A Psycholinguistic Study
of Temporary Ambiguity Resolution
in Sentence Processing

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Final Year Project
May 2005
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Declaration

I hereby declare that this thesis is entirely my own work and that it has not been submitted as an exercise for a degree at any other university

____________________________________ April 15, 2005

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Acknowledgements

I would like to thank my supervisor Dr. Martin Emms who was always helpful and patient. His advice was welcomed and appreciated.

I would also like to thank my parents, Teresa and Michael Grant, for giving me the opportunity and support needed to achieve personal goals.

I would also like to thank Yvette Graham, the experiment manager, who was extremely helpful in setting up the on-line experiment.

Finally, I would like to thank all my friends who listened to me throughout and offered their valued opinions, especially Lauren Bretnach.

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Abstract
This paper describes a psycholinguistic study that has been undertaken to investigate the human resolution of temporary ambiguity. It describes a web-based experimental tool, which has been designed to evaluate the ways in which humans treat temporary ambiguity, the different types of ambiguity and the problems related to the processing of such ambiguity. The treatment of these complexities in language is compared to those associated with bilingualism and considers whether previous linguistic instruction plays an important role in this process. The actual make-up of the human language processor is also investigated and looks at the ways in which the study of temporary ambiguity may inform us, in terms of the model that most resembles the human faculty.

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“The basic task of readers is similar to the task of a prospector. Just as the prospector picks away at the surface to discover the gold hidden underneath, readers dig away at the surface structure, searching for and demanding meaning.”

‘Helping Children Learn to Read’, Searfoss and Readence

Chapter 1

Introduction
1.1 Introduction

This chapter is an introduction to my final year project, which is concerned with the resolution of temporary ambiguity. Using a web-based tool to conduct an experiment, I hope to establish certain facts about the nature of the different types of temporary ambiguity and the difficulties faced in resolving such phenomena during the processing of sentences. In addition, I hope to be able to infer some of the properties of the human processing faculty. The background to the project is explained in section 1.2 with the motivation behind the paper and the overall aims being covered in section 1.3. A background in psycholinguistics is provided in section 1.4 which is followed by an overview and structure to the remainder of the project in section 1.5.
1.2 Background

Ambiguity can be found under many guises and in many different contexts. It has often been used by scientists in order to verify or contradict certain hypotheses as to how the human language faculty actually functions. In this paper and by means of experimentation, I hope to further understand the underlying concepts behind temporary ambiguity. It must be noted that temporary ambiguity is often studied under the concept known as “Garden Paths”. See Crain&Steedman (1985) in which a substantial body of work has been accomplished on this particular topic. This study also considers the different types of temporary ambiguity, how they are related to each other and the difficulties faced whilst processing sentences containing such ambiguity. It also attempts to define and categorise those people who find the resolution of such sentences more difficult than others.

Experiments are used by linguists to prove or disprove certain hypotheses. Native speakers often play their part in these discoveries. Whorf (1957) stated that:

“scientific linguists have long understood that ability to speak a language fluently does not necessarily confer a linguistic knowledge of it.”

The intuitive construction of sentences by native speakers is one of the factors, which promotes effective experiments to advance the understanding of human linguistic processes. The subject of the experiment is generally unaware of that which is being tested and is therefore unable to influence the results. The intuition of native speakers can also be used in contrast to those of bilinguals. The language that bilinguals possess is clearly different and particular differences can be uncovered by the effective use of experimental tools.

Following research on the topics of “Garden Paths” and sentence processing, an interesting experiment was conducted to establish how the two concepts intertwine and to how they can be used to clarify hypotheses to which they relate. The difficulties that were experienced in conducting the experiment were mitigated, to some extent, with the aid of computers. Several tools were used on the computer in order to gather material and run the final experiment.

A corpus based software tool was employed to gather the relevant material for the experiment. It is described in section 4.4 but at this stage, I will simply describe it as a useful tool that has been developed over the past fifteen years that can be applied to a wide range of applications. A web based tool was also employed.

The generic web-based experimental tool used to conduct the experiment was one previously developed for a final year project by several past graduates of Computer Science, Linguistics and a Language. It was more recently improved upon by Fionnuala Hourihane (2002) and is currently being refined by Yvette Graham, a masters student in computational linguistics. This programme allowed me to set up an experiment in which I
could test peoples’ reaction to temporary ambiguity and determine how quickly they could resolve different sentence constructions.

The third piece of software was used in processing to the results. The temporal analysis of Chapter Six used a Microsoft Excel spreadsheet to create graphs. It is an extremely diverse programme that can accommodate a variety of uses.

1.3 Motivations and Aims of the Project

Four years of studying Computer Science, Linguistics and French has, I believe, taught me a great deal about language as a means of communication. I have studied the mechanisms involved in learning and understanding language and have found that the methods by which we communicate are very complex. Human language is incredibly intricate and it is this level of intricacy that so fascinates me. Ambiguity in language is also a common phenomenon. The ways in which people communicate with each other, given their varying levels of ability, is of great interest to me. For instance, why are some people able to resolve structures faster than others or, why does one particular type of ambiguity produce an overall increase in difficulty when compared to another. These are some of the questions, which I have sought to answer and are the motivating factors in my undertaking this project. Whilst studying these aspects of ambiguity, it adds to my overall understanding of how the language faculty functions.

Language can also be described as being extremely diverse among our species and it is the learning of this diversity that I find so enjoyable. Polyglotism is, therefore, an area of great interest to me. The differences that are evident between the language of native speakers and learners of that language is the motivation for studying the way in which bilinguals approach such pitfalls as temporary ambiguity. The quirks and idioms of the different languages of the world has fascinated me since my study of language began.

Psycholinguistics is, I believe, one of the most important aspects of linguistics and this particular area of research has captivated me throughout my studies. To understand the faculty that allows us to communicate through language is another motivation behind this project. The study of how the brain is used to comprehend is an essential part of language communication. It is widely believed, as discussed in Chapter Four, that there are two distinct loci of computation in sentence processing (see Michael Niv 1993). There is a great deal of controversy surrounding which of these two models is responsible for resolving ambiguity. It is the aim of this project to acknowledge which of these is the more plausible model for human processing. The aim of this paper is to encompass a greater overall understanding of ambiguity and how this concept is treated by us during processing. It should, therefore, be possible to draw certain conclusions as to what is involved in the processing of sentences.

An answer to the question of whether previous formal instruction in linguistics can alter the way in which we process information is also an aim of this project. More specifically, can linguists resolve complexities in language more efficiently than those who have not been formally taught the underlying structures.
1.4 Psycholinguistics

Psycholinguistics is a very important area of study. As its name suggests, psycholinguistics is a discipline that links psychology and linguistics. In other words, it is basically the study of how our minds process language. More specifically, it is:

*The study of the mental faculties involved in the perception, production, and acquisition of language*¹

As you might expect, the psycholinguistic discipline is extremely large and can vary from areas concerned with speech therapy to those involving brain surgery. Caron (1992) suggests a definition of psycholinguistics as the interdisciplinary experimental study of the psychological processes through which a human implements the system of a natural language, the relationship of language to human thought.

The goal of psycholinguistics is to find the most comprehensive and unified theory of language behaviour. It is also concerned with the discovery of structures and processes which underlie the human ability to produce and perceive natural language. Production can therefore be studied in contrast to acquisition and it is under these two headings that many psycholinguistic studies have taken place. Differences and similarities discovered between the two, can alleviate many communicative problems from which members of our species suffer. A sophisticated means of communication is the greatest advantage separating us from every other animal on the planet. Language is so complex and diverse that for every psycholinguistic study providing the answer to one question, another two can be postulated as a result. Psycholinguistics is striving to reduce the unknowns each and every day.

Psycholinguistics can be concentrated on either the theoretical side or the practical side. The theoretical side is concerned with explaining the nature of language and how it is acquired. The practical or applied perspective side of the discipline, attempts to apply certain linguistic and psychological knowledge to problems such as reading, polyglotism, and teaching. This involves producing hypotheses about language and then experimentally testing these predictions, thus maintaining its claim to scientific status.

This paper is more concerned with the practical side of psycholinguistics. An experiment was conducted to further understand the processes involved in the perception of language. How these processes may differ across age and proficiency is also considered.

It must be mentioned that the study of psycholinguistics interacts with all of the social sciences and the humanities. This is because it is such an intricate part of what makes us human. As Kess (1992) suggests, psycholinguistics has far reaching connections with disciplines such as philosophy, anthropology, sociology, communications engineering and more recently, artificial intelligence. The importance of psycholinguistics is evident.

¹ Definition from Merriam Webster on-line dictionary
1.5 Structure of the Report

Chapter Two: Temporary Syntactic Ambiguity

This chapter is primarily concerned with research into the current experiment. It more specifically defines temporary syntactic ambiguity, a key notion of the paper. It begins by generally defining what syntax in language is, and the role it plays in Section 2.2 and 2.3. Ambiguity is then treated in section 2.4 and this, is in turn, related to temporary syntactic ambiguity in the subsequent subsections.

Chapter Three: Sentence Processing

This chapter is concerned with the research behind the project and explains the principles involved in the experiment. In Section 3.1, the role of syntax is considered with respect to processing. This is followed in Section 3.3 by the background to general syntactic difficulties that may present themselves during processing. Section 3.4 examines other important aspects of sentence processing i.e. the working memory. Section 3.5 is a very important section to the paper and describes the two hypothesised models of sentence processing, serially or in parallel. These two models will be discussed again in Chapter Seven during the analysis of the results. It represents part of the motivation behind the experiment.

Chapter Four: Methodology

Chapter Four examines the methodology of the psycholinguistic experiment that this paper describes. In Section 4.2, the categories of ambiguity that will be used in the experiment are described. This is followed by a discussion in Section 4.3, outlining the general premises that psycholinguistic experiments should follow. Schutze (1996) offers recommendation parameters that can be adopted. In Section 4.4, the means of gathering material for the experiment is discussed. A software programme called ICECUP is used and its disadvantages are also debated. The design of the experiment is discussed in the final section of this chapter and the individual aspects that coordinate to produce the final experiment are discussed here.

Chapter Five: Experimentation
This chapter deals with the way in which the experiment is implemented. The web based experimental tool is described in Section 5.2 and an overview of its workings is also discussed. Section 5.3 relates to the design of the experiment and Chapter Four explores the practical use of the web tool. The subsequent section explains how participation in the experiment is achieved. In Section 5.5, the extraction of the results from the tool is described. This subsection is concerned with the necessary changes that were made to the tool in order to extract the relevant results. The final two sections of the chapter discuss the problems encountered with the tool and possible future improvements to it.

**Chapter Six: Results**

This chapter considers the results that were extracted from the experiment. The introduction treats the overall participation in the project. Section 6.2, describes the parameters under which the results are discussed. The results for each ambiguity category are then dealt with, in turn, in the subsequent five sections. In Section 6.8, the context sentence results are juxtaposed with the ambiguous parts of the isolated sentences. The conclusion brings this chapter to an end.

**Chapter Seven: Analysis of Results**

This chapter treats the conclusions that were drawn from the results of the experiment. Section 7.2 deals with each category of ambiguity and compares the results obtained for each of them. Section 7.3 discusses the results in relation to male and female participation. Section 7.4 considers the linguists’ results and how they differ. Section 7.5 discusses how bilinguals performed in the experiment and the processing theories of Chapter Three are discussed further in Section 7.6. The final section of this chapter simply discusses the main findings in light of the analysis.

**Chapter Eight: Conclusion**

This chapter brings together all the points that have been raised by the experiment and subsequent results. It discusses the achievements of the experiment, the knowledge gained and how this was possible. The paper finishes with a brief description of the difficulties encountered and areas of possible future study.
Chapter 2

Temporary Syntactic Ambiguity
2.1 Introduction

Within the study of language, linguistics can be dissected into five main topics. They are phonology, morphology, semantics, phonetics and syntax. Each one plays its own role in the make up of language with some topics being more important in some languages than in others. Syntax is universally one of the most important features of language and is dealt with in this paper, together with semantics; the meaning of language. Both are closely linked, for one cannot refer to the meaning of a sentence, until one has first processed the constituent elements of that sentence\(^2\). In English, the main device for describing relationships is in fact, word order itself. This implies that syntax plays a crucial role.

2.2 What is Syntax?

Languages have rules. The rules governing language are referred to collectively as grammar. The reason for having rules is that people need to be able to speak an indeterminate number of sentences in their lifetime. If each of these sentences had to be learned separately, the task would be impossible. So, learning the rules for connecting words, it is possible to create an infinite number of sentences, all of which are meaningful to the people who understand the syntax. It is possible, therefore, to construct sentences that the speaker or listener have never heard before. Thus, from a finite number of rules, an infinite number of sentences can be simultaneously understood.

For this system to work with any degree of success, the rules have to be precise and have to be consistently adhered to. The rules cover such things as: the way words are constructed; the way the endings of words are changed depending on the context; the classification of words into parts of speech (noun, verb, pronouns, etc ...) and; the way the parts of speech are connected together.

\(^2\) There exists research, dealt with in chapter 2.3.2, to show that we may process semantic information after a quick, unfinished syntactic analysis.
The rules of grammar do not have to be explicitly understood by the speaker or the listener of the language. The majority of native speakers of a given language will have no formal knowledge of the grammar of that language but are fully capable of speaking it to a degree of grammatical accuracy. The rules are subconsciously assimilated whilst the language is primarily being learned as a child. The syntax of a language is thus, the way word elements must be construed to make well-formed utterances.

Syntax is an English word derived from the Latin *syntaxis*, meaning to arrange together. There are two definitions, closely linked, that form the use of syntax today:

1. (a) The way in which linguistic elements (as words) are put together to form constituents (as phrases or clauses)
   (b) The part of grammar dealing with this
2. A connected or orderly system: harmonious arrangement of parts or elements\(^2\).

In order to clarify the definition of syntax, take the following sentence as an example:

\[
\begin{array}{ll}
\text{subject} & \text{verb} \\
\text{object} & \\
1. & \text{The boy} \quad \text{loves} \quad \text{his dog}
\end{array}
\]

This sentence follows the standard subject-verb-object word order. If the order of the words were switched in some way, either the meaning of the sentence as a whole would change or the sentence would be rendered meaningless. If one takes a transitive verb such as *to give* as an example, a different syntax can change the meaning completely:

2. The boy gave the dog the woman
3. The boy gave the woman the dog

By merely changing the word order of the sentence, the whole interpretation of the sentence changes. In (2) the dog is the direct object of the verb *give* i.e. its being given. In (3) the object being given is the woman. One can see the great reliance on syntax in English, at least, to disambiguate the meaning of sentences.

\[^2\text{Definition gathered from Merriam-Webster Online Dictionary}\]
2.3 The Role of Syntax in a Language

The understanding of syntax is an integral part of mastering any language. If one does not grasp it during the early years of childhood, many language problems can ensue. The controversial debate, whether the faculty of syntax in language is innate or learned, divides many linguists throughout the world. Whether it is down to nature or nurture however, the fact of its importance remains.

The role of syntax, as referred to above, may vary from language to language. In English it is quite important, but in a language like Latin, syntax is much more flexible. This can be attributed to the fact that word endings in Latin indicate the case of a noun or an adjective; such inflections make it unnecessary to rely on word order to indicate a word’s function in a sentence. The relationships in a sentence must be explicitly stated, some languages do this through heavy reliance on syntax, others achieve this through reliance on word cases. In all languages, however, it plays a role of sorting smaller units of meaning into larger units of meaning, like sentences or phrases. The meanings of such sentences often depend on the syntactic structure employed. The absence of an integral syntactic unit can often reduce an utterance to nonsense:

Figure 1.1.1. This diagram shows a syntax tree analysis for a basic sample sentence like “The boy ate the bread.”

3 This image was taken from a website, www.harmony.org.uk.
The syntactic rule, that to make a well formed sentence it must contain at least one noun phrase and one verb phrase, is broken here. If a native speaker of English reads the sentence (4), without any formal knowledge of the rule, they can instantly see that it is nonsense. They may try to insert a predication over the sentence but if it originally lacks one, the true meaning cannot be conveyed. Adherence to the syntactic rules of a language is consequently a fundamental prerequisite in conveying a message.

In second language acquisition, many problems arise out of the fact that there is a different syntactic structure to convey the same meaning within the target language. Take the following sentences as an example of the difficulties faced:

Subject | Verb(auxiliary) | Verb | Pronoun | Adverb | Adverb | Pronoun | Verb | Adverb | Pronoun | Verb
---|---|---|---|---|---|---|---|---|---|---|---
5.
He | has | done | it | already

This is in contrast to the French equivalent sentence:

Subject | Verb(auxiliary) | Pronoun | Adverb | Ver
---|---|---|---|---
6.
Il | l’a | déjà | fait

These examples illustrate that even the most basic sentences, under translation, can require a syntactic structure that may be alien to a speaker of the source language. Whilst it comes naturally to a native speaker, the importance of a correct syntactic structure can often be vital for a foreigner to achieve understanding. Syntax can therefore be seen as the building blocks required in creating meaningful utterances. The topic that will be discussed in the next section is that in certain utterances, can you have two syntactic interpretations for the same sentence?

2.4 **Ambiguity**
Ambiguity is defined as:

1. Subjectively wavering of opinion; hesitation, doubt, uncertainty, as to one’s course

2. An uncertainty, a dubiety

3. Objectively: Capability of being understood in two or more ways; double or dubious signification, ambiguousness

4. Word or phrase susceptible of more than one meaning; an equivocal expression

A word, phrase, sentence or other form of communication is called ambiguous if it can reasonably be interpreted in more than one way, as the above definition suggests. The simplest example of this is the smallest semantic unit, a word. Take an example such as the word “row”. This word, taken in isolation, can refer to many things due to its homonym status. It can mean the act of rowing a boat, an argument between two people or a queue of people in a line. Sometimes this is not a serious problem, at the word level at least, as the context in which it’s used usually disambiguates the intended meaning. For instance, if one read, “they all formed into a row”, it is unlikely, though not impossible, that it means they had begun arguing or that they were rowing a boat.

More problematic, however, are words whose senses express closely related concepts. Good for example, can mean “useful”, “functional”, “exemplary”, “pleasing”, “moral” and probably other similar things. If you said “I have a good daughter”, you would not know which interpretation is intended.

There are several different types of ambiguities in language, some of which are used purposely, whilst others cannot be avoided. In spoken language, lexical ambiguities can arise as in the following example:

7. “Ice cream”
8. “I scream”

This is rarely a problem however because it is nearly always disambiguated by the context in which it is uttered. Philosophers and other users of logic, spend a vast amount of time removing ambiguities from arguments because it can lead to incorrect conclusions and can equally conceal bad arguments. In the case of a politician, this can be used to good effect.

9. “I oppose taxes which hinder economic growth”

If a politician announced the above statement (9), a number of interpretations could be considered equally valid. In each case, the interpretation is expected to suit the way in which the hearer desires it to be understood. Some, might conclude that the politician

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4 Definition gathered from Oxford on-line dictionary, dictionary.oed.com
5 A morpheme is the smallest semantic unit but for the purpose of this paper a word will constitute such a notion
6 This meaning is not strictly a homonym as its phonemic qualities are different to the other meanings. It suffices as an example because it is orthographically the same.
opposes taxes in general because they hinder economic growth. On the other hand, there will be those who interpret the statement as though the politician opposes only those taxes that he/she believes will hinder economic growth. There are also other ambiguities and it is the topic of syntactic ambiguity with which this paper is primarily concerned.

2.4.1 Syntactic Ambiguity

Syntactic ambiguity is a property of sentences that can be parsed in more than one way. This may or may not involve one word having two parts of speech as in many homonyms. Due to syntactic ambiguity, it is often difficult to understand the intended meaning as in the next example:

Figure 2.3.1.1 describes a valid syntactic interpretation of a sentence. This interpretation is depicted by the fact that the prepositional phrase is at the same level as the noun phrase and verb. In other words, it implies that the prepositional phrase is modifying the verb itself and in doing so renders the interpretation that, it is with the use of the telescope that the girl was able to see the man. This is in contrast to figure 2.3.1.2.
The interpretation here is somewhat different. The syntax tree in this instance describes the situation in which the prepositional phrase is below the noun phrase, N’, and at the level of the other noun phrase relating to “the man”. The interpretation that is intended from parsing the sentence like this would imply that the girl simply saw the man, who was carrying a telescope on his person.

This is just one example of how the intended meaning of a sentence can be syntactically ambiguous. Depending on the position of the syntactic nodes, the meaning of the sentence can change dramatically. In the above sentence however, there are only two possible syntax structures. In the next example there can be four.

“Time flies like an arrow”

Although one immediately jumps to an interpretation that best fits a sentence like this in isolation, there are many other ways that it could be interpreted, however bizarre. The four possible meanings of such a sentence can only be told apart by their syntactic analysis. They are all valid parses but it is the first interpretation that fits best and as a result, is the one most likely to be true in an isolated reading.

a. Time passes as fast as an arrow flies  
b. Measure the speed of flies as you would an arrow  
c. Measure the speed of flies like an arrow would  
d. A kind of fly, time flies, like arrows

There are hundreds of possible examples of syntactic ambiguity in every natural language in the world. Our brains can decipher the meaning of a sentence in a split second
yet if there are two possible interpretations, it chooses one over the other. This must be accomplished by other than purely syntactic means and will be dealt with later in the paper. But first, one must look at the concept of temporary syntactic ambiguity.

2.4.2 Temporary Ambiguity

Temporary ambiguity is, as its name suggests, ambiguity that is temporary. In other words, it is ambiguity that can be resolved by the individual constituents of the sentence, but at a slower pace than if the sentence did not contain such ambiguity. It is also commonly known under another guise, the Garden Path effect. The Garden Path effect is a phenomenon that has been well researched, see Crain & Steedman (1985). The concept is self-descriptive as one is “led up the garden path” by the structure of the sentence and hence difficulty arises when the first syntactic parsing does not fit the rest of the sentence. For the remainder of the paper the term ‘temporary ambiguity’ will be used. Temporary ambiguity usually arises if part of the sentence is compatible with two syntactic structures.

10. While Nigel was reading the newspaper

Could be continued in at least two different ways:

11. While [Nigel was reading the newspaper] his tea was getting cold
12. While Nigel was reading [the newspaper lay unnoticed on the floor]

In (11), “the newspaper” is the direct object of the verb “read” whereas in (12), “the newspaper” is the subject of the main verb “lay”. This means that when a listener or reader comes into contact with a sentence that begins like that at (10), then it is impossible to be certain which structural analysis is required to complete the sentence. It could be that of (11) or (12) which implies that “the newspaper” may initially be incorrectly analyzed. This is a classic example of temporary ambiguity.

One must concede that every type of ambiguity treated earlier in the paper can, in fact, fall into the broader sense of temporary ambiguity. All that is required in each case is that some pragmatic or semantic information be added in order to resolve the true meaning. Temporary ambiguity in that sense, however, does not strictly follow the provided definition. The discrepancy arises in that the sentences cannot be resolved by the individual constituents of the sentence, i.e. further information is required. Temporary syntactic ambiguity is the main topic of this paper and conforms to the narrower definition. Temporary syntactic ambiguity is therefore ambiguous, but only for a short time and can be resolved purely on the basis of the constituents of the sentence.

Figure 2.3.2.1
Above, is an example of temporary syntactic ambiguity in a sentence. It is a fully grammatical sentence. As it illustrates, there is only one possible way to parse such a sentence and in that sense, it is syntactically unambiguous. Yet it falls into the category of temporary syntactic ambiguity, due to the way in which we process the information that we gather from the sentence. The unfamiliar syntactic construction of two prepositional phrases side by side in a sentence, demonstrates the difficulties faced during processing. Whilst these types of sentences can be described as temporarily syntactically ambiguous for this reason, they cannot be referred to as purely syntactically ambiguous.

The illustration in figure 2.3.2.1 is just one example of temporary ambiguity. There are several other syntactic constructions that create the same kind of temporary ambiguity during processing. They will be dealt with extensively, later in this paper.

2.5 Temporary Syntactic Ambiguity in Language

As one might imagine, ambiguity is avoided in language wherever possible. This is due to the fact that the main aim of producing an utterance in the first place, is to be understood. Thus, syntactic ambiguity is generally avoided, making the occasions when one might have to decipher such a message quite seldom. However, when one encounters a message containing this type of ambiguity, other semantic or pragmatic factors are used to decipher the intended meaning.

In relation to temporary syntactic ambiguity, it is not necessary to take any other outside factors into account. It is therefore a more common occurrence than normal ambiguity in language because one does not unconsciously strive to avoid it. The sentences’
constituents relay all the information that is required to interpret the meaning. If the processing and reprocessing of the utterance does not result in a satisfactory outcome then other pragmatic means may have to be employed. To fully understand temporary syntactic ambiguity, we must explore at the thought processes that prevail in order to decipher such an utterance.

Chapter 3

Sentence Processing
3.1 Introduction

Sentence processing is the term used to signify the process which our brains undergo in order to comprehend an utterance. The earlier analogy to a prospector is quite intuitive in that there are many current theories that draw on the notion of subconsciously picking away at a sentence to gain its meaning. This paper is primarily concerned with the processes involved in deciphering written material, i.e. sentence comprehension with regard to reading.

Sentence comprehension is the ultimate goal of sentence processing. If someone produces an utterance, it would be for the purpose of being understood by someone else. Effective comprehension relies primarily on vocabulary and in order to understand, the reader must possess the ability to decipher the basic lexical items that make up the sentence. Word recognition can only be achieved through the concept of decoding. Decoding is where the individual letters of a word can be correlated to phonemes, thanks to alphabetic principles, which can be blended together to allow a person to recognize a word.

Word recognition can however, only help the reader to a point. Sentence comprehension involves much more than just recognizing the words of a sentence. To become a successful reader, one must also be able to comprehend the words read, within the context of the sentences containing those words. In other words, one must weave the meanings of the individual words into the meaning of the sentence.
If one were to choose a tent as another analogy, one could imagine being faced with the task of taking down a tent that one has never seen before. Granted, most tents are quite easy to take down, as are some sentences, but what would happen if it were an antique tent? It is conceivable, that one may have some difficulty in packing it all away. In similar fashion, sentence comprehension relies heavily on the person’s ability to decipher the structure of a sentence, i.e. the syntax. In addition to this, the reader must be able to retain all of the words that have been read, until the entire sentence has been processed. Such storing of words is commonly termed, working memory. As syntax plays such an important role in sentence processing, it is an issue that we will look at first.

3.2 The Role of Syntax in Sentence Processing

Syntax is an important part of sentence processing. Consider the following simple sentence:

1. Mary saw a cat

The main process being employed is that of word association. In sentences like this, syntax plays a secondary role and is only employed to corroborate the associations. When the associations are ambiguous or the syntax is complex, however, simple word associations will not provide a satisfactory understanding. One must have a clear comprehension of syntax in order to establish how each word forms part of the sentence structure and subsequently understand the sentence in its entirety.

It is obvious that when a sentence is encountered, one does not casually puzzle one’s way through in order to achieve an interpretation. Sentence processing is, in fact, completed at very high speed and we are largely unaware of the processes involved. We are aware of its presence, however, as is evident by the final outcome; comprehension.

The role of syntax in sentence processing, as elaborated, still remains rather vague. This is due, in part, to the fact that complete agreement does not exist between scientists, as to the exact function played by syntax in sentence processing. In Sections 3.5.1 and 3.5.2, syntax will be considered again, but in relation to each of the hypothesised processing theories. It may then be possible, to define the role of syntax more accurately within the context of sentence processing. Nevertheless, it is worth mentioning, that in each case, syntax and syntactic structures play a vital role in the ultimate comprehension of a sentence.

3.3 The Syntactic Challenges in Processing Written Sentences
Children are constantly learning about syntactic structures without being unduly aware of it and learning to listen and speak are the primary sources of this knowledge. By the time they start learning to read, their considerable knowledge of syntax can be employed to manipulate that which they are reading, so that a correct interpretation can be obtained. There are a few relatively simple strategies that a learner employs in order to process a sentence and this section will discuss the concepts that are relevant to the processing of sentences, which are learnt at an early age.

### 3.3.1 Word Order

In English sentences, the word order is generally in the form of subject-verb-object\(^7\). As a result, a learner encountering a new sentence will try to apply this order to the corresponding words in the sentence. This is, of course, assuming that that each sentence is processed by structure first and meaning second.

This very point will be picked up later in the section but for now, it is suffice to say, that due to reliance on the SVO word ordering, early readers can understand simple active sentences such as:

2. He called her

But have much more difficulty in correctly parsing a sentence in the passive voice such as:

3. He was called by her

Often a passive sentence such as (3), is interpreted as ‘he called her’ so that it complies with the ordering that was previously learned by the young reader.

### 3.3.2 Minimum-distance Principle

Another learning reader tendency is that of minimum-distance. This terms refers to the incorrect assumption that a word refers to the closest related word. For instance, they might assume that a verb refers to the closest preceding noun or, that a reflexive pronoun refers to the closest preceding noun of matching gender. Take the following as an example:

4. She brushed her hair all by herself
5. She brushed the hair of the short girl all by herself

---

\(^7\) SOV and SVO orderings are the most common in languages but all permutations do exist in some form
In the first sentence, a young reader would have little problem matching up the reflexive pronoun ‘herself’ with the correct reference pronoun, ‘she’. On the other hand, the second sentence would cause greater difficulty as the reader would try to match the reflexive pronoun with the noun ‘the short girl’. Readers usually tend to rely on the minimum-distance principle, when their working memories are taxed by the need to remember many words throughout the course of a sentence.

3.3.3 Coined-clause Analysis

Coined-clause analysis is a term used to describe the assumption by a young reader, that the existence of two clauses in a sentence means that the clauses are automatically conjoined. In other words, that there are two main clauses and that they are joined together by a conjunction such as ‘and’. A classic example of this would be:

6. The cat caught the mouse that chased the shrew
7. The cat caught the mouse, and the cat chased the shrew

The first sentence is the original sentence containing the relative clause. The second sentence is a common misinterpretation of that sentence. A beginning reader would often make such a mistake whilst trying to apply a syntactic analysis.

The three strategies described above would be used by a naïve reader to fall back on in the event of processing an unknown sentence. They have not yet read extensively enough and therefore have only enough syntactic ability as their spoken tuition has allowed. Their sentence processing ability is constantly improving with practice and along with this maturity, the increase in efficiency of their working memory. Soon they are capable of switching from these strategies to paying attention and comprehending the actual syntax of the sentence. However, they are important to mention as matured readers, in times of difficulty, will naturally fall back on techniques such as the ones discussed. There are other syntactic structures as well that pose problems for a beginner. They include the passive voice, negation and embedded clauses. The difficulties with these will now be described.

3.3.4 Passive Voice

Passive structures are harder to understand, learn and produce than their active counterparts. This is due to the object-verb-subject (OVS) construction of the sentence. Passives are even harder to interpret if they are reversible. Take the next couple of sentences as an example:

8. He was called by her
9. The house was burgled by the thief
The first example shows the difficulties faced. In this case either the guy or girl involved could technically be able to do the calling. In the second example however, the house could hardly be capable of burgling anything and so a correct interpretation would result relatively quickly. It takes time and practice to refine such processing techniques so as to correctly interpret a passive sentence like in (8) without any difficulty. If passive voice requires such difficulty to process and understand then why do we use it? Would it not make life easier to forget about it entirely? The short answer is no. Passives are useful for many reasons. They are useful, for instance, when you really don’t know who the subject is:

10. My wallet has been stolen

Or in order to emphasise something in the sentence:

11. It was the women that was seen by the old man

Or even when a non-active noun has to be used as in the sentence:

12. A non-active noun must be discussed!

The majority of sentences are in the active voice but passive voice is the next most used structure in written text. It is for this reason that one must grasp the structural analysis required for the passive voice as early as possible.

3.3.5 Negation

Sentences in the negative are also quite challenging for a young reader to master. When reading a sentence containing negation, the reader generally processes the positive sense of the sentence and then takes another processing step to arrive at the negative sense. For instance, a learning reader will find it easier to process and respond to a sentence such as:

13. Can you see an object that is square and blue?

In comparison to a sentence such as:

14. Can you see an object that is square and not blue?

Once again, practicing and contact with negative sentences improves comprehension and reading fluency so that a person can be relatively comfortable with constructs like this quite quickly.
3.3.6 Embedding

Embedded sentences can prove quite difficult to process. As already described above in the coined-clause analysis, young readers find it difficult to correctly interpret a sentence in which the object of the main clause can be the subject of the embedded clause like:

15. The lion bit the buffalo that chased the hyena

This is in contrast to the ease at which one can process a sentence in which the subject of the main clause is also the subject of the embedded clause as in the following example:

16. The lion that chased the buffalo bit the hyena

There are even more examples of where embedded clauses cause learning readers more difficulties. For instance, sometimes the subject of the main clause is the object of the embedded clause:

17. The lion that the buffalo chased bit the hyena

These types of sentences are particularly difficult to process as they violate not only the minimum distance principle but also the subject-verb-object sentence word order structure. They will be seen again throughout this paper as a difficulty that can cause problems to even an accomplished reader.

Another type of embedding that causes processing difficulties, especially in the naïve reader, is that of cleft transformation. This type of embedding changes the subject and object order just like the passive voice. Cleft transformation increases the focus on a concept by dividing a perfectly serviceable single clause into two clauses, each with its own verb.

18. The girl drank the juice

19. It was the juice that the girl drank

The sentence at (18) is a perfectly good sentence. If one needed to emphasise the juice, then the cleft transformation is required as in (19). Early readers soon pick up all these processing quirks and have refined an efficient technique within a couple of years that stand to them for the rest of their lives. The more they come in contact with structures as described in this section, the quicker they learn to think carefully and logically about sentence structure. Ultimately they arrive at processing techniques that are fully matured and reasonably flexible to the consumption of new, unseen sentences.
3.4 The Role of Working Memory in Sentence Comprehension

Just like syntax, the working memory plays a vital role during the processing of a sentence. Working memory is the conceptual part of the brain that we employ to store the words of the sentence that we have already read. Syntactic comprehension can only achieve so much if we are unable to remember the words that make up the sentence.

When one encounters a sentence, each word is processed as fully as possible the first time it is read. The results of processing each word such as the letters, the sounds, the meaning, and the word associations are then all stored in working memory until the entire clause has been read. Different clauses contain a different amount of words, some large, some small, thus efficient storage can prove quite important in the overall retention of the clause. For instance:

20. My new shoes, my red book, my pencils and my papers were lying on top of each other on the table

This sentence is relatively simple to process but it contains a large amount of words. Efficient storage is the means that we rely on to remember all the details of such an utterance.

As someone recovers a clause from their working memory, they form the gist of what is implied by the message. In other words, they form an interpretation and mental representation of the clauses meaning. This is then kept in working memory until subsequent sentences, clauses or phrases are read to modify this into another interpretation of the intended meaning. Naturally enough, the process becomes complex when one clause contains a reference to the subject or object of another clause. The process is even more complicated when an entire clause functions as part of another clause as in the following sentence:

21. The fact that he couldn’t finish the race doesn’t faze me in the slightest

As one reads down through a passage, a hierarchical structure of each gist is constructed in working memory. For example, a sentence is processed which leads to an interpretation for that sentence. A subsequent sentence or clause may modify this interpretation slightly. A higher level gist is then constructed to encompass everything that has been read. Eventually, one interpretation succeeds another until the whole paragraph has been read thus creating a gist for the entire paragraph. A person’s ability to temporarily store words in working memory depends on many factors such as their age, experience and language proficiency.

The code that people use to store this information in working memory is always phonological. For this reason, phonological decoding skills are crucial for the use and development of working memory abilities. Therefore, someone with efficient decoding skills will possess the ability to create and maintain effective phonetic representations of written words and will be able to retain, in working memory, both the words themselves and the order in which they occur in the sentence. An efficient working memory is an
advantage in understanding not only the sentence at hand, but also the paragraph, the chapter, the book, the series and so on. The longer the passages one reads and understands, the greater the development of the working memory and hence the greater the ability in the future.

### 3.5 The Processing Theories

As one would imagine, it is very difficult to find agreement among scientists as to how we actually process a sentence. This is due to the fact that we are still largely unaware of the neural processes that take place whilst processing an utterance. There have been many conflicting experiments that favour one theory in the place of another. Nowadays, there are two main theories that seem to be the most plausible models to most scientists, serial processing and parallel processing. They are, however, completely different from each other with regards to the way in which each part of the process is activated in the brain and the interaction among the individual parts during the processing.

#### 3.5.1 The Serial Model

The serial model is, as its name might suggest, a linear chain of neurological processes that link with one another to arrive at overall comprehension. Each part of the processes involved do not interact with each other, they only pass information on to the next process in a manner described by the illustration below:

![Figure 3.5.1.1](image)

In the first stage, a phonological representation of the sentence is processed. This is then handed on to the lexicon facility that recognises the phonological representations as words. These words are retrieved and passed on to the syntax faculty in the brain that goes through three sub-stages. The first is a first-pass parsing action that filters the words into an initial syntactic structure. This is then handed on to a reanalysis phase that makes sure all the constituents fall correctly into a satisfactory parse.

It is worth mentioning that at this stage, according to Frazier&Fodor (1978), the semantic context first plays a role. The conclusion to their experiments favoured a process
in the reanalysis phase that involved the evoking of a rough semantic representation during which a meaning is mapped to the constituents of the sentence. The syntactic analysis would then reconvene in a repair stage where the final output is computed.

Other scientists disagree with this and favour a process where the output of the syntactic process is further refined by the repair stage before being passed on to the semantic analysis phase. Holmes (1979) states that:

“The syntactic approach...requires that the subject complete the syntactic analysis of at least a clause before semantic analysis can begin”

If the serial model is the correct model of the human ability to process sentences then each link in the chain corresponds to a separate and non-interactive step in the process to comprehension. An overall diagram of the language processor is suggested by Forster and is illustrated in figure 3.5.1.2. The serial model is the basis for such a processor.

According to this structure of the language processor, the input features would be the individual words being read. The GPS (general problem solver) has no linguistic stimuli and is employed to process any problems. For the purpose of comprehension however, it needs linguistic input and it receives this from the three processors.

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Illustration taken from *Levels of processing and the structure of the language processor*

Forster, K.I., (1979)
The **lexical processor** sorts the inputs and hands the results to the syntactic processor and the GPS.

The **syntactic processor** sorts the results into a syntactic structure and passes the results to the message processor and the GPS.

The **message processor** takes the syntactic analysis and maps a semantic representation to it before handing the results to the GPS.

The **GPS** gathers all this information from the processors and together with the help of the **general conceptual knowledge** of the surrounding world, the GPS can judge if it is a satisfactory message analysis and output a decision. The decision reached can be seen as a correct interpretation of the message and a subsequent decision is made.

The serial model is a plausible way that our language faculty in the brain processes a sentence. It has, in recent times, come under a lot of scrutiny from scientists. Many experiments have been conducted that find flaws with this model in favour of the model in the following section, the parallel model.

### 3.5.2 The Parallel Model

The parallel model differs from the serial model in one main way, the influence the semantic mappings have on the other processes. Whereas the serial model had each stage independent of one another, its parallel counterpart allows multiple interactions between all stages of the process. In other words, all sources of information are available simultaneously. This semantic approach is described by Holmes (1979) as:

"scanning the input for the major content words and putting these together in the most sensible way. Purely syntactic analysis, such as paying attention to the order of words, their inflections, and so on, is only necessary when this preliminary semantic analysis fails to come up with an unequivocal message."

Many experiments have employed ambiguity resolution as a means to conclude that the parallel model is the only theory that stands strong in the face of criticism. It concedes that there must be an initial syntactic “surface structure” analysis but that this is directly followed by a semantic analysis. Any deep-structure syntactic analyses are left until after the two previous stages have been completed. The following diagram illustrates this. Figure 3.5.2.1
The parallel model is also a plausible explanation of the way we process a sentence. It simply advocates that both semantic and lexical information are used in the process of syntactic analysis. Experiments have showed that it is likely that we, in some way, map semantic associations before we finish processing the sentence. Using the parallel model as a basis, Forster (1979) suggests a system of processing language, in figure 3.5.2.4, that vastly differs from the processor based system suggested for the serial model.

Figure 3.5.2.2

In this diagram, the GPS collects information from all areas of the language faculties. These messages can be intertwined allowing for a process in which results so far can be relayed and used by other areas to guide a correct interpretation. The final decision output is reached by the interaction of all these processes and the overall judgement of the GPS. In this way, a brief structural analysis can be passed to the GPS which then uses semantic rules to find a possible interpretation. If a deep structure analysis is required, the information can then be passed back to the syntactic analyser again.

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9 Diagram taken from *Levels of processing and the structure of the language processor*
Forster, K.I., (1979)
The two models presented show that it is very difficult to totally disprove one model in favour of the other. Experiment results show varying biases towards one or the other model. In his conclusion, Holmes (1979), states:

“The evidence I have presented amply demonstrates that any model of sentence comprehension that minimises the importance of syntax is misguided”

He continues by offering another conclusion in light of his experiments with ambiguity resolution:

“Semantic analysis is preceded by a superficial analysis in which a unique surface structure representation is imposed on the clause”

Further research is required if we are to find out which of the two models better fits our own ability to process sentences. Later in the paper I will refer to these two models again and will offer, under the guidance of my own results, which model seems the most likely to be used by humans.
Chapter 4

Methodology

4.1 Introduction
Syntactic and semantic analyses, as have been discussed in the previous two chapters, combine in some neurological manner during the processing of a sentence to produce what we know as comprehension. In the last section, two theories were put forward to explain this phenomenon. To gain a greater understanding of which process is a more likely model of the way we do, in fact, comprehend, an experiment has been compiled. Drawing from research documented in the first section of this paper in relation to temporary syntactic ambiguity, the rest of this paper will be concerned with discovering more about how we process such analytical pitfalls. More precisely, how much longer it may take us to resolve a sentence in which temporary syntactic ambiguity is present and also, which type of temporary ambiguity we find most difficult.

This type of study naturally raises the question of which people can resolve this ambiguity more quickly and also whether this is an advantage to some people? The domains that this paper will be concerned with are the traits of a bilingual’s processing of temporary ambiguity. It is also concerned with whether or not contact with linguistic instruction prior in one’s life helps to resolve these difficulties more quickly. Each of these questions will be dealt with in chapter seven when the results of the experiment are discussed.

To study the way in which we process a sentence is extremely difficult. After all, we are still largely unaware of the neurological processes involved. However, there are a few areas that we can analyse. The most obvious of these is the time factor. With this in mind, section 4.2 attempts to document the parameters that must be adhered to in order to create a valid experiment. These parameters are described from research in the area. The experiment that has been undertaken in this paper is a psycholinguistic study of how quickly or slowly we can resolve temporary syntactic ambiguity. In achieving this, five different categories of temporary syntactic ambiguity have been used. These categories will be explained further in the section 4.3. In each case, a piece of software was used, ICECUP3, to traverse the ICE-GB corpus of English to find examples of each category of temporary ambiguity. This is further described in section 4.4. This will lead on to the final section in the chapter where the final design of the experiment will be discussed.

4.2 Experiment Parameters

To conduct any experiment, a set of rules must be adhered to in order to maximise the validity of the conclusions that can be drawn from it. In his book, “The Empirical Base of Linguistics”, Schütze assesses traps that other linguists have fallen into. He describes possible biases and general issues that can arise whilst constructing an experiment and also advises the experimenter on how to avoid such obstacles. According to Schütze (1996), these factors can be split into two main groups; materials used i.e. the sentences employed in the experiment, and the procedures employed, which include the subjects, the instructions, and pitfalls to avoid and the second. The first of these groups, the procedures,
will be treated in the subsequent subsections. The materials used will be discussed in the next section.

4.2.1 Selection of Subjects

The selection of subjects is an obvious starting point when devising an experiment. The correct strategy of choosing participants is vital in validating an experiment’s conclusions. The subjects must be a diverse cross section of the population in order to claim that they are a representative group of the entire population, and that their judgments are representative of the entire population. For an experiment of the kind this paper describes, such a prerequisite is necessary. Schütze writes:

“…that if it is the study of competence of normal native speakers that we claim to be investigating, we need to study random samples of normal native speakers.”

In relation to the current experiment, the average age and sex of the participants must be kept track of. This is a parameter that must be followed in order to validate a representative group of the entire population. How this is achieved will be discussed in section 5.4. Schütze feels that this is a parameter that theoretical linguists rarely adhere to.

Another pitfall that Schütze warns against is that participants must not be people with any linguistic training. As one might expect, through the very nature of studying language, a linguist might unconsciously be applying rules that a non-linguist would not even be aware of. Greenbaum (1977b) states that a linguist:

“…has been examining over a period of time a set of examples exhibiting close similarities and therefore his judgments will tend to become blurred”

and also that:

“he is inevitably prejudiced by his general theoretical position and by the specific hypothesis he is testing”

In light of these prejudices, the linguistic background of the subjects in an experiment must be discovered so that valid conclusions can be extracted from the exercise. In relation to the current experiment, the requirement that the subjects not be a linguist is not strictly adhered to however. This is due to a couple of reasons. The first is that the experiment, by definition, includes a comparison that can be made between linguists and non-linguists. It can be conceded that linguists may have an upper hand at tackling temporarily ambiguous sentences. But, instead of these subjects being omitted from the experiment, they have been included in order to compare how much of an advantage they may possess. To achieve this, the subject’s linguistic background must be documented after completion of the experiment and compared later in the results. This will be discussed as the topic of section 7.5.
4.2.2 The Instructions

The instructions are also a crucial part to the experiment. There are several components to take into account when drawing up the instructions for an experiment. Schütze recommends that linguists must make specific exactly what is required of the subject. A definition or explanation of any of the terms that are required in the experiment should also be present. Schütze explains that instructions “…must be specific…”

Another important parameter that must be acknowledged is the necessity of keeping the statement of instructions to a reasonable length. If this is not the case, obvious inaccuracies in relation to results would surface. The participant’s concentration is the key to accurate results and if the length of instructions is too large, they may get bored and not read them properly.

Greenbaum (1977b) suggests telling the participants what the experiment is really about so that they will not introduce variability in the results by making guesses as to what it’s about. If you don’t explain to subjects what you want, each one takes his own interpretation and the results may become meaningless. This parameter is not adhered to in the instructions of the current experiment for a few reasons. They will be more fully explained in the section 4.5.2 when the design of the experiment is being discussed. For now it suffices to mention that the less the subject knows as to what the experiment is about, the more accurately one can obtain results for the way in which they resolve temporary ambiguity. After all, the resolution is a largely unconscious process that should remain so. The next section specifies how the material was found for the experiment.

4.3 Temporary Syntactic Ambiguity Categories

There are many temporary syntactic ambiguity categories. Many are commonly known under the guise of garden path sentences. Five such categories were chosen to be dealt with in this paper. They are:

a. Complement clause Vs Relative clause
b. Object noun phrase Vs Main clause subject
c. Direct object Vs Embedded subject
d. Prepositional phrase attachment
e. Main clause Vs Complement clause

These five categories were chosen on the basis that they were well documented and there were numerous examples that could be employed in the experiment itself.

Each category can be relatively easy to understand and this was another prerequisite if bilinguals are taking part in the experiment. The easier the construction of the sentence, the more likely the results will reflect the ambiguity resolution that is being measured.
In truth, any number of categories could have been chosen but five of the most frequent ones were used. This can give us an overall view of which temporary ambiguity might be the most challenging for either native speakers or bilinguals to process. This may ultimately help future teaching methods to avoid such difficulties before they are encountered.

4.3.1 Complement Clause Vs Relative Clause

The first of the ambiguities that are being dealt with in the experiment is between the complement clause of a sentence and the relative clause of a sentence. The complement of a sentence is traditionally a constituent of a clause such as a noun phrase or an adjective phrase that is used to predicate a description of the subject or object of the clause\textsuperscript{10}. There are two possible functions that complements can play in a sentence, namely as an object or subject complement.

1. The nation made Berti the king

2. Berti was the king

In the first sentence, the noun phrase “the king” has the function of object complement. This can easily be resolved by asking the question, what did the verb in the sentence do to the object of the sentence? The answer in this example can be clearly seen as, “making Berti the king”. In the second sentence however, the complement is qualifying the subject and is hence, a subject complement. A common question that can be asked to verify this is, what did the verb do to the subject of the sentence? For this example, the answer can be confidently given as, “being the king”.

In light of this, a complement clause can be defined as a notional sentence or predication that is an argument of a predicate\textsuperscript{11}. In other words, it acts in the same way as a complement of a sentence except it has a clause status. Therefore it acts as the complement of the hierarchically superior clause. Here are a couple of example sentences:

3. We thought that you were coming

4. For you to come would be a mistake

As you can deduce from the above examples, complement clauses can function as a subject complement clause or an object complement clause. Sentence 3 acts as an object complement clause as it answers the question as to what the verb does to the object, namely the fact that you were coming. On the other hand, as a subject complement clause, sentence 4 states that “for you to come” is qualifying the subject i.e. what would be a mistake.

\textsuperscript{10} Definition taken from What is a complement?, www.sil.org

\textsuperscript{11} Definition taken from What is a complement clause?, www.sil.org
Complement clauses can become very complex and difficult to resolve when the qualifying complement clause is embedded or nested; this is out of the scope of this paper.

A relative clause is a clause which describes the referent of a head noun or pronoun. It often restricts the reference of the head noun or pronoun. There are several types of relative clauses such as external, internal, restrictive, non-restrictive, etc… The study of these is outside the scope of this paper and will not be dealt with any further. There are however, many different ways of spotting relative clauses but the easiest are by looking for key words such as who or that. They can come in many guises such as the following two sentences:

5. The man who went to the shop
6. The passengers leaving on flight fr045 are lost

The examples illustrate that despite being able to spot a relative pronoun, this doesn’t always mean success in spotting a relative clause as sentence 6 contains no such pointers. The question that can often be asked to verify the existence of a relative clause is, does it qualify the noun that precedes it? In both the above cases this is a positive outcome.

Using the two areas that have been discussed above, the question must be posed as to how these two concepts can be linked to temporary syntactic ambiguity. The answer is in the way they are processed. Read the sentence below:

7. The president told the journalist that the first lady annoyed that he should go jump in the Potomac.

On first reading the sentence, you might find that you paused, however little, at a certain point in the sentence. This point in the sentence is where temporary ambiguity has arisen and your brain needs a split second to resolve it. You are largely unaware of the process. It happens as a result of the way we process the sentence. As we read through the sentence, a syntactic analysis is being formed. When we stumble upon a word that does not fit in to our syntactic analysis thus far, a reanalysis has to be employed. This is what is responsible for the slight pause. To illustrate the processes involved in the previous sentence, it is broken up slightly. After reading:

8. The president told the journalist that the first lady annoyed

The syntactic analysis is expecting a word such as “him” or “the man” or some sort of noun to fit the overall sentence analysis. Instead, when the word processed is “that”, a reanalysis of the sentence is required.

The complement clause versus relative clause ambiguity arises in that we process the sentence expecting “that the first lady annoyed” to be a complement clause. This is, in fact, not the case as we should be reading it as a relative clause. It takes us a split second to realise this and continue.

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12 Definition taken from What is a relative clause?, www.sil.org
13 Sentence taken from Sentence comprehension, www.ling.udel.edu
4.3.2 Object Noun Phrase Vs Main Clause Subject

The second ambiguity category that the experiment contains is that of object noun phrase versus main clause subject. These terms need less of an introduction to understand. An object noun phrase is simply the noun phrase part of the constituent of the sentence that functions as the object in the sentence. This could range from “the man” to “the ugly duckling” as long as it acts as the object of the sentence. For instance:

9. He added *yet another comment*

In this sentence, “yet another comment” acts as the object or equally, the object noun phrase.

The main clause subject of a sentence is the constituent of a sentence that functions as the subject of the verb in the main clause. It is commonly referred to as simply the subject of a sentence. It is merely termed as it is in order to distinguish it from other clause subjects.

The temporary ambiguity that may arise between these two concepts is extremely slight and but can cause all sorts of semantic pitfalls. Take the following as an example:

10. While Wallace was reading the newspaper was burning

To illustrate what happens during the processing of this sentence, two diagrams have been drawn out. Figure 4.2.2.1 shows a diagram of our syntactic analysis up to a certain point in the sentence. After this point, a reanalysis must be performed as the following word does not fit into the current syntactic analysis. Figure 4.3.2.1

14 Sentence taken from *Sentence comprehension*, www.ling.udel.edu
So far, this is a quite plausible syntactic representation of the sentence. The processing of the sentence draws us to a syntactic construction where “the newspaper” is regarded as being the object noun phrase of the predicate. The next expected word might therefore be a noun phrase such as “the leg” in “…the leg of the chair broke” or “he” as in “…he slipped into unconsciousness”. Instead of this, we next process the word “was”. This is neither expected nor desired in the current syntactic interpretation and therefore we must undergo a reanalysis. After finishing the sentence we have resolved the difficulty and analysed the sentence correctly as:

Figure 4.3.2.2

While Wallace was reading the newspaper was burning

As you can see from the diagram, the syntactic analysis surrounding the underlined region has changed dramatically from the first diagram. This is the area that was reanalysed after the temporary ambiguity had arisen. The “newspaper” was correctly interpreted on the second attempt to belong to the subject of the main clause and not the object noun phrase as initially perceived.

4.3.3 Direct Object Vs Embedded Subject

The next section deals with direct object versus embedded subject ambiguity. The terms require a little introduction before their ambiguous interaction can be explained. The direct object of a sentence is a grammatical relation that exhibits a combination of certain independent syntactic properties, such as the following:

- The usual grammatical characteristics of the patient of typically transitive verbs
- A particular case marking
- A particular clause position
• The conditioning of an agreement affix on the verb

• The capability of becoming the clause subject in passivization

• The capability of reflexivization

This is a convoluted definition that requires a certain amount of background linguistic knowledge to decipher. A direct object can however, be spotted quite quickly if you follow a simple question, what does the verb do? For instance, if the sentence is “They make cars for a living”, the question would be, they make what? In every instance, it is the cars that they make and so the direct object is located.

An embedded subject is somewhat more difficult to find. It is however quite easy to explain. The subject constituent of a certain sentence is merely embedded in the sentence to the extent that it might cover a whole clause in the sentence. The subject clause is still treated as the subject of the sentence, yet it may contain many elements that themselves are good candidates for being the subject in their own right. Take the following as an example:

11. The gardener sweeping the pathway which had become over run is too old

The underlined words in the above sentence altogether constitute the subject of the sentence. It is made up of many words though. As you can see, this embedded subject concept can be extended indefinitely creating additional, even more complex, sentences.

Combining these two linguistic phenomena together in a single sentence can result in temporary ambiguity. The ambiguity in this case is raised when an embedded subject is misinterpreted on the first parse as being a direct object. For instance:

12. The smart student remembered the answer was probably misleading

Here the reader would progress through the input until the word “was” is read. At this point, the syntax of a full sentence has been satisfied in that the noun phrase, “the smart student” and the verb phrase, “remembered the answer”, combine correctly. The noun phrase “the answer” is therefore parsed as the direct object of the verb.

15 Definition taken from What is a direct object?, www.sil.org
16 Sentence taken from Sentence comprehension, www.ling.udel.edu
When the next word after “answer” is discovered, namely “was”, a reanalysis must be performed so that the new structure can be accommodated. This may come in the form of just a split second and once again, we are largely unaware of the process. This type of ambiguity should not pose many problems to resolve. The possible reasons for this will be discussed in chapter seven. For now, it suffices to mention that it is not very syntactically challenging to reanalyse.

### 4.3.4 Prepositional Phrase Attachment

To discuss prepositional phrase attachment temporary ambiguity we must first give a definition of what a preposition is. Quite simply, a preposition is a word that we use to indicate location. Usually these prepositions show or relate this location in the physical world. To define them more precisely, they are words or phrases placed typically before a substantive and indicating the relation of that substantive to a verb, an adjective, or another substantive\(^1\). There are more than one hundred prepositions in English which is quite small in comparison to nouns and verbs but their relative frequency in the language is the greatest. Some common prepositions are:

<table>
<thead>
<tr>
<th>Preposition</th>
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<th>Preposition</th>
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<tbody>
<tr>
<td>At</td>
<td>To</td>
<td>From</td>
<td>On</td>
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<td>From</td>
<td>For</td>
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<td>Under</td>
<td>By</td>
<td>With</td>
<td>Over</td>
</tr>
<tr>
<td></td>
<td>By</td>
<td>With</td>
<td>Past</td>
</tr>
<tr>
<td></td>
<td>Along</td>
<td></td>
<td>Outside</td>
</tr>
</tbody>
</table>

A prepositional phrase is therefore a phrase that contains a preposition as its head and a modifying clause thereafter. Examples of such phrases are:

**Figure 4.3.4.1**

13. On the bus
14. To the car

\(^1\) Definition taken from Oxford English Dictionary-online, [www.oed.com](http://www.oed.com)
At first sight you would wonder how these may be ambiguous in any way. The simple answer is when they fall, one after the other, in a sentence, their attachment to referent objects becomes temporarily unclear. For example:

16. The cook placed the cake in the oven on the table

Similarly to the last category of ambiguity, a fully grammatical sentence lies within the main sentence. In this case, the syntactically sound utterance:

17. The cook placed the cake in the oven

Is parsed in such a way that no more words are expected by the reader.

As the input is processed, the next word discovered, “on”, requires a reanalysis of the syntactic structure up to this point as it does not fit the current “provisional” structure. This reanalysis is caused by the temporary ambiguity of the prepositional phrase attachment. In other words, on first reading, the reader assumes that the cook merely “placed the cake in the oven”, but after the syntactic reanalysis, realises that the cook placed the cake “on the table”. The prepositional phrase that was first thought to refer to where the cake was placed, is discovered to refer to the place where the cake had been before it was moved i.e. in the oven.

This type of temporary ambiguity should be more difficult than the others to process. The main reason for this is the relatively low frequency of sequential prepositional phrases in the English language. The reader simply has not come in contact with a sentence of this structure before and so, does not expect it. This will be further discussed later in the paper in connection with the results from the experiment in chapter seven.

4.3.5 Main Clause Vs Complement Clause

This category of ambiguity is relatively easy to explain. It should be more difficult to process however. As has already been discussed in the previous sections, the main clause of a sentence is where the main predication lies. It is only referred to in order to distinguish it from other types of clauses that may be present in the sentence.

A complement clause is defined in section 4.2.1. In this instance of ambiguity, the main clause is so termed to distinguish it from the complement clause in the sentence. With both of these arguments sufficiently defined, it remains to show how they might be confused when found together in a sentence.

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18 Sentence taken from *Sentence comprehension*, www.ling.udel.edu
18. The boat floated down the river sank without a trace\(^9\)

Whilst the reader progresses through the sentence, the constraints of a main clause are fulfilled by the part of the sentence at (19).

19. The boat floated down the river

Like the other ambiguities however, when the next word is processed, a reanalysis is required as it does not fit the initial interpretation. By the time the reader has reached the end of the sentence, he realises that it was not in fact a main clause that had been read, but rather a complement clause. The semantics of the main clause are therefore “the boat sank without a trace”.

This type of temporary ambiguity might be expected to be the most difficult of them all to process and gain a correct interpretation from. The main reason for this can by hypothesised as the fact that this type of sentence construction is extremely rare in the English language. A regularly preferred replacement for the example given would instead be the unambiguous counterpart at (20).

20. The boat that was floated down the river sank without a trace

This will be discussed again later when the experiment is the topic of the section.

4.4 **ICECUP VERSION 3.0**

Once the individual categories of temporary ambiguity have been decided upon, further example sentences are required to satisfy the material needed for an experiment. After all, more than just one example is needed of each category if we are to draw any substantial conclusions from such an experiment.

In order to find enough material for an experiment, a corpus was used. In theory, this allowed for a searching procedure to find different instances of the five categories of temporary ambiguity.

The piece of software that was used to gain material for the experiment is called the *International Corpus of English Corpus Utility Program* or in short ICECUP version 3.0. The two previous versions of the software were developed by Akiva Quinn (1992) and Porter & Quinn (1996) respectively. The third version was realised by Sean Wallis (1998) which was designed from the outset for exploring the parsed version of ICE-GB, the related corpus.

The software was received from Dr. Martin Emms and was gratefully employed to find ambiguous sentences. From a CD ROM format, the program runs quickly and with relative ease.

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\(^9\) Sentence taken from *Sentence comprehension*, www.ling.udel.edu
ICECUP is a program that can achieve many different goals. For the purpose of finding material for an experiment, it can be employed in a number of different ways. The first is that it contains, as stated above, a parsed version of the corpus ICE-GB. From this parsed version, a particular syntactic construction can be unified with a self constructed syntax tree. This allows us to find all the similar syntactic constructions in the corpus. In theory, relating that to the purpose of finding material for the experiment, we can enter a syntactic construction of an ambiguous category and are able to find other examples that can be used in the experiment.

To define such constructions in ICECUP is relatively easy to do. The button entitled “New FTF” starts a new interface that graphically represents the syntactic tree you are about to look for. Figure 4.4.1 illustrates how a syntactic tree might look after a few functions and sentence constituents have been added. The head node is signified by the yellow node to the top left. The “PU” stands for parsing unit and it stands as the root of any tree you may require. The “CL” stands for the fact that you are searching for a clause. Instead of the tree structure from top to bottom as is commonly used in linguistics, ICECUP employs a left to right equivalent.

Figure 4.4.1

The five black arrows in between the nodes in the illustration signify that the next node is directly following the other i.e. there cannot be any other node in between.
Once a syntactic tree has been decided on, the search button in the top right corner of figure 4.4.1, entitled “start”, begins the exploration of the corpus. The results are then displayed in a graphically pleasing manner as you can see from figure 4.4.2. The relevant sentences can then easily be read off and added to the experiment.

The second way in which the software can be used to find material for the experiment is the fact that it can search the corpus for not only a syntactic structure but also a word. In order to search the corpus for a word, the big button entitled “text” at the top of the page in figure 4.4.1 must be pressed. A small window appears with a text box in the centre. It is here that a word may be entered. To begin the search, simply press the start button.

Figure 4.4.2 also demonstrates that you can stop the search mid-way through finding all the results. This can be achieved by pressing the start button whilst the program is running a search. This can be quite an advantage if the set of results found is extremely large and of which, only a small subset may be required. By pressing the same button, the search can be reconvened.

In addition to this, ICECUP allows for the search of a word as part of a syntactic structure itself. This makes the procedure easy to follow when searching for relevant material. Below, in figure 4.4.3, a typical snapshot shows how to incorporate the search for a word into the syntax tree.

Figure 4.4.3
4.4.1 Disadvantages

There are a number of disadvantages with the software however. The first is probably the most important with respect to the intended experiment. Despite numerous ways of being able to search through the corpus, not one ambiguous sentence could be found. This, it must be assumed, reflects the unambiguous nature of language in general. Ambiguity is generally avoided, unless intended, and this phenomenon results in the unambiguous corpus.

In order to overcome this disadvantage however, the search can be concentrated on the sentence’s unambiguous counterparts. For example, the syntactic structure that could be searched for was a sentence like:

20. The cook placed the cake that was in the oven on the table

In lieu of an ambiguous sentence such as:

21. The cook placed the cake in the oven on the table

This type of approach achieves moderate success, enough to make it a viable means of gathering material. As such, it is employed for the current experiment.
A further disadvantage with the software is that it does not use universally agreed annotation in its syntax tree. For example, verbal constituents were not necessarily dominated by a verb phrase as in figure 4.4.1.1 below.

Figure 4.4.1.1

This disadvantage can be overcome by some straightforward learning. For each syntactic structure that is required, a structure with all the necessary components must be found in the corpus. For example, if a structure is required where a noun phrase follows a relative pronoun, then a similar sentence must be found in the corpus. This could be achieved by searching for specific words in a sentence that corresponds to a noun phrase followed by a relative pronoun such as “the man who”. By double clicking on the identification number to the left of each of the resulting sentences, illustrated in figure 4.4.2, the syntax tree for that result sentence is displayed. From this example construction, the syntactic annotation can be learned. This is a little time consuming but after the specific syntactic quirks are realised, this disadvantage diminishes considerably.

Overall, ICECUP is a very useful tool to possess when dealing with language. It can perform many tasks which range from looking for simple words to finding complex syntactic structures. The program can be used to find unambiguous sentences. The ambiguous sentences that are required can then be formulated from their unambiguous
counterparts. This is the method that was employed in order to find material for the experiment.

4.5 Design of the Experiment

Taking all the previously described factors, recommendations and parameters into account, an experiment has been constructed to test the temporary ambiguity resolution potential of humans. More specifically, which type of ambiguity proves most difficult to understand and process. A comparison of the results from these ambiguities can then be used to highlight the differences between certain sections of the population that possess varying level of resolution competency.

The experiment tests the relative time it takes for an ambiguous sentence to be resolved. It is relative to the closest unambiguous copy of the sentence. For instance, if a subject sees an unambiguous sentence such as:

22. The milkman remembered the address that was left at home

Then he would also see its ambiguous counterpart, as in sentence (23). This relation is reciprocal. Therefore if he was first to see sentence (23) then he would later see sentence (22).

23. The milkman remembered the address left at home

As the subject is reading through, say sentence (22), he will only see the sentence one word at a time. This type of experimentation is used by a number of previous linguists such as Traxler (2002). The subject needs to prompt the next word through a stimulation of some sort. This is described in the next chapter under the topic of experimentation but for now it suffices to know that a computer is employed for such a task. To stimulate the next word, the subject must click a button with a mouse. After each click, the word that they have read disappears whilst being replaced by the next sequential word in the sentence. To illustrate this, the subject would progress through the sentence as described below:

The………………………………………………………………………… [Click of button]
………….milkman………………………………………………………… [Click of button]
…………………remembered……………………………………………………… [Click of button]
…………………………….the……………………………………………………. [Click of button]
……………………………………..address…………………………………… [Click of button]
The same process is enacted for sentence (23), that is, when the time comes for the subject to read it. Let us now introduce the term, “ambi-pair”, to cover this couple of ambiguous and unambiguous sentences that a subject sees. For the above example, the ambi-pair would consist of sentences (22) and (23).

In addition to being shown a set of ambi-pairs, each subject will finish the experiment by being shown a paragraph in the same way as the ambi-pairs, one word at a time. The paragraph will contain a few short sentences but will always have a temporarily ambiguous sentence as its last. This ambiguous sentence will have appeared in an ambi-pair of another subject. For example, if one subject had the ambi-pair of (22) and (23), then a different subject may have the ambiguous sentence of (23) as the final sentence to their paragraph.

This part of the experiment is to test if prior contextual knowledge might aid a subject in the relative time it takes him to resolve the ambiguity. In other words, the relative time it takes for a subject to resolve the final sentence in their paragraph can be compared to the time it took another subject to resolve the exact same sentence but in an ambi-pair, which is, the same sentence but in isolation. To revert back to a hypothesis of the parallel model of section 3.5.2, if this was a more realistic model of the way in which we process sentences, then you would expect the ambiguous sentence in the paragraph to be resolved relatively more quickly than the one in isolation. To further specify how the experiment is set up, it is first necessary to mention the five different versions construction.

4.5.1 Five Versions

The experiment is set up on the basis of five different versions. Each version contains a different set of sentences. A participant in the experiment can only complete one of the five versions. All five versions however share the exact same construction. If we were to allow one subject per version then we would trivially have five subjects. Let’s call them Subject (A)….Subject (E).

Subject (A) is shown five ambi-pair’s in total. Each one corresponds to a different category of temporary ambiguity as described in section 4.3. In addition to this, he is shown a paragraph. He makes his way through the paragraph in the same way as the sentences. His final sentence however will be ambiguous. The same sentence is seen in an ambi-pair of say, Subject (B).

Each subject sees only one paragraph as there is only one paragraph at the end of each version. Each of the five paragraphs contains a different example of one of the
categories of ambiguity as described in section 4.3. For instance, Subject (C) may have a main clause versus complement clause temporarily ambiguous sentence in an ambi-pair that Subject (D) has as the last sentence in his context paragraph. To clarify what each of the five subjects are exposed to, a general plan for the five versions is illustrated below. Let the five categories of temporary ambiguity be Category (1) …Category (5):

Figure 4.5.1.1

<table>
<thead>
<tr>
<th>AMBI-PAIRS</th>
<th>PARAGRAPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject(A)</td>
<td>Category(1) Category(2) Category(3) Category(4) Category(5) CATEGORY(5)</td>
</tr>
<tr>
<td>Subject(B)</td>
<td>Category(1) Category(3) Category(4) Category(5) Category(2) CATEGORY(1)</td>
</tr>
<tr>
<td>Subject(C)</td>
<td>Category(3) Category(4) Category(5) Category(1) Category(2) CATEGORY(2)</td>
</tr>
<tr>
<td>Subject(D)</td>
<td>Category(4) Category(5) Category(1) Category(2) Category(3) CATEGORY(3)</td>
</tr>
<tr>
<td>Subject(E)</td>
<td>Category(5) Category(1) Category(2) Category(3) Category(4) CATEGORY(4)</td>
</tr>
</tbody>
</table>

The above diagram shows the actual layout of the five versions. Subject (A) therefore starts with a sentence from an ambi-pair of the first category. This is followed by a sentence from the second category and so on. Subject (C) starts with a sentence from category three, etc… In relation to the paragraphs, Subject (E) is shown an ambiguous sentence from category four. The structure of the ambi-pair layout in each of the versions is treated in section 4.5.3. The next section discusses the instructions that each participant receives.

4.5.2 The Instructions

The instructions that each of the participants sees at the beginning of their version of the experiment is the exact same, after all, the five versions differ only in the set of sentences employed. As discussed in section 4.2.2, the instructions must be very specific and clear. As described in the appendix, they are extremely short as well so as to not bore the subject.

The instructions do not make any attempt to inform the participant as to the motivation of the experiment in contrast to Greenbaum (1977b) suggestion. This is due to the fact that syntactic and semantic processes are largely unconscious and any overt attempt to inform the subject of the motivation behind the experiment would jeopardise the validity of the results. This desire to keep the motivations behind the experiment hidden from the
participant is an ultimate goal throughout. The subjects are informed as little as is required for them to complete the experiment successfully.

They are first informed of what they are about to see i.e. ten sentences and a paragraph. They are then informed as to how they will see these sentences. An important instruction given is the fact that all the sentences are fully grammatical. This will encourage the user to treat the sentences at face value i.e. not to look deeper into the sentences than a short glance allows. They are then informed of how they can progress through the experiment. The instructions then state that questions will appear after the sentences. With all this taken on board, the subject is equipped to begin the experiment.

4.5.3 The Sentences

The sentences that each subject sees are described in the appendix of the paper. There is one aspect to the sentences however that has not been discussed so far. Which sentence of the ambi-pair should the subject be exposed to and at what stage in their version?

To get a second opinion on the matter, Dr. Martin Emms was consulted. The outcome of the consultation was that each subject should start their version of the experiment with an unambiguous sentence. This would introduce them to the make up of the experiment as the sentence should not pose any difficulties to parse. So, for Subject (A), he sees an unambiguous sentence from category (1) first. The ambiguous-unambiguous sentences are then alternated so that Subject (A)’s second sentence is an ambiguous sentence from category (2). His third sentence is then an unambiguous sentence from category (3), etc…

To recap, the order as described in figure 4.5.1.1 is repeated for each subject before a paragraph is seen. There are five ambiguous and five unambiguous sentences that follow the order with an unambiguous sentence beginning the experiment. Each subject merely sees a different example sentence of the temporary ambiguity categories.

In addition to reading through the sentences, the participants must demonstrate, at the end of each sentence, that they resolved the ambiguity successfully. Therefore, at the end of each sentence in the ambi-pair, a control question must be answered. These are all documented in the appendix. In essence, the control question requires that the subject has correctly parsed the sentence; otherwise the answer will be incorrect.

4.5.4 The Participants

The majority of the participants that took part in the experiment were Trinity College students. Many Trinity College lecturers also took part. Originally, the links to the
experiment were intended for outside participation, family and friends, but due to technical difficulties, discussed in the next chapter, outside use was prevented. This unavoidable problem left the experiment short in relation to the premise that the participants must be a representative cross section of the entire population. However, great efforts were gone to in order to make the participants as representative as possible.

Friends and fellow students were the main source of participants to satisfy the category of non-linguists in the population. Fellow CSLL students were the main source of results for the category to represent linguists in the population. In addition to this, many friends and lecturers helped out in order to record results for the bilingual analysis category. Non-linguists were the most difficult category of the population to find. More precisely, older non-linguists were the most difficult to get to do the experiment. As access to the system is limited, often even within the college network, time had to be spent recruiting middle aged non-linguists.

When the initial response was insufficient however, a new tactic was employed to generate subjects. In order to increase the size of the experiment, making the results a better representation of the population, and in order to recruit more non-linguists, time was spent in computer labs throughout college. A small slip of paper was distributed to allow the receiver to access the experiment on-line. The idea behind this will be discussed further in the next chapter. It suffices to mention that in total, 110 slips were given out with moderate success of hits to the site. This was the main method employed for getting non-linguists to complete the experiment.

All the participants that took part had to fill in a personal form at the end of the experiment. The details of the form are left to the next chapter. For now it suffices to say that the questions asked of the subjects are done so in order to categorise them during in the consideration of the results. Their linguistic background was asked of them along with whether they were male or female. Their age is also asked of them so that a representative population can be simulated as much as possible i.e. to reduce the domination of student-aged participants.

Chapter five

Experimentation
5.1 Introduction

Experiments can be quite difficult to get right. As described in the previous chapters, there are a lot of parameters that must be taken into account. The experiment that is described in the previous chapter has a further requirement. This requirement however, is the most important one.

In order for the experiment to be achieved successfully, a machine must be employed to handle the experiment. The obvious machine that is used is a computer. A computer must be used for the experiment for several reasons. Firstly, computers can be used to not only run the experiment but to also store all the results of the experiment. They can be easily manipulated to run efficiently and effectively. The second reason, and probably the most important one, is in relation to the specifics of the experiment.
Time is the essence of the experiment, more specifically, time intervals. The experiment is not primarily testing answers to questions as such or how someone thinks; it is simply testing the time it takes to read sentences. A sentence may take any amount of time to read, but words take a much shorter length of relative time. In fact, a word is generally processed in a split second, depending on its length and complexity. It is virtually impossible to time a person, word by word, reading a sentence. You would be starting and stopping a stopwatch far too quickly to gain any information from the exercise. Therefore, without the aid of a computer, this type of experiment would prove virtually impossible.

A computer is, on the other hand, well equipped for the purpose of timing. As the participants progress through the sentence they see one word at a time. To see the next word they must stimulate the computer into action through the pressing of a button. For a computer, timing a person’s response to a button stimulus is simple. In this sense, a computer can be employed to do nearly all of the experimentation work.

This chapter discusses the method of experimentation. A computer is used as the basis for the experiment. To make the experiment more accessible however, the program that runs the experiment is not reliant on software being run on a single computer. A web-based tool is employed so that the experiment can be accessible from a theoretically enormous source, the entire world. As a result of difficulties faced, this was not possible for the current experiment but in theory, any number of participants from all over the world could participate.

5.2 Web Tool

To implement the experiment, a web tool was employed. The web tool that is referred to throughout the remainder of the paper is an automatic web-based experimentation tool that has been previously developed by past final year students of Computer Science, Linguistics and a language. Six students have previously worked on or with the tool as part of their Final Year Project (see Kenny(1998), McGowan(1999), Guennouni(2000), Ryan(2001), Hourihane(2002) and Harrow(2003)). Sarah Kenny originally worked on the idea in 1998. The motivation for the project in the first place was Kenny’s interest in working on a multidisciplinary project that encompassed intense programming in a psycholinguistic domain. In this, she maintained a balance between computer science and linguistics, a concept on which the degree is based. The idea for creating such a web based experimentation tool is down to the fact that:

“no serious tool exists for those involved in creating linguistic experiments to model their experimental work on the web”\(^{20}\)

In more recent years, Fionnuala Hourihane (Hourihane 2002) improved upon the initial design. She added the function of allowing multiple experimenters, a facility that is very important for the accessibility of such a program. She also designed an Experiment

\(^{20}\) Quote taken from A Generic Automatic Experiment Creation and Presentation Tool, Kenny (1998)
Manager to oversee these experimenters and the entire system. Yet another facility that she added was a system that provided user authentication to control the access to the experiment, this is very important so as to control the participants that take part in an experiment and in doing so, to safeguard the authenticity of the results. She achieved other successes as well such as creating a list of previously created experiments along with their details, a redesigning of the file storage system, an editing of experiments facility and a facility to allow the experimenters to view and check their own experiments without recording any results for themselves. In all, Fionnuala refined the web tool so that it could be used more easily and effectively by possible experimenters.

Gratitude must also be extended to Yvette Graham who is currently undertaking a Masters by research program with the computational linguistics group in Trinity College Dublin. Yvette acted as the Experiment Manager for the current experiment. She is currently working on the web experimentation tool by further adding the facilities to analyse experiments, edit them and to greater improve the user interface.

The amalgamation of all the stated ideas and subsequent improvements has resulted in a web tool that has enormous potential and functionality. There are several advantages for using such a tool. Some of these have already been alluded to but they will now be explained in more detail.

Hoy & Sheehan (1999) outline seven advantages of using the internet to conduct experiments. The first of these is design flexibility. Design flexibility refers to the fact that experimenters:

“can take advantage of the graphic power available through programming languages”

Another advantage, referred to in the previous section, is that it allows a much greater audience to partake in the experiment. This advantage is coupled with the possibility of comparing dialectal variations of the language experiment. The web based tool also encourages the participant to partake in the experiment at their leisure i.e. in their own time and space. This generally makes the results more accurate and in doing so improves the conclusions that can be drawn from the experiment.

The internet also cuts down on the costs to the experimenter in both time and resources. A high number of responses can be generated relatively quickly. In addition, the experimenter is not required to be present during an on-line experiment which allows him more time to generate possible subjects and ultimately analyse the results.

There are many advantages connected to the absence of the experimenter from his experiment. Subject anonymity is the most important of these. The subject is unknown to the experimenter which improves accuracy of results even further and can also cleanse the experiment of any biases that the experimenter may have with respect to the individual participants that he would otherwise have had to meet, face to face. With all the inherent advantages, the current experiment was made available to be conducted on any computer that could gain access to the Internet. In practice however, due to technical difficulties it was largely confined to the Trinity College network. The specifics of the web tool and how it was used to achieve this are described in the following section.
5.3 Using the Tool to Define the Experiment

To begin the process of constructing the experiment, contact was made with Yvette Graham, the Experiment Manager. A link was attached to her responding e-mail whereby the program could be accessed. A login name and password was also attached. This information was then used to gain access to the login in page and subsequently to the home page.

The first page that is displayed is the personalised home page for the experimenter. It contains all the experiments that the individual experimenter may be using. There is no limit on the number of experiments as they are all stored on the computational linguistics research groups file space, but the names of the experiments must have no spaces contained in them. Armed with this information, the construction of the experiment can begin. In figure 5.3.1, the final version of the homepage can be seen. There are a couple of practice experiments entitled “TempSubject1”, “Temp” and “Tempguity”, etc… which were not used but were vital to the learning process involved in using the tool.

Figure 5.3.1
Experimenter’s homepage. Subject one, two, three, four and five represent the five versions of the experiment. Some of the others represent the trial and error files.

The five versions of the experiment as described in section 4.4.1 can be seen in figure 5.3.1. They are named “Subject1”–“Subject5”. These will be discussed again later in this chapter.

The tool caters for a variety of different styles of experiments. Each experimenter that uses the system may require an Experiment Manager to tailor the program to the necessities of the individual experiment. After a brief self introduction to the program, a meeting was arranged with Yvette. The outcome of the meeting was to clarify the needs of the experimenter for the experiment and also what the limits of the web tool are. The accessibility was explained and the basic platform of the experiment was decided.

5.3.1 The Ambi-pair Design
The tool is easiest described as a basic platform of sequential slides. On each slide, there are several options available to the experimenter. The specifics of the current experiment require that a sentence be shown one word at a time. Every word was therefore represented by its own individual slide. The sentences were modelled around a series of slides which together make up a section. Each section corresponds to a different sentence as shown in figure 5.3.1.1.

Figure 5.3.1.1

<table>
<thead>
<tr>
<th>Slide1</th>
<th>Slide2</th>
<th>Slide3</th>
<th>Slide4</th>
<th>Slide5</th>
<th>Slide6</th>
<th>Slide7</th>
<th>Slide8</th>
<th>Slide9</th>
</tr>
</thead>
<tbody>
<tr>
<td>The</td>
<td>man</td>
<td>fell</td>
<td>over</td>
<td>the</td>
<td>tall</td>
<td>lady's</td>
<td>plastic</td>
<td>bag</td>
</tr>
</tbody>
</table>

The options available to the experimenter on each slide are illustrated in figure 5.3.1.2. These are the options after a passage for the slide has been selected and the word “the” has been typed to represent the slide. The option to add a passage was chosen each time to represent a word. The passage in each of the sequential slides therefore contained the words to the sentences as shown in the example of figure 5.3.1.1 above. Initially, the tool was constructed in a way that required each slide to contain a question. The Experiment Manager soon alleviated this drawback.

On the last slide, an additional option was used however. This was to facilitate the presence of an ambiguity control question. The final slide in each section contained a question. The questions are only strictly required after the ambiguous sentences to show that the sentence had been adequately understood but through trial and error the experiment was constructed with a question at the end of every sentence. This was done so that the subject was given a break after progressing through each sentence.

The first version of the experiment just contained questions at the end of the ambiguous sentences. This was decided to be inefficient as the participants began the next ambiguous sentence straight after the unambiguous one which would have belittled the unambiguous sentence in the eyes of the subject and may have ultimately distorted the results. After all, the times of both sentences in the ambi-pair are equally important as they are compared to one another in the results.

Figure 5.3.1.2
As described in the previous chapter, the experiment was constructed to contain five versions. These five versions represent five different subjects as defined by the web tool and illustrated in figure 5.3.1. Each subject sees a different set of experiment sentences. Each of these sentences must be added in the manner described by figure 5.3.1.1. Each of the participants sees five ambi-pair categories which equates to ten sentences. This corresponds to ten sections of a varying number of slides, depending on the number of words in each sentence. There is however an eleventh section. This corresponds to the context paragraph as described in the previous chapter.

5.3.2 The Context Paragraph Design

The context paragraph is set up in similar fashion to the ambi-pair sentences. Each slide corresponds to a single word in the paragraph. The difference with this final section is that there are many sentences before an ambiguity control question is asked. The question is still asked in the last slide of the section but there have been many sentences that have already been read by the subject without any question at the end of them. These previously read sentences should construct a gist as explained in section 3.4, which could aid the resolution of the final ambiguous sentence. This will be further discussed again in section
7.7. A sample slide with a question is illustrated in figure 5.3.2.1 below. The same layout of the page is relevant to any of the previously mentioned slides that contain a question such as at the end of each ambi-pair sentence.

Figure 5.3.2.1

With the treatment of both ambi-pairs and the context paragraphs, the experiment is nearly ready to be run. It remains to explain the construction of the form that is used to gain personal details form the participant. This information is the key to the possible explanation of results and the conclusions that can thereby be drawn.

5.3.3 The Form Design
The form is an essential part of the experiment. It gathers participant data that will ultimately be used in the analysis of the results in chapter seven. A form can be placed at the beginning or end of an experiment. For the purpose of the current experiment, the personal form was put at the end. There was an important reason for constructing it like this. Temporary ambiguity resolution is a mainly subconscious event. Therefore, the less they know about the experiment before completing it, the more accurate the results will be. If the subject is aware of the aims of the experiment on the other hand, some unexpected conscious decisions may obstruct their results. On this principle, the form was put at the end of the experiment. If the participant filled the form in beforehand, they may be biased or prejudice in some way towards the experiment knowing that their details are being used.

Figure 5.3.3.1

Form page. Personal questions that each participant must fill in at the end of the experiment.

The form is constructed to gather all the relevant information from each participant. Data for the areas of comparison must be acquired. This is achieved by asking questions as to their linguistic background to see if they can be classed as a linguist. The fact that they are male or female and whether they are bilingual or not will also be compared in the results. With the different classes of participants, one further control question is required. To try and keep the set of subjects as close to an accurate cross section of the population as possible, the age of the subjects is asked. To keep a good representation, there must be an
equal number of different aged participants; the age field in the form relays this information to the experimenter. The graphical layout of the form is illustrated in figure 5.3.3.1.

As one can see from the illustration, there is a fifth and final question. This was included to see if the participant was aware of the aims of the experiment. This is crucial to know as the unconscious nature of the experiment is vital. Linguists, by definition, should naturally be more conscious of the unconscious and therefore one would expect a greater accuracy of guessing for this set of subjects. The final question is therefore a control question to insure that the results are as accurate as possible.

5.4 Participation

As discussed in the previous chapter, the participants varied in their backgrounds. Participation in the experiment is quite straightforward however and this is an advantage in relation to older subjects who may not be too familiar with a computer as means of experimentation.

To participate in the experiment, three items were needed; a web site address, a login name and a password. At first, these three items were supplied to possible subjects via e-mail. Due to a poor hit rate however, a new approach can be taken. In figure 5.4.1, an example slip of paper can be seen. It contains the three items that are required to participate in the experiment.

Figure 5.4.1

wilde.cs.tcd.ie/Experimenter/Version1/Data/canice/Subject1/participate.html
Login name: experimentmethere
Password : nice1

After the subject has completed the experiment, a result file is automatically created that can be accessed from the experimenters home page. The participant does not have any more access to the system after they have finished. There is however, one participant that can do the experiment without recording results i.e. the experimenter. From his home page he can decide to run the experiment to check it before any participation. This procedure was enabled by Hourihane (2002) and is an extremely useful addition.
A final aspect to the participation that needs to be mentioned is that there are five versions of the experiment as described in section 4.5.1. These five versions are saved as different files on the system. A participant is simply given an address that contains access to just one of these five files decided by the experimenter. Each different file requires a different login name and password. For simplicity, all five login names were kept the same, namely “experimentmethere”. The passwords however were numbered from nice1 to nice5 depending on which number file was being accessed. So, for example, if a person was intended to complete version 4 of the experiment, they were distributed with a piece of paper as in figure 5.4.1 but with slight numerical difference. In their url address, “Subject4” would appear instead of “Subject1” and the password would read “nice4” instead of “nice1”.

With all this in place, the experiment can be conducted. Any participant that accesses the system will have their details saved on file. At the end of the experiment, the results can be calculated. To achieve this, another meeting was necessary with the Experiment Manager to taper the system to the experimenters needs.

5.5 Viewing the Results

After a version of the experiment has been completed for the first time, a new results directory is created and their details are added to it in a new file. The next time that version of the experiment is completed, a new result file for that subject is added to the existing directory. In order to view these results, there is an option on the experimenter’s homepage to view the results of a particular experiment. This page leads to another one which queries whether the results are to be displayed by subject or by question. If you choose to view them by subject, the resultant page is illustrated in figure 5.5.1. Here you can specify which subject’s results you wish to view.

As the system originally stood, you were either able to view the resultant slides of the experiment that the participant had filled in, or view all the answers to the questions for that experiment. So, in relation to the current experiment, the experimenter could only view the answers to the ambiguity control questions and the form at the very end. There was however, no facility for the experimenter to check the type of results that the current experiment requires i.e. a temporal analysis of every slide contained in the version of the experiment. A brief meeting with the Experiment Manager sufficed to get the results that are required for the current experiment. The system already contained a facility that times slide exposure but this was not initially displayed in the results. Yvette Graham was able to alter this so that a temporal analysis file was enabled.

Figure 5.5.1
Result directory page. The five subjects that completed version one of the experiment can be seen in the diagram. By clicking on one of them and pressing the “continue” button, the ambiguity control questions and the form for that subject can be viewed.

5.5.1 The Temporal Analysis

The addition to the system comes in the form of the temporal analysis of the slides. This was achieved by altering the program to contain an option to view the times associated with each slide that a particular participant saw. The system already contained options to view the results by subject or by question. The option to view the times was simply added to this page.

To view the individual times however, a little extra bit of work is required. The temporal results come in the form of a “.csv” file. These files contain all the times corresponding to the exposure that a particular subject received to each slide. They come in a particular format which separates the data by a series of commas and tabs. These files, once copied and pasted to notepad, could then be loaded into a Microsoft Excel platform. The files were designed by the Experiment Manager to load into Excel in such a way as to assign each value into the correct row and column. Figure 5.5.1.1 shows a typical “.csv” file saved as a notepad text file.
The Excel program allowed the viewing of the temporal analysis in an eloquent way. Excel functions could then be easily run on the figures to demonstrate graphs and bar charts that will be discussed in the next two chapters. Figure 5.5.1.2 shows the “.csv” file in an Excel spreadsheet.
The only change that was made to the files in figure 5.5.1.1 and 5.5.1.2 was to edit the column names. As the files show, the column names were assigned the section and slide identification of the experimentation tool. In order to improve the quality of the resultant graphs, these names were systematically replaced by the actual words that they represented in the experiment. In achieving this, the graphs could be read more easily. The portion of the text file that contained the identification names were simply deleted and replaced, each word being separated from the next by a comma. The file could then be loaded into an Excel platform in the same manner as before.

5.6 Problems Encountered

There were numerous problems encountered with the web tool. As mentioned in the previous chapter, technical difficulties were a large obstruction to the experiment running smoothly. The tool is simply not robust enough and needs to be treated very delicately. It often tended to crash at the slightest mistake such as giving two experiments the same name or pressing the “Back” button on the web browser. In the case of it crashing, the system had to be restarted from the server which caused long delays and annoyance in setting up the experiment.
The tendency to crash during the setting up of the experiment could be overcome by persistence and patience but one of the biggest drawbacks to the experimentation tool as a whole is that participants do not have the same patience as the experimenter. After all, they gain very little from completing the experiment. As a result, the hit rate to the experiment was extremely poor. The participants complained of many difficulties faced. One such problem was simply being faced with a blank screen, indicating that the system had crashed. Another complaint was that only a grey box could be viewed, this indicated that the computer would not run the program for an unknown reason. In other words, the applet that should have opened in order to view the experiment simply didn’t load. Yet more complaints were that the web page didn’t load at all, this can be explained by certain browsers that are incapable of viewing the page from outside the college network.

The patience required to use the system cannot be asked or expected of the participants. Due to this, many possible subjects were lost and this in turn affects the accuracy of the results as you have a much smaller set of subjects with which to represent the entire population. There were however, enough successful participants to deem the experiment a success and the persistence on their behalf is greatly appreciated.

A final aspect of the tool that proved troublesome was during the construction of the experiment. Quite simply, there was no means of editing an experiment that is under construction. For example, five ambi-pairs and several sentences in the context paragraph needed to be entered for each version. Each sentence was made up of a group of slides as described in figure 5.3.1.1. If any of the slides were constructed incorrectly or a word spelt incorrectly and the button had been pressed to begin the next slide, it was too late to correct it. In other words, every word of every sentence had to be entered correctly with the correct questions on the right slides or otherwise the procedure has to be started all over again, wiping what had been constructed to that point. If this happens at the end of the context paragraph for instance, the maximum time is lost. This proved to be quite time consuming.

5.7 Possible Improvements

Despite all the disadvantages to the system as laid out by the previous section, the web tool proved to be extremely easy to use. It is very user friendly and no previous formal computing instruction is necessary in order to use the program. In this sense, it is the ideal tool to use in order to create an experiment. Without it, an experiment of this nature would have been virtually impossible to achieve.

The most obvious and essential improvement to the system would be to facilitate the editing of experiments. The time it takes to construct an experiment is needlessly long. An option to navigate through the experiments, with the possibility of changing parts where required, would be a huge advantage if it was added to the system.

Another advantage would be to link the experimenter’s homepage with any sub-page of the homepage. For instance, after an experimenter has finished an experiment he
needs to retype the address to get back to the homepage. A little shortcut button would make a big difference.

Improvements to the overall robustness of the system are very important for the future uses of the web tool. Its tendency to crash over the slightest of irregularities needs to be attended to. The web tool is still in its prototype phase and further extensions must be added to it in order to make it the all round experimentation tool that it is intended for. It is however, more than adequate for the purpose of the current experiment and gratitude must be extended to all those who have been involved in its creation.

Chapter 6
6.1 Introduction

The Web based experimentation tool records all the results that are needed to analyse the way in which the sentences are processed. Each of the five versions of the experiment received a varied number of subject participation. Below in figure 6.1.1 is a chart that illustrates the amount of subjects a particular version received.

Figure 6.1.1
As the chart illustrates, 38 participants took part in the experiment. The distribution of participation in each of the different versions of the experiment was satisfactory. According to the experiment parameters as outlined in section 4.3.1, Schütze suggests that in order to validate conclusions, a diverse cross section of the entire population must participate. Figure 6.1.2 illustrates the age distribution of the participants.

Figure 6.1.2

Unfortunately, this chart illustrates that the distribution of age was not satisfactory and therefore cannot represent a valid cross section of the population. This occurred for a number of reasons. The first of these is that many of the participants were students. As the experimentation system was not robust enough to handle off-campus participation, the natural consequence to the experiment was that only participants of student age took part. On the other hand, figure 6.1.3 below, demonstrates that the distribution between the sexes was satisfactory for the experiment.

Figure 6.1.3
Both of these charts could be plotted with data gathered from the form filled in by the subject at the end of the experiment. Two other areas were of significance to the experiment at hand. To compare data between linguists and non-linguists, a portion of the participants must have studied linguistics before. Figure 6.1.4 illustrates that the frequency of linguists in the experiment was satisfactory.

Figure 6.1.4

Another factor that has to be taken into account is whether or not the particular subject was a native speaker of English, the language of experimentation, or not. Once again, data from the form could be plotted resulting in figure 6.1.5 below.

Figure 6.1.5
Figures 6.1.4 and 6.1.5 both illustrate that there is enough data from both these areas to draw conclusions from their results. Just over one third of the subjects had studied linguistics before. A preferable portion might have been half and half but this proved too difficult to attain. Likewise in relation to bilinguals, just under a third of the males and just over a sixth of the females were bilingual. The female bilingual figures were a little disappointing compared to the males but overall, enough data is present to analyse the results under these categories. The poor age frequency is the only area that is cause for concern.

6.2 Structure of Results

The results to the experiment are dealt with in respect to two areas. They are separated so as to juxtapose the relevant data for future comparison. The first part of the experiment is concerned with the ambi-pair, more specifically, the processing difference between the pair. There are five versions of the experiment and so there are five example ambi-pairs per ambiguity category that can be studied. The following five sections of this paper correlate to the treatment of these ambi-pairs one category at a time.

The second part of the experiment is concerned with the ambiguous sentences that are found at the end of the context paragraphs. The data from the isolated ambiguous sentences of the ambi-pairs is then treated with respect to the data gathered from the context ambiguous sentences. The results for both parts are discussed in relation to two major data sources. These are:

A. The answers to the ambiguity control questions and

B. The temporal analysis of each sentence in the experiment
The ambiguity control questions are designed so that the participants can demonstrate whether they grasped the true meaning of the sentence or not. An important implication that can be applied through the analysis of these results is whether the failure to satisfactorily gain the correct syntactic interpretation is reflected in the way they process the sentences. This is dealt with further in the next chapter.

The results to the temporal analysis are also an important source of data. They signify the way in which the different sentences were processed by each subject. Difficulties encountered by a particular participant can be seen from these results. This is important as, to resolve temporary ambiguity, one would expect a slight temporal discrepancy at a certain stage in the ambiguous sentences when compared to its unambiguous counterpart. The graphs of all the sentences can be found in the appendix, category by category. The results to the temporal analysis can be further split into two other data sources. These are referred to when the results to each category is discussed. The two sources of data are:

B1. The pauses by each subject in selected areas where ambiguity resolution is expected and

B2. The time it takes for the subjects to respond to the question at the end of each sentence.

The pauses at certain points in the sentences are recorded as the percentage of subjects that paused, ever so slightly (+0.5sec), after reading the word in question. The selected part of the sentence is where the resolution of the ambiguity is expected. In order to supplement this data, the second part of the temporal analysis may prove equally significant.

The final word of every sentence was constructed to be on the same slide as the ambiguity control question. The time of exposure to this slide is important as it shows how long it took the subject to answer the question. The significance of this time is that even though the temporal analysis of the sentence may not show any significant results from word to word, it may show it in the time it takes them to answer the question. A reason for this might be that the subject just whisks his way through the sentences and resolves the ambiguity at the end, having resorted to his working memory, see section 3.4, to memorize the words.

Throughout the next five sections, a number of tables are used to record the correctness of the ambiguity control questions. In every case, a 1 signifies that the subject gave a correct answer and a 0 signifies an incorrect answer. The two columns for each “version” in the table represent the answers to both ambi-pair questions. The sub-column on the left represents the unambiguous sentence, whereas the one on the right represents the ambiguous sentence. The “C” signifies the answers to the context paragraph which only contains an ambiguous sentence. This format will be kept throughout this chapter. In total, the grid represents 76 responses to questions (38 participants * 2 ambi-pair questions). 38 of these are unambiguous sentences and 38 are ambiguous ones. In addition, the grid contains a varying number of context responses as it depends on which version completed the respective category as to how many response it gained.
The graphs referred to in this chapter that can be viewed in the appendix were constructed using Microsoft Excel 2000. The text files discussed in the last chapter were simply loaded into an Excel spreadsheet and there is a built-in function to produce charts from the data stored in its rows and columns. It is an extremely powerful program that enjoys multifunctional uses.

There are several points to note about these graphs. Firstly, the time it takes for the instructions to be read by a subject is included. Each version began with a different category which means that the instructions data will be present at the start of only five of the sentences. This can aid in the analysis as it is clear which sentence the subjects see first, a factor that may play a role in their processing of the sentence.

6.3 Complement Clause Vs Relative Clause

This type of temporary ambiguity is typified by the double use of the relative pronoun “that”. The unambiguous sentence does not use this construction in favour of the passive voice to represent the complement clause of the sentence. The reader should originally miss-analyze the syntax of the sentence in favour of a complement clause and soon realize this not to be the case. Figure 6.3.1 shows the results to the ambiguity control questions. In this case, the context paragraph was seen by version two subjects.

Figure 6.3.1
These results can be plotted in a bar chart as illustrated in figure 6.3.2 which shows the trend in relation to how the subjects handled the correct resolution of the temporary ambiguity they encountered.

**Figure 6.3.2**

<table>
<thead>
<tr>
<th>Complement clause Vs Relative clause</th>
<th>Version 1</th>
<th>Version 2</th>
<th>Version 3</th>
<th>Version 4</th>
<th>Version 5</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Subject 3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Subject 5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Subject 6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Subject 7</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 8</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 9</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Subject 10</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

These results can be plotted in a bar chart as illustrated in figure 6.3.2 which shows the trend in relation to how the subjects handled the correct resolution of the temporary ambiguity they encountered.

What is immediately striking about these results is that more subjects correctly answered the questions relating to the ambiguous sentences than the unambiguous ones. This might
suggest that the sentences containing this type of temporary ambiguity are more easily understood. Overall, there is not a large difference between the two which also implies that those who were able to retrieve the correct information from the unambiguous sentence did likewise in the ambiguous one. Roughly three quarters of the participants answered both sets of control questions correctly which implies a satisfactory level of ambiguity resolution.

Studying the results to the temporal analysis (graphs 1V1A – 1V5B), one can see a pattern emerging. In this category the graph must be studied around where the relative clause begins as this is where the syntactic reanalysis is expected. The diagram below shows the percentage of participants who paused after reading the words denoted by “-----“.

<table>
<thead>
<tr>
<th></th>
<th>Unambiguous</th>
<th>Ambiguous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>32%</td>
<td>11%</td>
</tr>
<tr>
<td>that</td>
<td>5%</td>
<td>32%</td>
</tr>
<tr>
<td>that</td>
<td>3%</td>
<td>24%</td>
</tr>
<tr>
<td>that</td>
<td>16%</td>
<td>16%</td>
</tr>
</tbody>
</table>

These figures show that after reading the start of the relative clause, a much larger portion of participants required a brief pause in one of the subsequent words, this was a third of the subjects on seeing the word “that” alone. The figures also show the percentage of pauses in the unambiguous sentence before the word “that” is the same as the percentage in the ambiguous sentence after processing the word “that”.

### 6.4 Object Noun Phrase Vs Main Clause Subject

This type of temporary ambiguity is typified by the starting of the sentence with a word such as “while” or “when”. It is distinguished from the unambiguous sentence by not including a comma mid way through the sentence. The reader is expected to miss-analyze the ambiguous sentence by initially expecting the actual subject of the sentence to be the object of the qualifying “while” or “when”. The control question data is as follows:
Once again, these results can be plotted into a chart which demonstrates the trend in relation to the resolution satisfaction of the sentences.

**Figure 6.4.2**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 4</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Subject 5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Subject 6</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Subject 7</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Subject 8</td>
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<tr>
<td>Subject 9</td>
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<td>Subject 10</td>
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<td>1</td>
</tr>
</tbody>
</table>

**Obj NP Vs Main C sub**

**Ambiguity control questions**

<table>
<thead>
<tr>
<th>Questions</th>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>1</td>
</tr>
</tbody>
</table>

Once again, these results can be plotted into a chart which demonstrates the trend in relation to the resolution satisfaction of the sentences.
As the figure 6.4.2 illustrates, nearly every unambiguous sentence question was answered correctly. This figure was reduced by over 50% for the ambiguous counterparts. With more subjects answering the ambiguous question incorrect than correct, it implies a poor level of overall ambiguity resolution.

Looking at the resulting graphs of the temporal analysis (graphs 2V1A – 2V5B), we can study the times around the words where the miss-analysis is expected. For this category, it begins with the word before the main clause begins. The beginning of the main clause is denoted by the comma present in the unambiguous sentence, but not the ambiguous one. The triple bar represents the processing area after which a possible re-analysis would be anticipated in the ambiguous sentence. The diagram below shows the percentage of participants who paused over the relevant word.

<table>
<thead>
<tr>
<th></th>
<th>Unambiguous</th>
<th>26%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13%</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>11%</td>
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<tr>
<td></td>
<td>11%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Ambiguous</th>
<th>3%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3%</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>13%</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>24%</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>18%</td>
<td>----</td>
</tr>
</tbody>
</table>

These figures show a significant increase in pauses where expected, at the point where a reanalysis of the syntactic structure of the sentence is required. Interestingly, the percentage of pauses in the ambiguous sentence is very similar to the percentage produced by the presence of a comma in the unambiguous sentence.

6.5 Direct Object Vs Embedded Subject

This type of temporary ambiguity is typified by a sentence that uses a verb that can be syntactically analyzed in more than one way, such as “to suggest” or “to believe”. The noun phrase immediately after the use of the verb is expected to be the object of this verb but in reality it is the subject of the embedded sentence. This is distinguished from the unambiguous sentence that employs the word “that” directly after the verb to allow the reader to know that an object will not be immediately present. The results for the ambiguity control questions are illustrated below.
This data can be plotted in a similar manner to the previous categories to accommodate future comparisons that will be discussed in the next chapter.
What stands out about the chart in figure 6.5.2 is that nearly everyone answered the unambiguous questions correct. This is reiterated in the ambiguous sentences where not one subject failed to resolve the temporary ambiguity. These results suggest that the resolution of this type of ambiguity poses little problems to people, regardless of whether temporary ambiguity is present.

Turning our attentions to the graphs corresponding to each of the sentences in the appendix for this category (graphs 3V1A - 3V5B), a diagram can be constructed, once again to show the percentage of pauses at certain points in the sentences. The study in both cases begins at the word immediately before the noun phrase which constitutes the embedded subject of the sentence. For the unambiguous sentences, this word is always “that”.

<table>
<thead>
<tr>
<th></th>
<th>Unambiguous</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0%</td>
<td>5%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>-----</td>
<td></td>
<td>the</td>
<td></td>
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<thead>
<tr>
<th></th>
<th>Ambiguous</th>
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<tr>
<td></td>
<td></td>
<td>11%</td>
<td>16%</td>
<td>14%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These percentages show a definite trend. The expected increase in pausing due to the necessity of re-analyzing the syntax of the ambiguous sentences is denoted as coming after
the triple bar in the diagram. Interestingly, nothing was recorded to show that this was the case. The percentage of pauses remained constant throughout the processing of this area of the sentences. The only difference is that the words in the ambiguous sentences were paused on much more regularly at the selected area.

### 6.6 Prepositional Phrase Attachment

This type of temporary ambiguity is represented by two prepositional phrases side by side in a sentence. The ambiguity arises out of the unfamiliar nature of such a construction. The difference present in the unambiguous sentence is the addition of the words “that was” to denote the first prepositional phrase.

Figure 6.6.1
The quality of the control answers are represented by the chart in figure 6.6.2. Once again, the questions to the unambiguous sentences proved to be of little difficulty as you would expect. There is however, a 25% decrease in correct answers when considering the
ambiguous sentences. This suggests that a quarter of the subjects found difficulty in resolving this type of ambiguity.

The temporal analysis of the sentences (graphs 4V1A – 4V5B), illustrated by the relevant graphs in the appendix, can be studied in the area surrounding the expected reanalysis. For this type of ambiguity, the selected area begins with the word before the start of the second prepositional phrase. The percentages were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Unambiguous</th>
<th>Ambiguous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>8%</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>3%</td>
<td>13%</td>
</tr>
</tbody>
</table>

These figures clearly show that after processing the second preposition in the ambiguous sentences, a brief pause is taken by nearly a quarter of the participants. This is three times higher than the same prepositions in the unambiguous sentences and therefore shows the difficulty faced by the subjects at this point in the sentences.

6.7 Main Clause Vs Complement Clause

This type of temporary ambiguity is typified by the employment of a past tense verb directly following the subject of the sentence which is followed by a qualifying phrase that constitutes the complement clause. The small alteration that was used to distinguish the unambiguous sentence was the use of the words “that was” to denote the beginning of the complement clause to the reader.
### Figure 6.7.1

#### Main Clause Vs Complement Clause

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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Subject 3</td>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subject 7</td>
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<td>Subject 8</td>
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<td>Subject 9</td>
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<tr>
<td>Subject 10</td>
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</tbody>
</table>

### Figure 6.7.2
The chart of figure 6.7.2 represents the data in figure 6.7.1. The first thing of note is that the unambiguous sentences posed no difficulty as expected. About 33% of the subjects however, subsequently failed to resolve the ambiguity satisfactorily in relation to the ambiguous sentence. This suggests that this type of ambiguity is relatively difficult to interpret correctly.

The temporal analyses of the sentences were studied (graphs 5V1A – 5V5B), once again, in the area where pauses were expected in order to resolve the temporary ambiguity. For this category, it is expected that the ambiguity will be present around the last few words in the sentence, where the subject realizes that the clause headed by the past tense verb is in fact a complement clause. This is illustrated below.

<table>
<thead>
<tr>
<th></th>
<th>Unambiguous</th>
<th>Ambiguous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>38</td>
<td>26</td>
</tr>
<tr>
<td>Incorrect</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

These percentages show that pauses were taken in the ambiguous sentences by double the amount of subjects after the expected reanalysis denoted by the triple bar when compared to those for the unambiguous sentences. Comparing the two shows that the
temporary ambiguity is not detected satisfactorily however due to the equal presence of pauses all the way along. We can also see that the overall amount of pauses on the words in the ambiguous sentences was higher than those without ambiguity. Despite this however, the results do not show satisfactory evidence of the temporary ambiguity present, as the same percentages for the initial word after the reanalysis were recorded.

6.8 Context Paragraphs

The results of the ambiguous sentences which appeared at the end of a paragraph are treated somewhat differently to the other results. In this section, the data from the ambipairs are separated so that the data from the ambiguous part can be juxtaposed with the data from the context ambiguous sentences. In figure 6.8.1, the percentage of control questions that were answered correctly in each category, both for the isolated ambiguous sentences and the context ambiguous sentences, can be seen.

Figure 6.8.1

This chart shows that categories three and five proved to be the least difficult to resolve when a context has been provided, 100% in each case. This is an improvement for category five only. Category one and two are quite similar in success rate for the context sentences but the resolution of category one ambiguity has decreased considerably. Category four was the most difficult to resolve after a context, to the point where the overall resolution is
unsatisfactory. The respective time it took for the participants to answer the questions for isolated and context sentences is described in the chart in figure 6.8.2 below.

Figure 6.8.2

![Chart showing response times for context vs isolated ambiguous sentences](chart)

The response times for category one and two are similar for both sets of sentences. The time taken to answer the context question of category three was much higher than the isolated version. The same can be said for category four. Overall however, category five seems to have taken the least amount of time to answer for both sets of sentences. The results for each of the context sentences in relation to the pauses taken in the selected region of the sentences will now be discussed. The illustrations in the respective previous sections are referred to.

**Complement clause Vs Relative clause**

The first category shows that the context ambiguous sentence showed a 10% pause rate at the first and second words after the reading of the word “that”. This is significantly lower than the figures for the isolated sentence.

**Object noun phrase Vs Main clause subject**

The second category’s context sentence figures merely show a 3% pause level after processing the first word after the triple bar. The rest of the words did not show the immediate presence of ambiguity resolution.

**Direct object Vs Embedded subject**

93
The figures for the context sentence of the third category show a 3% pause rate after processing the first word of the selected area, another 3% over the word before the expected re-analysis and 3% for the first word after the expected reanalysis. Once again, this does not show any significant pauses in the sentences.

**Prepositional phrase attachment**

The context sentences of the fourth category only show a 3% pause rate over the second preposition. The presence of any ambiguity resolution cannot be seen from these results.

**Main clause Vs Complement clause**

The context sentence for the fifth category shows a 3% pause rate over the last two words in the sentences as described above. Once again however, this is far less than any of the isolated sentences.

**6.9 Conclusion**

In this chapter we have discussed the results to the experiment described in chapters four and five. The results of the ambi-pairs have been discussed separately to the context paragraphs. The ambi-pairs are compared within the confines of each ambiguity category whereas the context sentences of the paragraphs are reported in comparison to the isolated ambiguous sentences of the ambi-pairs. This is achieved in section 6.8 where the different data sources are discussed. The results on the whole are quite satisfactory.

It remains to mention that seven of the participants guessed what the experiment was about and out of these, six were linguists. This means that a very low percentage of the subjects were aware of what was being tested and this upholds the prerequisite that the results reflect the unconscious nature of the experiment. The fact that most of these were linguists implies that past formal instruction in linguistics has a role in making the unconscious linguistic processes, conscious ones. The next chapter will discuss the relevance of all the results and the implications that can be made from them.
Chapter 7

Analysis of Results
7.1 Introduction

In this section the significance of the results will be discussed. There are several topics on which the analysis of the results will focus. The first topic that will be addressed is which ambiguity category caused the most difficulties to process and possible reasons as to why this was the case. Section 7.3 deals with the analysis of the results with respect to the two participating sexes. Section 7.4 treats the linguistic orientation aspect of the experiment while section 7.5 looks into the results for the bilinguals that took part.

The penultimate section in the chapter delves back into the processing theories that were discussed in the third chapter with a view to inferring possible conclusions from the experiment at hand. Which processing theory is a more likely reality relies on the significance of the data retrieved from the context sentences, as opposed to the isolated ones. The chapter will end with a brief discussion of the experiment’s results.

7.2 Temporary Ambiguity Categories

An aim of the experiment was to study five different temporarily ambiguous categories seeing which ones proved more difficult to process and offer answers as to why this could be the case. Ambi-pairs were used to contrast the processing data between the ambiguous and unambiguous sentences. Figure 7.2.1 shows the response times to both parts of the ambi-pairs in each category.

Figure 7.2.1
What is apparent about the analysis of this graph is that the ambiguous sentence control questions all required roughly the same amount of time for the subjects to answer, regardless of the category. The Prepositional Phrase Attachment ambiguity records slightly the longest time. Interestingly, category three, Direct Object Vs Embedded Subject category, is the only category to receive more time for the unambiguous sentence control questions to be answered than for the ambiguous ones. This may seem quite strange as the opposite would be expected. The clarity of the sentences of this category must therefore be better in the ambiguous part of the ambi-pairs. This implies that we may be more practiced at interpreting the ambiguous construction, albeit, at a very slow pace.

Categories two and four, Object NP Vs Main Clause Subject and Prepositional Phrase Attachment, both have the largest difference between the two parts of the ambi-pairs, the latter being the overall slower of the two. This would imply that these types of ambiguous constructions are much less common and hence more difficulty to process. The next graph, figure 7.2.2 investigates the correctness of the control questions.

Figure 7.2.2
This shows that Direct Object Vs Embedded Subject sentences were resolved with an excellent success rate even though the time it took for the subjects to respond was much higher than the other categories. Both parts of the ambi-pairs were answered at nearly a 100% correct rating, once again it is the ambiguous control questions that were answered slightly the better, a trend that is mimicked in the response times for that category.

Complement Clause Vs Relative Clause ambiguity shows that the ambiguous sentences were resolved much better than the unambiguous ones even though it took about the same amount of time to answer both. Once again, this is an unexpected result as you would expect the ambiguous sentences to prove more difficult.

The greatest difference was recorded in Object NP Vs Main Clause Subject category where the understanding of the ambiguous sentence proved extremely poor, less than 50%, especially compared to its unambiguous 100%. This would confirm what its response times show as its ambiguous sentence times are much greater.

Prepositional Phrase Attachment and Main Clause Vs Complement Clause have similar differences between the two parts of the ambi-pairs. This difference is reflected in the response times for both categories too with the prepositional phrase attachment seeming slightly more difficult.

If we look at the temporal analysis of each category (appendix graphs), we can see that Complement Clause Vs Relative Clause, Object NP Vs Main Clause Subject, and Prepositional Phrase Attachment categories detect a significant pause percentage increase at the expected re-analysis point of the ambiguous sentences. Interestingly, this is not shared by the other two categories. With respect to category three, the temporary ambiguity encountered in processing sentences of this kind proves least troublesome to the point where it does not even show on the word to word analysis analysis. Category five shows a little more anticipated pausing but still unsatisfactory.
In light of this analysis, category one seems to conform to the expected results of the presence of temporary ambiguity. The temporal analysis showed the expected pauses were present, the correctness of the ambiguous sentences was far less and the time it took to answer the ambiguous sentences questions was much higher too. The second category showed similar results for the anticipated pauses and also results for the questions that conform to the presence of temporary ambiguity, at a moderately high difficulty level of processing. Category three seems to be the easiest to process as least difficulty was encountered. The ambiguous sentences actually proved to be both easier to understand and quicker to answer questions on. There wasn’t even temporary ambiguity found through the pauses in the processing of the sentences. This would suggest familiarity with constructions of category three. Category four on the other hand seems to be the most difficult to process. The pauses show a clear re-analysis area in the sentence, the ambiguous sentence questions were much more poorly answered and the time it took to answer all leads to the conclusion that this category proved the most difficult. This may be explained through the low frequency of constructions in the English language of two prepositional phrases side by side. Finally, category five demonstrated inconclusive pausing in the sentence to claim that it is proof of temporary ambiguity. Despite this however, the level of correct answers and response times would suggest that it is a relatively difficult ambiguity to process.

7.3 Male Vs Female

The sex of each participant is gathered in the final form that each subject had to fill in. From the data gathered at this part of the experiment, a few charts and conclusions can be drawn as to how each sex dealt with the temporary ambiguity. The sources of data that are discussed in this section are the percentage of correct answers to the ambiguity control questions and the response times to these questions. Figure 7.3.1 below shows the response times for male and female participants.

Figure 7.3.1
This chart shows that for both the ambiguous and unambiguous questions, the male participants took longer to answer. In the case of the ambiguous sentences, it took them a lot longer. The females answered the ambiguous questions nearly as fast as the males answered the unambiguous questions. This suggests that women are able to resolve temporary ambiguity faster, but in figure 7.3.2 below, the accuracy of these answers can be seen.

Figure 7.3.2

![Ambiguity Control Questions](chart)

These figures show that women’s answers were more accurate than the men’s. Taking figure 7.3.1 into account, it can be concluded that overall female temporary ambiguity resolution is more efficient than male resolution. The results from the experiment show that women can resolve the individual constituents of temporarily ambiguous sentences both faster and more accurately than men.

### 7.4 Linguists Vs Non-linguists

The next area of interest in relation to the results gained from the experiment is whether or not linguists posses an enhanced ability to process and understand quirks in language such as temporary ambiguity better. To investigate this further, the same charts have been plotted as the last section. This will show us the speed and accuracy of the linguist’s resolution.

Figure 7.4.1
As one might expect, overall, the linguists that took part in the experiment answered both the ambiguous and unambiguous sentences control questions faster than non-linguists. Interestingly, the actual difference between the ambiguous and unambiguous parts were quite similar which would suggest that despite the linguists being much faster, the actual difficulties in resolving the ambiguity remained constant. The accuracy of the answers may show more as to whether this might be the case.

Figure 7.4.2
These figures confirm that linguists do possess a better understanding of language. They failed to answer one unambiguous question wrong and scored extremely highly on the ambiguous sentences. As you can see, the accuracy difference between the ambiguous and unambiguous sentences for both categories remains constant. This suggests that having studied linguists before improves accuracy and speed of temporary ambiguity resolution but the fundamental challenges to each individual in processing the two types of sentences remain the same regardless.

7.5 Bilinguals Vs Native speakers

The next analysis is that of the difficulties that a bilingual faces when confronted by temporary ambiguity in a sentence. One would expect that a non-native speaker would find linguistic pitfalls such as ambiguity an extremely difficult task. The speed and accuracy of answers to the control questions were once again used to draw this contrast between the two types of people who completed the experiment.

Figure 7.5.1

<table>
<thead>
<tr>
<th>Ambiguity Control Questions</th>
<th>Response Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Exposures time Per person (sec)</td>
<td>Bilinguals</td>
</tr>
<tr>
<td>Unambiguous</td>
<td>68.2228571</td>
</tr>
<tr>
<td>Ambiguous</td>
<td>71.66285714</td>
</tr>
</tbody>
</table>

The chart demonstrates that, as predicted, native speakers can understand unambiguous sentences much more quickly and the ambiguous ones a bit more quickly. Interestingly, the bilingual results show that whether or not temporary ambiguity is present in the sentence
makes very little difference to the time it takes them to respond. The implication for this would mean that foreign speakers of a language might not undergo the same sentence processing procedure as they do in their own language. This would need to be investigated further for a claim of such sort to be made but the evidence does point to this being the case. The accuracy of the answers can be seen from figure 7.5.2.

![Figure 7.5.2](image)

The accuracy of the answers conforms to what one would expect for these two types of people. Overall, native speakers find it very easy to resolve unambiguous sentences whereas bilinguals find it more difficult. The similar response times for both sets of sentences for bilinguals is not reflected however in the accuracy of their answers, the ambiguous sentences proving a lot more difficult to extract the true meaning. On the whole, these results would conform to those one would expect for a foreign speaker.

### 7.6 Processing theories revisited

The processing theories that were described at the end of chapter three will now be discussed once again. This time it will be in light of the experiment and the results that have been gained through the analysis of how humans process temporarily ambiguous sentences. To briefly recap on what is the main topic of this section, we must summarise the two theories once again.

The serial model suggested by Frazier & Fodor (1978) claims that the syntax faculty in the brain resolves the constituents to a sentence before any semantic interpretation is resolved. The parallel model on the other hand suggests that a semantic interpretation is gained during the interaction of both the semantic and syntactic faculties of the brain. These two models can be put to the test using the results from the current experiment.
If the serial model is a better representation of the human brain, then the existence of prior contextually qualifying sentences would make a negligible difference. In this case, the subjects would record similar results for both the isolated and context sentences of the current experiment. If the parallel model is more representative of the processing procedure of the brain then one would expect that the semantic mapping of previous sentences would guide subjects in resolving the temporary ambiguity faster than if the ambiguous sentence was isolated. This is due to the fact that if the subject already possesses a likely semantic interpretation for the constituents of the sentence, he can apply the correct syntactic structure to the temporarily ambiguous sentence faster as it is a more appropriate analysis.

All this relates to the current experiment where the context ambiguous sentences can be contrasted with the isolated ambiguous sentences of the ambi-pairs. This is achieved through the analysis of the response times and the accuracy of the answers to the ambiguity control questions. Figure 7.7.1 shows the figures for the response times.

Figure 7.6.1

These figures would suggest that prior semantic mappings have no effect on the resolution of temporary ambiguity. It is clearly shown that, on average, it took 6.5 seconds longer for each participant to answer the control questions when the sentence appeared in context. One must concede however, that the results for the isolated sentences are far more representative of the reality than the context results. This is due to the fact that there is five times the amount of material to work on in relation to the isolated sentences as each subject sees five examples of them compared to just one context sentence. Further material would be necessary for a conclusion to be made. However, it does demonstrate an initial trend that the resolution of temporary ambiguity is not aided by prior contextual knowledge that may
guide a person to the correct syntactic interpretation more quickly and hence, this would favour the serial model.

Figure 7.6.2

Figure 7.6.2 tells an interesting story. In only two of the ambiguity categories did the context ambiguous sentences take longer to resolve. This would have the effect that the figures for all the context sentences would raise. Clearly, this does not reflect the reality. It has already been seen that isolated sentences in category four are the most difficult to resolve and prior contextual information, it seems, just convolutes the overall analysis. If categories three and five were omitted from the results, the opposite trend to that typified by figure 7.6.1 would result. Interestingly, category five seems to be the easiest to resolve when there is prior semantic knowledge which may guide the syntactic analysis. This suggests a preference to the use of the parallel model.

Figure 7.6.3
To help in the analysis of response times and possibly further refine a possible conclusion, figure 7.6.3 compares the response times per slide of the different areas of analysis. As the diagram shows, in every case, the context sentences proved longer to resolve. In the case of the females, this length is negligible. The most surprising of these results is the difficulty faced by the males in the experiment to resolve the context sentences. The figures show that it even took bilinguals less time to resolve such linguistic pitfalls. As the male figures seem a little unsatisfactory, a study was performed on the data for the males. It was discovered that two males, one of them bilingual, took an aggregate of 126 seconds to answer their context sentence control question. This added more than 7 seconds to the male average per slide that can be seen in figure 7.6.3 and as such explains the unrealistically high figures. The reason for such pauses might be explained by a mere distraction in the room at the time of the experiment.

Taking the above observation into account, one can conclude that there is very little difference between the times taken for isolated sentences and those in context. As stated, more data is needed for the context sentences in order to make the results more conclusive. We can however, take a look at the categories again to see if there is any trend between the isolated ambiguous sentences and the context ambiguous sentences. This is achieved in discussing whether the answers to the control questions were answered correctly or not. The following diagram illustrates the trend.

Once again, it can be seen that the context questions were much more poorly answered to the point where nearly half of them were answered incorrectly. It is necessary to reiterate that the lack of equal material may play a role in these figures but it does appear that context plays little to no role in the resolution of temporary ambiguity. The next graph will show if any ambiguity category in particular pushed this poor accuracy level up for the rest.
As you can see, all the categories apart from the third and fifth decreased in the accuracy of their context answers. Category four decreased to such an extent that one could say the subjects resolved the ambiguity very poorly. The lack of data could also be a contributing factor. Category one’s accuracy dropped by over a half when in context whereas category two’s level of accuracy remained relatively constant. As for category three, it was equally well answered regardless of its location. Category five is the only category of ambiguity that recorded faster and more accurate answers to the control questions in context than the isolated cases. This implies that prior semantic interpretations may guide a person to a faster and more appropriate syntactic analysis in this type of temporary ambiguity. The individual figures for the selected analyses may help to shed some light on the make up of the above diagrams.
The above chart shows that although the men were generally slower to answer the questions, they were a lot more accurate in their answers to the context sentences than the women. This suggests that women may have a poorer working memory. The context sentences were unsatisfactorily answered overall by the females which would lead to suggestions that they found resolving temporary ambiguity in context much harder. Interestingly, the bilingual accuracy of answers did not change from isolation to context, which suggests that they process each sentence as though it stands alone. Overall, it can be concluded that every participant found it more difficult to resolve the ambiguity in context.

The results that have arisen from the experiment can be applied to the notion of which processing theory seems the more likely. Although further research is needed, and more material on which to base the results, the early indication is that context plays a negligible role in the resolution of temporary ambiguity. In some categories it proved to make a difference whereas in others it had the opposite effect. Taking everything into account, the existence of context can be deemed, at least from the current experiment, that it has little effect on the resolution of temporary ambiguity. This would lead to the conclusion that we process sentences more akin to the serial model of chapter three. It must be stressed however that the data for the context sentences is inadequate to firmly conclude this and as such I will refrain from doing so. The study does however give an initial insight into the negligible role context may play on the resolution of sentences. It suffices to mention that if these results demonstrate the actual trend, we do, in fact, process sentences serially.

7.7 Discussion

This section will discuss all the relevant data that was gathered in relation to the two areas of the experiment, the ambi-pairs and the context paragraphs. Final conclusions to the experiment at hand will be offered.
7.7.1 The Ambi-pairs

The study of the ambi-pairs for each category generally demonstrated the presence of temporary ambiguity through the analysis of the pauses. In every case apart from the Direct Object Vs Embedded subject ambiguity this proved a success. A possible reason for the lack of success in this category might be that we are well practiced at resolving such constructions in everyday language. This is due to the fact that the verbs employed are commonly found in a number of syntactic constructions and as a result, we are well practiced at quickly reanalyzing them. The accuracy of answers to the control questions was impeccable which would support such a claim. The fallacies noted in section 3.4 with respect to embedded subjects did not reflect in the results implying that mature readers do not suffer from early reading difficulties.

Interestingly, the Object Noun Phrase Vs Main Clause Subject ambiguity showed that the percentage of pauses at the sight of a comma in the unambiguous sentences, was equal to the percentage of pauses that were taken in order to resolve the relevant ambiguity. This needs further investigation if there can be any claims made to the relevance of this figure. The accuracy of the answers to the control questions for this category was insufficient to claim that the ambiguity was satisfactorily resolved as there was a drop in understanding by just less than 50% compared to the unambiguous sentences. This suggests that the use of a comma to disambiguate the meaning of the sentence is extremely important as we have very little practice at seeing such ambiguous sentences.

The results for the Prepositional Phrase Attachment ambiguity pauses showed three times the amount of pauses on the second preposition, which would suggest a difficult processing point in the sentences. Both sets of questions were answered satisfactorily with the ambiguous ones recording a drop of less than 25% whilst maintaining an 80% understanding rate. This suggests that although there are significant pauses during processing, the syntactic reanalysis is good enough to resolve the ambiguity with success.

Results for the Main Clause Vs Complement Clause ambiguity showed mediocre results in relation to the pauses picked up in the sentences. The resolution of ambiguity however was sufficient to claim that the reanalysis functioned satisfactorily with a total of just less than 80% of participants answering the ambiguous sentence control question correct. This represented a drop of roughly 33%. Overall, this category was dealt with quite easily by the subjects, which might reflect its frequency of use in everyday language.

The results for the Complement Clause Vs Relative Clause category showed an interesting trend. It was the only category that had its ambiguous control questions answered more accurately than the unambiguous ones, albeit a slight margin. A total of a more than three-quarters resolved the ambiguity successfully. Pauses showed in the expected areas as well which suggests that this type of ambiguity, whilst requiring a mid-sentence reanalysis, can be resolved easily enough.
The results for the context paragraphs showed a mixture of trends. In every case, the pauses were not found to exist in any substantial way, which leaves the data on response times and accuracy the only method of investigating whether the resolution of temporary ambiguity is affected by prior context. In categories one, two and five, the response times to the control questions for the context sentences were less than that of the isolated cases. This might suggest the presence of a semantic interaction in their resolution.

The Object Noun Phrase Vs Main Clause Subject ambiguity showed negligible differences between both the response times and accuracy of answers. The accuracy of the context answers are slightly worse than in the isolated cases which could possibly be explained by the marginally faster response times for these sentences.

The Direct Object Vs Embedded Subject ambiguity category showed similar degrees of accuracy for both the isolated and context sentences. This was not reflected in the response times for this category. The isolated sentences took a lot less time to respond to, which suggests that although the ambiguity was successfully resolved in the context sentences, prior semantic knowledge did not aid in the faster resolution of it.

Complement Clause Vs Relative Clause and Prepositional Phrase Attachment ambiguity showed that when a context is provided, the resolution of the ambiguity is insufficient. This processing difficulty is also reflected quite clearly in the much larger response time for the latter category. Despite the first category having a slightly shorter response time for the context sentences, the failure to answer the control questions with a sufficient degree of accuracy means that these ambiguities do not show that prior contextual knowledge aids in the ambiguity resolution.

Main Clause Vs Complement Clause ambiguity showed that the accuracy of answers improved when a context was provided. This was the only category that demonstrated that this increase in accuracy did not imply a larger response time. This suggests that use of prior semantic knowledge in the processing of sentences may play a heavy role in the resolution of Main Clause Vs Complement Clause ambiguity. More research is necessary however if this claim is to be upheld.

The analysis of the genders showed that women resolve temporary ambiguity faster and more accurately in the isolated cases but the opposite when there is a context present. Linguists showed that formal instruction in the make-up of language helps when you encounter such ambiguity. The bilinguals who took part in the experiment suggested that they might process each sentence in isolation anyway so that prior context becomes irrelevant. They naturally find ambiguous sentences more difficult in every sense.

In relation to the context analysis, category five seems to be the most affected by the presence of context. The answers and speed of answers improved greatly where there was a qualifying context. This is the only category however, that showed any signs that the
human processing faculty is informed by the interaction of semantic and syntactic mappings. Due to the conflicting results for the context paragraphs, the debate must be left open on whether our faculty is a serially or parallel based system.

Chapter 8

Conclusion
8.1 Introduction

This chapter is the conclusion to this paper. It will sum up all that has been gained from the experiment to investigate temporary ambiguity resolution in humans. The particular difficulties that were faced will be discussed and a suggestion of further study will bring the chapter to a close.

8.2 Achievements and Knowledge Gained

The completion of this study has provided me with knowledge in several important areas relating to computational and experimental linguistics. The first of these must be in relation to ambiguity. Before undertaking this study, I was aware of this phenomenon but knew very little about it. Through research in other works, see Crain&Stedman (1985), Forster (1979), Kurztman (1984), Nive (1993) and Traxler (2002), I was able to grasp the uses of ambiguity and what can be implied from the study of it.

To complement this area of study, sentence processing was another area that was heavily researched, see Townsend&Beaver (2001), Merril Garett (1979), Forster (1979) Frazier&Fodor (1978). This allowed me to understand all the principles that are involved in how humans process sentences and more specifically, how they do this in the presence of ambiguity and what processing ambiguity can reveal to us.

This leads on to the knowledge I gained on the experimental linguistics side. Once again, research in the area, see Greenbaum (1977), Hoy (1999), Schütze (1996), allowed me to construct a valid experiment to test the resolution of temporary ambiguity. To successfully
achieve this, the research I had done played a vital role. Information regarding parameters and pitfalls to avoid were essential for me to achieve a valid experiment.

The computational aspect of the study involved the use of a number of bits of software. Each one added to my knowledge of computer programs and how they can be used for linguistic purposes. The web tool allowed me to set up an on-line experiment. ICECUP allowed me to gather material for the experiment and Excel was essential for the results to be analysed. Each program was used to its full potential and the knowledge gained from these exercises will be invaluable.

In relation to the knowledge gained from the results, I have learned that temporary ambiguity is a complex problem that can tell us a lot about the linguistic faculty of the brain. There are different types of temporary ambiguity and the way in which we treat each one is different. Some are easier dealt with than others. The study of the way we process sentences is an area of deep complexity and it is of little wonder as to why there is still no comprehensive agreement on a processing model.

8.3 Difficulties Encountered

There were several difficulties encountered throughout the study. The biggest difficulty was in relation to the experimentation tool. A lot of time was spent constructing the experiment as time and time again, the lack of its robustness caused problems. It also had to be adapted slightly and although this was in the hands of the Experiment Manager, the design of the experiment depended on it.

Learning to use three programs from scratch was also quite time consuming and added a lot of difficulty to the overall study. The results that have been achieved from each one however were astonishing and despite the difficulties in familiarising myself with them initially, the rewards for doing so are evident.

8.4 Suggestions for Further Study

Suggestions for further study have been noted throughout the paper. The inconclusive results for the relation that context plays on ambiguity resolution is the most obvious catalyst for further studies. The investigation, through ambiguity resolution, of how we process sentences is a topic that needs further attention. Each individual temporary ambiguity category can also shed light on this and it is essential that each category be studied in its entirety. Many conclusions can be drawn from results of ambiguity resolution studies and it is this that must inspire the ultimate explanation of the human processing faculty.
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Appendix
Experiment instructions

1. You are about to read ten sentences and a paragraph
2. All the sentences are fully grammatical
3. The sentences and paragraph will be shown, word by word
4. To progress through the sentence, click the “next slide” button
5. After some sentences, you will need to answer a short question

Experiment sentences

Each subject (#1, #2, #3, #4, #5) sees one pair of ambiguous and unambiguous sentences per category. These have been split up into five separate experiments as described in chapter four. Each sentence has a #number to indicate which subject sees which sentences and paragraphs.
Complement clause vs. Relative clause temporary ambiguity

1. #1, The spokesman told the journalist that the defendant annoyed that he should go jump off a cliff.
2. #1, The spokesman told the journalist who was annoyed by the defendant that he should go jump off a cliff.

Ambiguity question: who was told to jump off a cliff?

1. #2, The son argued with the workman that the children hindered that he was too old.
2. #2, The son argued with the workman who was hindered by the children that he was too old.

Ambiguity question: who was too old?

1. #3, The old man suggested to the young lady that the men were courting that she shouldn’t be so loving towards them.
2. #3, The old man suggested to the young lady who courted the men that she shouldn’t be so loving towards them.

Ambiguity question: who shouldn’t be so loving?

1. #4, The boardroom discussed the presentation that the man gave that was shocking.
2. #4, The boardroom discussed the presentation that was given by the man that was shocking.

Ambiguity question: who gave the presentation?

1. #5, The sergent persuaded the batallion that the king had lost that they had to fight on.
2. #5, The sergent persuaded the batallion that had been lost by the king that they had to fight on.

Ambiguity question: who had to fight on?
#2, The solidiers found themselves without a clue of where they were. They had been separated from their king and even their fellow comrades. The sergent finally came over the brow of the hill. After a long deliberation, the sergent persuaded the battalion that the king had lost that they had to fight on.

**Object NP vs. main clause subject temporary ambiguity**

1. #1, While Nigel was reading the newspaper lay unnoticed on the floor.
2. #1, While Nigel was reading, the newspaper lay unnoticed on the floor.

Ambiguity question: what was Nigel reading?

1. #2, Whilst Duncan was writing the manuscript fell to the ground.
2. #2, Whilst Duncan was writing, the manuscript fell to the ground.

Ambiguity question: what was Duncan writing?

1. #3, While Mary was mending the sock slipped off her leg.
2. #3, While Mary was mending, the sock slipped off her leg.

Ambiguity question: what was Mary mending?

1. #4, While Stevie was smoking the cigarette fell on his lap.
2. #4, While Stevie was smoking, the cigarette fell on his lap.

Ambiguity question: what was Stevie smoking?

1. #5, When the princess was sweeping up the dirt was everywhere.
2. #5, When the princess was sweeping up, the dirt was everywhere.

Ambiguity question: what was the princess sweeping up?

#3, The princess hated cleaning. She was always stuck with the worst jobs. The children would always have the rooms back to their awful state by the time she was finished. Before she started however, the rooms were in a worse state. For example, when the princess was sweeping up the dirt was everywhere.
Direct Object vs. Embedded Subject ambiguity

1. #1, The smart student remembered the answer was not correct.
2. #1, The smart student remembered that the answer was not correct.

Ambiguity question: what did the student remember?

1. #2, The judge finally announced the punishment was insufficient.
2. #2, The judge finally announced that the punishment was insufficient.

Ambiguity question: what did the judge announce?

1. #3, The prostitute warned the young boy was too small.
2. #3, The prostitute warned that the young boy was too small.

Ambiguity question: what did the prostitute warn against?

1. #4, The young woman suggested the way was over the hill.
2. #4, The young woman suggested that the way was over the hill.

Ambiguity question: what was suggested by the woman?

1. #5, The wise man finally believed the fortune teller was talking jiberish.
2. #5, The wise man finally believed that the fortune teller was talking jiberish.

Ambiguity question: what did the wise man believe?

#4, The wise man decided to see the fortune teller. He had been complaining to his wife of a constantly reoccurring nightmare. His wife however was against the idea. She said that the fortune teller is a load of nonsense. After an hour session with the fortune teller, the wise man finally believed the fortune teller was talking jiberish.
Prepositional phrase attachment ambiguity: NP-modifier vs. VP-modifier or VP-argument

1. #1, The cook placed the cake in the oven on the table
2. #1, The cook placed the cake that was in the oven on the table

Ambiguity question: where was the cake before it was moved?

1. #2, The princess put the frog on the basket on the table
2. #2, The princess put the frog that was on the basket on the table

Ambiguity question: where was the frog before it was moved?

1. #3, The soccer player kicked the ball on the penalty spot into the goal
2. #3, The soccer player kicked the ball that was on the penalty spot into the goal

Ambiguity question: where was the ball before it was kicked?

1. #4, The mechanic finally attached the bolt on the bonnet to the car.
2. #4, The mechanic finally attached the bolt that was on the bonnet to the car.

Ambiguity question: Where was the bolt before it was attached?

1. #5, The musician plucked the harp in his hands on stage
2. #5, The musician plucked the harp that was in his hands on stage

Ambiguity question: where was the harp?

#5, It had been a hard days work for the mechanic. He only had a few more things to do before he was able to go home. There were nuts and bolts everywhere. His last job was always the hardest. The mechanic finally attached the bolt on the bonnet to the car.

Main clause Vs complement clause temporary ambiguity
1. The boat floated down the river sank without a trace
2. The boat that was floated down the river sank without a trace

Ambiguity question: what initially happened to the boat?

1. The man gave the dog a bone fell on a bath
2. The man gave the dog that a bone fell on a bath

Ambiguity question: what did the man give the dog?

1. The horse raced past the barn fell
2. The horse that was raced past the barn fell

Ambiguity question: what was happening to the horse before it fell?

1. The speeding car driven past the police crashed.
2. The speeding car that was driven past the police crashed.

Ambiguity question: What was the car doing before it crashed?

1. The students taught in the open air do well
2. The students who are taught in the open air do well

Ambiguity question: where do the students do well?

#1, A range of experiments were tried by the postgraduates. Students were taught in a variety of different places to see how they would react to the environment. One conclusion at the end of the experiment was, the students taught in the open air do well.
Temporary Ambiguity Results

1. Complement clause Vs Relative clause
2. Object noun phrase Vs Main clause subject
3. Direct object Vs Embedded subject
4. Prepositional phrase attachment
5. Main clause Vs Complement clause

Bilingual and Linguist participation

| Version 1 | - Subject 3 | Linguist |
| Version 1 | - Subject 4 | Linguist, Greek |
| Version 2 | - Subject 5 | Spanish |
| Version 2 | - Subject 8 | Linguist, Finnish |
| Version 2 | - Subject 10 | Linguist |
| Version 3 | - Subject 3 | Linguist, Greek |
| Version 3 | - Subject 4 | Linguist |
| Version 3 | - Subject 5 | Linguist |
| Version 3 | - Subject 6 | Linguist |
| Version 4 | - Subject 3 | Linguist |
| Version 4 | - Subject 4 | Linguist, German |
| Version 4 | - Subject 5 | Linguist, French |
| Version 5 | - Subject 3 | Linguist |
| Version 5 | - Subject 5 | Linguist, German |
| Version 5 | - Subject 6 | Linguist |
The spokesman told the journalist who was annoyed by the defendant that he should go jump off a cliff.
The boardroom discussed the presentation that was given by the man that was shocking.

Subject 1
Subject 2
Subject 3
Subject 4
Subject 5
Subject 6
Subject 7

Time
Words
Participants

Comp C Vs Rel C (Version 4)

Comp C Vs Rel C (Version 4, amb)

1V5A
the sergent persuaded the battalion that the king had lost that they had to fight on
While Nigel was reading, the newspaper lay unnoticed on the floor.

Subject 1
Word: 0.922
Time: 0.343

Subject 2
Word: 15.716
Time: 0.523

Subject 3
Word: 1.951
Time: 0.428

Subject 4
Word: 1.178
Time: 0.731

Subject 5
Word: 1.075
Time: 0.466

Subject 6
Word: 2.367
Time: 0.798
Whilst Duncan was writing, the manuscript fell to the ground.

2V2B

Obj NP Vs Main C (Version 2)

Participants

Words

Time

2V3A
While Mary was mending the sock, it slipped off her leg.

![Graph of Obj NP vs Main C sub (Version 3)](image1)

Obj NP Vs Main C sub (Version 3)

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![Graph of Obj NP vs Main C sub (Version 3, amb)](image2)

Obj NP Vs Main C sub (Version 3, amb)

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133
While Stevie was smoking the cigarette fell on his lap.

### Table 1: Obj NP Vs Main C sub (Version 4)

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2V4B

2V5A
When the princess was sweeping up, the dirt was everywhere.
when the princess was sweeping up the dirt was everywhere
The smart student remembered that the answer was not correct.

### Dir Obj Vs Embedded Sub (Version 1)

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3V1B

3V2A
The judge finally announced that the punishment was insufficient.
The prostitute warned that the young boy was too small.
The young woman suggested that the way was over the hill.

Dir Obj Vs Embedded sub (Version 4)

Dir Obj Vs Embedded sub (Version 4, amb)

3V4B

3V5A
The wise man finally believed that the fortune teller was talking jiberish.

Dir Obj Vs Embedded sub (Version 5)

3V5B

Dir Obj Vs Embedded sub (Version 5, amb)

3C
The wise man finally believed the fortune teller was talking jiberish.

Subject 1
Subject 2
Subject 3
Subject 4
Subject 5
Subject 6
Subject 7

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4V1A
The cook placed the cake that was in the oven on the table.

4V1B

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4V2A

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The princess put the frog that was on the basket on the table.

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Prep phrase attach (Version 2, amb)

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4V3A
The soccer player kicked the ball that was on the penalty spot into the goal.

4V3B
The mechanic finally attached the bolt that was on the bonnet to the car.

- Subject 1
- Subject 2
- Subject 3
- Subject 4
- Subject 5
- Subject 6
- Subject 7

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Prep phrase attach (Version 4)

Prep phrase attach (Version 4, amb)
The musician plucked the harp that was in his hands on stage.
The mechanic finally attached the bolt on the bonnet to the car.

Subject 1
Subject 2
Subject 3
Subject 4
Subject 5
Subject 6
Subject 7
Subject 8
The boat that was floated down the river sank without a trace.

Subject 1

Subject 2

Subject 3

Subject 4

Subject 5

Subject 6

5V1B

Main C Vs Comp C (Version 1)

5V2A

Main C Vs Comp C (Version 1, Amb)
The man gave the dog that a bone fell on a bath.
The horse that raced past the barn fell

5V3B

Main C Vs Comp C (Version 3)

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Participants

5V4A

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Participants

5V4A

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Participants
The students who are taught in open air do well.

Subject 1  Subject 2  Subject 3  Subject 4  Subject 5  Subject 6  Subject 7

Time 0 5 10 15 20 25 30

Words

Participants

Main C Vs Comp C (Version 4)

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Main C Vs Comp C (Version 4, amb)

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5V5A
The speeding car driven past the police crashed.
The students taught in the open air do well.

### Context Main C Vs Comp C (Version 1, Amb)

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