & Renouf, 1996; Baayen, 2011) as well as previous research suggesting L1 characteristics might influence L2 processing (Uygen & Gürel 2017).

Concerning the possibility of a parallel processor: If my participants show an in-group equivalent PE in both constituents across both stimulus categories without an increase in RTs, this would imply that a parallel processor is in play, wherein morphological decomposition and whole word look-up can be processed simultaneously. Based on (and mentioned in) my other hypotheses, the orthographic and normative differences between my participants' native languages (Baayen & Lieber, 1991; Baayen, 1992; Baayen & Renouf, 1996; Baayen, 2011), different languages making its users employ different processing methods (Kim, Wang, Taft, 2015), implications of one's first language affecting L2 processing (Uygen & Gürel 2017) as well as few previous masked LDTs having produced results to that effect in the past, I do not expect to find evidence for a parallel processor which runs a decomposition process simultaneously with a whole word look-up.

5 Data: Exclusion criteria, results and analyses

A total of 55 Norwegian L2 English speakers participated in the experiment, of whom two participants' data was excluded due to them reporting Norwegian as not being their native language. A total of 29 native English speakers participated. All Norwegian participants were asked to provide some basic information about the amount of English media they consumed, along with a self categorization of proficiency on a scale from 1-10. All responses <300 ms and >1500 ms were excluded from the dataset, along with any incorrect answers. These exclusion criteria were chosen to be in line with the Li et al. (2015) study which is the only previous study cited in this thesis that has a similar prime-target design as my experiment. The resulting Norwegian dataset consisted of 9867 (out of 11054 possible; 89%) observations across all conditions, and the native English speaking dataset consisted of 5618 (out of 5879 possible; 95.5%) observations across all conditions. In terms of proficiency, my Norwegian L2 English speaking participants were heavily skewed towards the high end of the proficiency spectrum, with only 4 out of 53 participants self reporting as being <=6, and 44 out of 53 participant self reporting as >=8. The accuracy rates of the subject groups were as follows;

Accuracy; Norwegian L2 English speakers

	# Wrong	# Total	% Accuracy	Mean RT on corr
Nonwords	*902*	*11273*	*92%*	*923 ms*
Real words	*198*	*11054*	*98.3%*	*658 ms*

Accuracy; native English speakers

	# Wrong	# Total	% Accuracy	Mean RT on corr
Nonwords	*582*	*6355*	*91%*	*774 ms*
Real words	*336*	*6231*	*94.7%*	*636 ms*

(Table 2; accuracy rates of both subject groups across nonword condition, and all real word conditions)

5.1 Statistics: Results

The numbers produced by the experiment were run through a linear mixed-effects model implemented using the Ime4 package (Bates, Maechler, Bolker & Walker, 2015) in an R statistical computational environment. Because there is a limit to how quickly one can respond to the target word, but not to how slowly, the data was log-transformed before statistical analysis to tighten the data spread and eliminate effects of outliers.

The RTs of Norwegians were higher on average than those of the native English speakers, signified by a main effect of the SubjectGroup variable ($t = 3.55$, $p < 0.001$). The average RT was significantly lower in conditions where the target was preceded by an established CN, indicated by a significant CompoundType main effect ($t = 4.24$, $p = < 0.0001$) For both groups the effect of Priming reached significance as a main effect ($t = 6.35$, $p < 0.0001$), and first constituents were recognized more quickly than second constituents, as indicated by a main effect by Constituent1/2 ($t = 2.72$, $p = < 0.01$).

These main effects were qualified by a number of two-way interactions: A significant CompoundType x Priming interaction ($t = 3.26$, $p < 0.001$) indicates that the mean priming effect was greater in novel CNs than in established CNs. Further, there was a significant two-way interaction in Constituent1/2 x Priming, meaning that first constituents (C1s) were primed more reliably than second constituents (C2s) ($t = -2.83$, $p < 0.001$). A significant CompoundType x Constituent1/2 interaction ($t = -4.20$, $p < 0.001$) indicates that first constituents from established CNs were processed more quickly than constituents from novel CNs. There was also a significant CompoundType x SubjectGroup interaction ($t = -2.15$, $p < 0{,}01$).

Finally, most importantly and crucially to the analysis and hypothesis of this thesis we have a *significant three-way interaction of SubjectGroup x Priming x CompoundType* ($t = 3.88$, $p <0.0001$), robustly suggesting that the PE for established CNs is greater with Norwegian L2 English speaking participants than with native English speaking participants. This three-way interaction grants license to divide the following analysis section in two; first looking at and comparing the results of the established CNs category for both subject groups, and thereafter doing the same for the novel CNs category for both subject groups.

5.2 Analysis: Priming with established CNs

The first category the participants of the experiment gave answers to was one where established CNs were used as masked primes, and their first and second constituents as target words. The results of these conditions are presented in the table below (table 3).

Established Compound Nouns; Norwegian L2 English speakers

	Unrelated Prime	Related Prime	Priming Effect	Observations
Constituent 1	*659 ms*	*630 ms*	*29 ms*	*1242 | 1247*
Constituent 2	*676 ms*	*646 ms*	*30 ms*	*1210 | 1235*

Established Compound Nouns; native English speakers

	Unrelated Prime	Related Prime	Priming Effect	Observations
Constituent 1	*601 ms*	*587 ms*	*14 ms*	*701 | 706*
Constituent 2	*616 ms*	*619 ms*	*-3 ms*	*704 | 695*

(Table 3; Results from Established CN materials by both subject groups).

It was found that there is a robust and significant and equivalent priming effect in both C1 and C2 conditions in Norwegian L2 English speakers, while the priming effects for native English speakers were weak in C1 conditions, and non-existent in C2 conditions. The data also shows that the mean RTs of native English speakers are significantly lower than those of native Norwegian L2 English speakers in all conditions, except for the primed C2 condition where the discrepancy is only 27 ms (contrasted with ~55ms in the other conditions).

5.3 Analysis: Priming with novel CNs

The second category of my experiment had participants decide on target words that were constituents of the prime word, where the primes were novel CNs. The results from this category is presented in the table below (table 4).

Novel Compound Nouns; Norwegian L2 English speakers

	Unrelated Prime	Related Prime	Priming Effect	Observations
Constituent 1	*677 ms*	*656 ms*	*21 ms*	*1238 | 1236*
Constituent 2	*673 ms*	*653 ms*	*20 ms*	*1227 | 1238*

Novel Compound Nouns; native English speakers

	Unrelated Prime	Related Prime	Priming Effect	Observations
Constituent 1	*651 ms*	*603 ms*	*48 ms*	*708 | 697*
Constituent 2	*630 ms*	*600 ms*	*38 ms*	*698 | 703*

(Table 4; Results from Novel Compound Noun category by both subject groups)

The Norwegian L2 English speaker subject group showed similar and statistically equivalent PEs in both constituent conditions; neither constituent seems to be more influential in terms of priming in Norwegians. Native English speakers, however, do not show the same behavioral-statistical tendencies in this category as in the established CN category. For the native speakers, we can see a marked and significant increase in priming effects for both constituents - with C1 being the stronger influence. Where there were only a very weak PE for C1 and a non-existent PE in C2 in the former category, we here observe very robust and significant PEs in native speakers. As for RT increases, neither group showed a significant increase or decrease from the established CN category to the novel CN category, while the RT disparity between the subject groups in this category remained around ~55ms - similar to the former category.

6 General discussion and implications

Before discussing anything, it is worth mentioning that the imbalance in the proficiency of our participants (44 out of 53 participants self reporting as >=8) should, based on previous research (Li et al. 2015; Wang 2010, cf. Uygen & Gürel 2017:93; Alonso 2016a), indicate that our numbers are able to represent the most native-like Norwegian L2 English speakers' mechanisms of lexical access. This is, of course, given that the self reported proficiencies are valid markers of actual proficiency. The RT data when distributed across proficiencies indicate a downward trend (albeit a statistically weak trend due to a low amount of low proficiency participants). Graphs and plottings of proficiency data vs. RT and by-participant PEs are included in a separate addendum (addendum 3).

6.1 Contributions to previously established phenomena

Starting with the three, already well researched hypothesized findings our numbers can illuminate further; Firstly, the data indicates that morphological decomposition happens, in line with predictions made by the current paper. This assertion can be made solely on the basis that there are observable priming effects. If the prime |toothbrush| eases the computing of |TOOTH|, then that suggests that a part of the cognitive activity initiated when accessing |toothbrush| spills over into the processing of its constituent |TOOTH| - and we do observe significant PEs in all conditions except native English speakers' processing of constituents of established CNs (where the PEs on C1 are weak, and on C2 they are non-existent). The basic assumption here is that this observed PE within our conditions would only be possible if the activity required in accessing the CN |toothbrush| overlaps with the activity required to access its constituents. When these cognitive activities overlap, that firmly suggests that accessing |toothbrush| is in fact a process of decomposing it into constituents to recompose a unified meaning thereafter.

Secondly, the fact that there are observable priming effects in an LDT employing a masked priming paradigm with *novel* CNs as primes and its constituents as targets suggests that the morphological decomposition (when it happens) happens at a stage preceding lexical access, and before full word form has been resolved. All previously conducted LDTs can be used as evidence that 50 ms is not enough to achieve lexical access to an item simply by pointing to the RT data we record. Because of this we have reason to conclude that any PE recorded by a 50ms priming stimuli is due to a cause which has a locus pre-lexical access. Moreover, due to the nature of the experimental design, it is implausible that |watersong| could prime |SONG| if the recognition process happens in a way that ignores the search for individual morphemes and has whole word recognition as a preliminary, first-level goal (which is the supralexical stance). Being a novel encounter, |watersong| is presumably not recognizable as a whole word form, therefore forcing us to presume the PE to be from ortho-morphological recognition. Because of this, the current paper suggests that the PE recorded in the novel CN category during the 50ms priming window implicates either a sublexical semantic priming, or an orthographic priming which has morpheme recognition as its goal (i.e separating |watersong| into |water| and |song|, rather than |wat| and |ersong| implies that a morpho-orthographic parsing is in play). Both of these explanations point to the decomposition being sublexical. And since both groups showed a significant PE in the novel CN category, this assumption is supported in both subject groups.

Thirdly, the data indicates that the first constituents are focalized by native English speakers, but not by Norwegian L2 English speakers. PEs are consistent across both constituents in both categories in Norwegians, while both categories indicate the C1 to be the focus of native English speakers. This might indicate that the subject group that expects a whole word-lookup to succeed fixates more on the onset of the word than the subject group that expects the need to decompose it - more discussion on this will follow.

6.2 Discussion on the novel contributions of the thesis

Moving on to the more intricate and novel suggestions of the data provided by the current paper; Even though the data lends plausibility to both subject groups employing a sublexical decomposition process, there are some very interesting differences between them. As laid out in the research questions the current paper wishes to look at whether there is a difference in the way native speakers and L2 speakers automatically process CNs - and if there is a difference, whether there is “a difference in the difference”. What is apparent from the numbers is that there is not a difference between Norwegian L2 English speakers' behavior in relation to novel CNs compared to established CNs, but that there is a difference in the way native English speakers behave between categories; meaning that there is a "difference in the difference" in that only one subject group shows a significant change in PEs. Thus, in analysis of the data gathered by the LDT, it seems that Norwegian L2 English speakers and native English speakers do, in fact, process CNs in different ways, and that they are different in the ways hypothesized by the current thesis; Norwegians show a more consistent PE across categories, while native speakers show a marked increase in PEs in the novel CN category. When stimulated with established CNs, native English speakers seem to employ a whole-listing lookup rather than a decompositional mechanism to reach lexical access - as shown by table 3. The same is not the case with Norwegian L2 English speakers, which show significant priming effects even in the established CN category. The data suggests that Norwegian L2 English speakers employ the same degree of decomposition (or that decomposition is as consistently the "first past the post" if they operate in parallel) in both established and novel CNs, while native English speakers seem to use a whole word-routing in established CNs and a decomposition routing in novel CNs (or that a whole word-routing is reliably faster in established CNs, and decomposition routing is reliably faster in novel CNs if they operate in parallel).

As for the question regarding whether the data indicates a parallel processing procedure or a serial one, this warrants some lengthy and in-depth discussion of all possible interpretations of the numbers. The data in table 3 (established CNs) suggests that one of two things is true: When contacting an orthographically contiguous CN, native English speakers utilize a whole-listing lookup as a first resort which succeeds in the established CN category - resulting in no/weak PEs, while Norwegian L2 English speakers utilize a decompositional route as a first resort - resulting in significant PEs. This first possible implication presupposes that the two mechanisms are employed serially (only one can operate at a time), where a whole listing lookup is preferred for native English speakers, while a decompositional lookup is preferred for Norwegian L2 English speakers. However, as mentioned, it is not given that these mechanisms operate serially - it might be that they operate in parallel. If they operate in parallel, both can operate simultaneously as separate procedures that compete in a “first past the post” fashion. Therefore, the other possible implication of the established CNs category is that; in native English speakers the whole word-lookup outpaces the parallel decompositional route, while in Norwegian L2 English speakers the decompositional lookup outpaces the whole listing route.

It is possible to develop this argument somewhat when we look at table 4; when stimulated with novel compound words that have never before been encountered, we see evidence that native English speakers do resort to decomposition as it is the only possible way to construct or gain any information from novel CNs. However, we do not see a strong increase in RTs despite this need to morphologically decompose. What can be argued from this is that native English speakers need to decompose novel CNs into its constituent parts to unify them into a whole, but that this decomposition effect does not cost much additional time. Perhaps the two processes are in fact active simultaneously. If we conceptualize these processes as loading bars, it might seem like the whole listing-loading and the decomposition loading in native English speakers are close to one another in terms of the time they take to load, but that whole listing wins when there is a whole listing available, while the decompositional route is given the short additional time required to be carried out when a whole listing is not available.

As for Norwegian L2 English speakers, if a decomposition and whole listing-lookup happens in parallel and simultaneously in non-exclusive competition, the data suggests that the decomposition route consistently finishes before the whole listing-route in established CNs (and naturally, by default finishes first in novel CNs). Again, we have to be open to a couple of explanations being plausible in this parallel routing scenario; This can be because the whole listing-lookup is slower in non-native English speakers due to established CNs not being contacted frequently enough to warrant them being separate, whole listings - or that these whole listings take longer to open as Mental Lexicon entries. It might also be because the decomposition process of a Norwegian is a faster and more readied process than in a native English speaker due to productive and creative word formation rules in contiguous orthography leading to more frequent decomposition.

However, the idea that a Norwegian L2 English speaker would decompose more efficiently in their second language than a native English speaker does in his or her first is not consistent with prior research, and it can be argued that it is not what we are seeing in these data either. We can interpret from the tables that when native speakers do morphologically decompose (as they did with novel CNs/table 4), they do it more efficiently; meaning they show a larger PE. This is logically sound, as one would expect the Mental Lexicon storage of a native speaker to be more efficient than that of a second language speaker due to more frequent and consistent exposure to the language (along with early age acquisition of the language instead of advanced age learning), and thus the priming effect would also magnify through that storage efficiency.

The entire hypothesis that the RT difference between the categories would imply whether or not "resources are wasted" decomposing presumes that more decomposition during the 50 ms prime equals more ease of access to the target word. This does not need to be the case. We might be dealing with a case of diminishing returns of time spent decomposing: This might be a scenario where in established CNs, 30ms (30 ms being an arbitrary example) of the priming time is spent looking for an entry opening possibility for a whole listing, and that when the possibility is ensured by orthographic recognition the decomposition process that would follow is aborted - and in novel CNs 30ms of the priming time is spent looking for a whole listing possibility based on orthographic recognition, and when that possibility is ruled out the remaining 20 ms is spent decomposing the prime. This is an explanation of my data, where assuming a diminishing returns-effect on decomposition (i.e. all sublexical decomposition that exceeds for example 20 ms bears very little additional ease of access) would explain why native English speakers show a PE without an increase in RT in novel CNs, while still supporting a serial priority system of access mechanisms. In other words; in established CNs, the hypothetical 20ms that are leftovers in the priming window are spent continuing the whole listing-lookup, while in the novel CN category these 20ms are spent decomposing - and those 20ms are enough to grant an equivalent ease of access to the target as 50ms of decomposition would. The reason I linger on the possibilities of serial routing still being a valid option will become apparent shortly. I would assert that the data quite firmly suggests that morphological decomposition routing and whole listing routing *do not operate in parallel with each other*, and here is why:

If there was in fact a parallel route processing in place, one would adamantly expect that there would be a noticeable PE from native English speakers in the established category as well as the novel category. The way I interpret the data, this is a silver bullet against the argument I laid forth supporting a parallel processor in the preceding paragraphs: If the two mechanisms were active simultaneously, this means that native English speakers would have begun the decomposition process during the masked priming phase in every single condition - and that they were given the same 50 ms amount of time to do it in every condition. And if decomposition is in effect in every condition for the exact same amount of time, this would necessitate the expectation of a consistent PE between the categories (as the sublexical decomposition process would grant the same increase in ease of access) in native English speakers - but that is not what we observe. In fact, *it is precisely what we do not observe*. Native English speakers show no/weak PE in established CNs, but a very marked PE in novel CNs, an outcome that is not consistent with the idea of a whole listing-routing and a morphological decomposition routing computing in parallel.

Therefore, it does seem that decomposition lookup and whole listing-lookup happen serially. If we pair this implication with the more clearly evidenced proposition that Norwegian L2 English speakers decompose all CNs regardless of novelty, while native English speakers only decompose novel CNs, we arrive at a very interesting assertion; it seems, based on the data produced by this experiment, that native English speakers prioritize looking for orthographically contiguous and lengthy orthographic stimuli like CNs as whole listings in their Mental Lexica, while Norwegian L2 English speakers prioritize decomposition when contacted with this same type of stimuli. When extending this line of reasoning, we must ask; what are the differences between these two subject groups - what might this difference be the product of?

The current thesis hypothesized that contiguous orthography in CNs was instinctually treated as a marker for a previously encountered word in English, while it is often a marker for a novel word in Norwegian - or at least not granting any conditioned expectation of it having been encountered previously - and that this difference between the two orthographies has made its users subconsciously and instinctually treat orthographically contiguous CNs in different ways. I would argue that the data presented here is in line with this prediction - and that the hypothesis is worth investigating further:

From the perspective of the Autonomous Search Model of lexical access, as well as the APPLE model of decomposition, we can assume that keeping a shortlist of derivational affixes (-s, -ed, -ing, etc.) is an efficient way to micro manage exact matching of stimuli through decomposition - but the same cannot be said of novel CNs. Realistically speaking, it is impossible to keep all possible noun-noun affixations readied on a shortlist due to the noun word class being open, thus making CNs infinitely productive. In the vacuum of a viable exact matching mechanism for CNs the ASM proposes the first legal parse hypothesis which is shown by the APPLE model to not hold up consistently - especially when contacting novel CNs. One explanation for the differences found and described in this thesis might be:

The orthographic norms and word formation rules of a language can affect the way the language conditions its users in contact with orthographically contiguous CNs. A language like English presents contiguous CNs with a general promise of them having been encountered before, and this might lead to its users having instinctually acclimated to looking for them as whole listings first and through decomposition if it fails, as this prioritization hierarchy usually yields faster access than if it were flipped. The Norwegian orthography, on the other hand, does not deliver any normative orthographic promises regarding novelty or establishment to its users when contacting orthographically contiguous CNs. Therefore, its users might be subconsciously conditioned to regard them as requiring decomposition with such regularity that always foregoing the whole listing-lookup is the prioritization rule that generally grants the fastest access.

7 Post scriptum: Improvements and further research

With more time, resources and thesis real-estate, there are several improvements one would have made to the experimental design of this thesis: A more substantial proficiency test such that one would not need to rely on participant self reporting their L2 proficiency. This would have allowed me to investigate the link between proficiency and increase/decrease in morphological decomposition, instead of relying on previous research to assert that having a very proficient participant pool indicates that they should show the most native-like behavior one can find in Norwegian L2 English speakers.

Further; even though my experimental design was such that form-priming was eliminated as distortion, and instead manipulated to be a contributing factor to mark sublexical morphological decomposition (as justified and explained in 4.1.2), it would still have been interesting to look at how large a portion of each priming effect was purely formal, and how much of it was semantic.

An even more comprehensive variant of this thesis would have included a Norwegian version of the experiment, conducted on native Norwegian L1 speakers as participants. This would have enabled me to contrast the decompositional tendencies Norwegian L2 English speakers portray in their English processing with the decompositional tendencies of their native Norwegian. As it stands, the thesis is left to assume that the differences between the subject groups' decompositional tendencies are due to a difference in their native languages - but this assumption needs to be solidified through further research which contrasts my numbers with the numbers Norwegians would produce when contacting established and novel CNs in their native Norwegian language.

As such, in terms of future project designs and in-/validation of the implications of the current thesis, I suggest the following: A masked LDT design that resembles or replicates the current thesis' experiment, but with the added aspect of a form priming control (restaurant-REST and restless-REST) to better suggest which type of decomposition - formal or semantic - is happening within the 50ms priming window. Furthermore, another L2 subject group whose orthography with respect to CNs is similar to English in orthographic contiguity rather than distinct from it. Both of these L2 subject groups should participate in two variants of the same experiment; one in their native tongue and one in their L2 English, in order to provide even more substance to suggest/refute that one's L1 is in fact affecting L2 processing. These two L2 subject groups (and ideally also the native English speaking subject group) should be run through a comprehensive proficiency test such that one can escape the need to rely on self reporting in assuming the degree to which their decomposition is or is not due to low proficiency.

8 Literature

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Appendix: Thesis relevance for the teaching profession

Because this thesis is written as part of the teacher training program at NTNU, it is asked that I briefly comment on its relevance to the teaching profession.

First of all, I would like to make mention of how studying the sub-field of psycholinguistics has opened my eyes to just how deeply ingrained in us linguistic competence really is. Superficially one assumes that the learning and use of language is just another skill to be learned - but the psycholinguistic literature highlights that there is something unique about the ways our cognitive faculties behave when contacting linguistic material of any form. My thesis went deep into the subconscious parts of language processing, and it has bolstered my passion for teaching and studying language as a cornerstone of the human experience.

Secondly; the fact that my thesis revolved around a hypothesis of the interface between one's acquired, first language and one's learned, second language can be very instructive to a teacher in a classroom setting. Based on the broader psycholinguistic literature along with my thesis, it is clear that there lies great importance in your first language - and that the features and systems of your first language seem interwoven with all languages you learn subsequent to it. Second language learning (and teaching) is not as simple as memorizing a new vocabulary which one can dress the same underlying skeleton with, and all too often in the past the L2 learner's classrom has been reduced to the idea that L2 learning is best practiced top-down.

Thirdly, I have learned so much about expressing ideas and structuring them sensibly: Manifesting complex ideas in a way which is nuanced enough to cover the details needed, while being simple enough to be understood is no small task. These competencies translate naturally to the classroom. I now have a better understanding of what it means to write clearly and structure a paper properly, which can be used when guiding students on their way to becoming competent speakers and writers.

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