

# **The Prevalence and Impact of Persistent Ambiguity in Software Requirements Specification Documents**

by

**Cristina Ribeiro**

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## **Abstract**

Despite a large amount of research in methods and tools for avoiding and detecting requirements ambiguity, recent studies have indicated that requirements ambiguity seems to be resolved through multiple inspections and discussions that characterize the requirements engineering process. However, this process may not catch ambiguity types that are likely to result in subconscious disambiguation. People are likely unaware of and incapable of recognizing these ambiguity types; therefore, these types are likely to remain after multiple inspections. This kind of ambiguity is defined as persistent ambiguity and may cause expensive damage. The potential impact of persistent ambiguity was investigated.

Initially, a comprehensive ambiguity model based on linguistic ambiguity and its application to requirements engineering was developed. The model was subsequently analyzed to determine the ambiguity types likely to result in subconscious disambiguation and therefore likely to persist. Three requirements specifications were inspected for instances of persistent ambiguity as defined in the model. Each chief requirements engineer verified whether the persistent ambiguities likely to have the greatest impact on each project were indeed interpreted ambiguously, and if so, what the impact was.

For the three requirements specifications inspected, there is an average of one persistent ambiguity for every 15.38 pages; project one has the highest average of one persistent ambiguity for every 3.33 pages, project three has an average of one persistent ambiguity for every 31.25 pages, and project two has the lowest average of one persistent ambiguity for every 56 pages. For the three projects, none of the persistent ambiguities reviewed by each chief requirements engineer caused expensive damage because all of the requirements engineers seemed to subconsciously disambiguate the ambiguities in the same way. For the three projects analyzed and the ambiguities reviewed by each chief requirements engineer, the least expensive approach would have been to forego initially identifying persistent ambiguity in these three projects.

The first main conclusion is that persistent ambiguity remained undetected by the teams of requirements engineers. The second main conclusion is that the process used by these particular requirements engineering teams for these particular projects is enough to prevent damage. The third main conclusion is that the identification of persistent ambiguity in requirements specifications is potentially an effective and efficient strategy for minimizing damage caused by ambiguity precisely because of its focus on ambiguity that remained undetected due to lack of awareness. Further study is necessary to determine what factors are involved in persistent ambiguity and its prevalence, as well as its potential impacts.

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## **Dedication**

This thesis is dedicated to my husband, Primoz Cresnik, my father, Antonio Ribeiro, my very dear friends, and Sox, each of whom I am blessed to have in my life.

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# LIST OF ABBREVIATIONS

<b>CBS</b>	Computer Based System
<b>NL</b>	Natural Language
<b>P1</b>	Project One
<b>P2</b>	Project Two
<b>P3</b>	Project Three
<b>PP</b>	Prepositional Phrase
<b>RC</b>	Relative Clause
<b>RE</b>	Requirements Engineering
<b>RS</b>	Requirements Specification
<b>SD</b>	Subconscious Disambiguation

## CHAPTER ONE

---

# INTRODUCTION

The primary goal of requirements engineering (RE) is to capture in a requirements specification (RS) all of the requirements that the client, users, and other stakeholders believe to be imperative in the computer-based system (CBS) being developed. Ambiguity in an RS could cause programmers to implement the CBS incorrectly from the client's viewpoint, resulting in major code re-writes, leading to delays in delivery, and introducing even more defects.

Almost all RSs are written in natural language (NL) [1]. Even when an RS is written in a formal language or with UML diagrams, it still begins with ideas expressed in NL

[2]. NLPs are inherently ambiguous. Therefore, it is worth researching writing less ambiguous requirements [3-6] and using restricted languages to write RSs [7-9], but there is no escaping ambiguous requirements [10].

Project failure has often been attributed to ambiguities in RSs. For example, Gause lists too much unrecognized disambiguation in RSs as one of the five most important sources of requirements failure [11]. This attribution claim has not been conclusively empirically proved; nonetheless, this claim has fuelled research in methods and tools for detecting ambiguities in RSs. There are two approaches for detecting ambiguities: manually [3, 4, 12] (See Section 1.1) or automatically with tools [10, 13-26].

As mentioned above, a number of researchers have focused on developing tools for the automatic detection of ambiguity. Rosenberg et al developed a requirements definition tool that produces reports that are used to identify requirements and structural areas within them that need improvement due to ambiguity [21]. They conclude that specifications developed using a requirements definition tool are more consistently numbered, better structured, and contain crisper statements than those developed based only on a documentation standard; however, no recall and precision are reported.

Bucchiarone et al presents an automatic NL requirements evaluation tool that identifies ambiguity, QUARS Express, with no reported recall and precision [22]. Gleich

et al presents an automatic ambiguity detection tool that has a recall of 86% and a precision of 95% [23].

Tjong tried something different, she implemented and evaluated a prototype potential ambiguity finder tool for RSs, SREE [24, 25], with a goal to achieve 100% recall by design even at the expense of precision. By limiting the scope of a manual search with a tool like SREE, the time required for a manual inspection could be decreased. SREE was unsuccessful in its goal of achieving 100% recall, having achieved a recall of only 80% and precision was not noted. SREE demonstrated that such a tool is promising in the ability to reduce the manual search time required for an inspection, and Tjong recommends that more research should be conducted to improve this approach.

Ferrari et al presents a method for pragmatic ambiguity (i.e., ambiguity that depends on the context of a requirement) detection in NL requirements specifications that has a recall of 63% and a precision of 51% [26].

While desirable, the use of tools for the automatic detection of ambiguity in RSs results in varying levels of recall. For example, the reported recall range of the tools mentioned above is 63% and 86%. This recall is problematic if your goal is to avoid all potential damage. In particular, a mission critical system in the area of medicine or banking requires 100% recall. If your goal is to catch all potential damage then a manual inspection is required even if a tool has been used.

Time is the single most important factor in software engineering. Defects that are not identified until the testing phase are at least 14 times more costly to fix than if the defect were identified in the requirements phase [27]. The earlier an ambiguous requirement or a defect is identified, the less expensive it is to repair it [28]. The least expensive time to identify ambiguous requirements is in the analysis phase, before any development begins. The cost to repair an ambiguity or a defect increases exponentially with the software development life cycle phase during which the defect is detected [28]. The paradox is that identifying ambiguities is itself expensive as it involves multiple, time-consuming, and focused inspections.

### **1.1 Research Problem**

A problem with all of these tools and methods for avoiding or detecting ambiguities is that we do not actually know if any of them are worth the effort. A cost – benefit analysis of these tools and methods would be valuable. De Bruijn tried to analyze the impact of ambiguity on project success [29].

De Bruijn’s overall goal was to determine the effect of ambiguity in a project’s RS on the project’s success, and he analyzed the RS for one failed CBS development project that consisted of 279 requirements. With his analysis, he attempted to answer the following research questions [29]:

- “1. How many requirement statements are ambiguous?
2. How many problems were caused by ambiguous requirements?”



De Bruijn's analysis determined that only one not very severe defect in the CBS was caused by ambiguous requirements. The independent test team and the third party development team had been able to work through all the other ambiguities. Thus, de Bruijn identified no expensive ambiguities.

De Bruijn's conclusion was that for the RS and CBS he examined, the ambiguities that remained were not critical and had nothing to do with the failure. In the end, he questioned whether focusing on ambiguities with special inspections and tools during RE is cost effective. Perhaps the normal conversation among stakeholders is sufficient to identify the RS ambiguities that would cause defects in the developed CBS.

The drawback of de Bruijn's study that could have caused him to come to an incorrect conclusion is that he took a random sample of the requirements. He started with the goal of identifying every ambiguity and determining if it caused damage. However, he quickly learned that there were far too many ambiguities. Nearly every requirement had some ambiguity, so to drastically reduce the number of requirements considered, he randomly sampled the requirements. To determine the number of problems caused by ambiguous requirements, he conducted a random sampling of a list of defects (problems) that he was fortunate to have access to.

In another study, Filippo went in the opposite direction from de Bruijn [30]. Instead of analyzing one failed CBS project as de Bruijn did, Filippo analyzed one successful CBS project that consisted of 205 requirements and was continually test-

ed. The drawback of Filippo's study, similar to that of de Bruijn's study, is that Filippo also conducted a random sampling of the defects, potentially leading to an incorrect conclusion. Filippo's analysis identified that only three out of the 100 defects he examined in the CBS were caused by ambiguous requirements. For the RS and CBS he examined Filippo concluded that, requirements ambiguity did not cause a significant number of defects. Of the three defects found to be caused by ambiguity, he estimated that the cost to repair is very small.

The random sampling approach used by both de Bruijn and Filippo could have missed a rare yet expensive ambiguity. Expensive ambiguities may be too infrequent to be reliably caught with random sampling. While ambiguities may be uniformly distributed among requirements, expensive ambiguities may not be. De Bruijn and Filippo did not identify any expensive ambiguities; however, this could simply have been the result of the random sampling each conducted. For example, if expensive ambiguities are rare then even sampling 80% of the requirements leaves a 20% chance of missing a rare expensive ambiguity.

## **1.2 New Approach**

I decided to use a different approach, one that I believe is likely to detect expensive ambiguities if they exist. My approach is to focus on the ambiguities that people are generally not aware of and therefore are not capable of recognizing. These ambiguities are thus likely to have been missed by stakeholders during requirements analy-

sis and RS production, and therefore likely to persist. This type of ambiguity is defined as persistent ambiguity.

Persistent ambiguity results in *subconscious disambiguation* (SD). SD of an ambiguity occurs when the reader or hearer of an ambiguous statement is not aware of the ambiguity and believes that his or her first understanding of the statement is the only possible understanding [4]. In some cases, SD leads to an understanding that is the same as the writer intended, and sometimes it does not. When SD of an ambiguity in an RS leads to an understanding different from what the writer intended, the final CBS delivered to the client may be incorrect.

Chapter 2 provides a comprehensive ambiguity model that includes a focus on persistent ambiguity, which are likely to result in SD. The intent is to perform a study somewhat similar to de Bruijn's. However, in order to both cut down the search for expensive ambiguities to a manageable size and to avoid the potential drawback caused by the random sampling, I examine all requirements, while narrowing the search to only those kinds of ambiguities included in the model that are likely to persist and therefore to result in SD. This amounts to using a purposive sampling method instead of a random sampling method, in which the purpose is to examine only persistent ambiguities that may be expensive.

### **1.3 Research Questions**

This thesis investigates the potential prevalence and impact of persistent ambiguity and if it is cost effective to devote effort to the avoidance and or detection of ambiguous requirements. A new approach different from de Bruijn's is taken to answer the following research questions:

1. What is the prevalence of persistent ambiguity?
2. What is the impact of persistent ambiguity?
3. Which approach has the lower cost: identifying persistent ambiguities in an RS during RE or repairing the damage caused by undetected ambiguities in later phases of the software development life cycle?

Ambiguities can be expensive to detect. As previously noted, the cost to repair a defect increases exponentially with the software development life cycle phase during which the defect is detected.

### **1.4 Thesis Structure**

Chapters 1 and 2 include all the relevant related work. Therefore, there is no explicit chapter on related work. Chapter 2 outlines the ambiguity model used in the study. Chapter 3 describes the research methods used to conduct the study and outlines the study's threats to validity. Chapters 4, 5, 6, 7, and 8 analyze the modifier, referential, elliptic, conditional clause reference, and plural results, respectively. Chapter 9 analyzes the interview results for all three projects inspected. Chapter 10

discusses all of the results of the study and presents recommendations for avoiding ambiguity in RSs. Chapter 11 lists the conclusions, limitations and contributions of the study, and discusses future work in the area of requirements engineering.

## CHAPTER TWO

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# THE SOFTWARE REQUIREMENTS SPECIFICATION AMBIGUITY MODEL

This chapter presents a comprehensive ambiguity model. The last section of the model discusses the ambiguity types likely to result in SD. The model's restrictions and application to RSs are discussed below.

Language usage is constantly evolving. Occasionally people's usage does not follow the rules of language for brevity or emphasis. Some sentences, although syntactically problematic, have become common usage. This model focuses on how people use language, syntactically problematic or not, and how that usage might cause ambiguity. This model restricts its focus to the English language.

A spoken ambiguity is more easily resolved because the hearer can ask for clarification on the spot; hence, clarification is just part of the dialogue. Ambiguities in writing are more problematic because often the reader does not have any access to the writer, and in cases that the reader does, it's not direct access. A reader might have to try multiple times to get in contact with the writer before receiving clarification, and the clarification may not even be unambiguous. The focus of this research is on the prevalence and impact of ambiguities in written RSs.

A single requirement varies in size, ranging from a single sentence to multiple sentences, and may include diagrams or tables. There is no agreed upon standard unit to identify a requirement due to its complex nature and the multiple levels of specification found in requirements. The smallest unit that can be examined is a sentence, a phrase or a clause. These units are chosen for identifying ambiguities in this model, but context will be used to disambiguate ambiguities.

When the context of an ambiguity is taken into account, there is often a clearly preferred interpretation, and any other interpretations seem contrived. In most am-

biguous cases, people assume the most salient interpretation and disambiguate the sentence as the writer intended. These cases have a low probability of being interpreted counter to the writer's intentions. Less common is an undetected ambiguity in which multiple interpretations are equally likely, and one interpretation is not more salient than the others. Such a case has a high probability of being interpreted counter to the writer's intentions. Other cases might be inherently ambiguous and require the writer to disambiguate.

Ultimately, in the investigation of ambiguities in RSs, context must be taken into account. Requirements in the RSs will not be analyzed in isolation. Rather, the context of the previous requirements, and paragraphs will be used to try to disambiguate each requirement.

An ambiguity that remains ambiguous after context is taken into account is a *nocuous ambiguity*. A nocuous ambiguity has more than one viable interpretation, whereas an *innocuous ambiguity* has a single viable interpretation [31]. An innocuous ambiguity does not cause damage. Conversely, a nocuous ambiguity may or may not cause damage.

In this model the assumed context of a definition of ambiguity is that of linguistic ambiguity. Linguistic ambiguity is researched in the fields of linguistics, computational linguistics [32-36], and philosophy.



Each ambiguity type is described by a definition, some examples, and its resolution when applicable. Throughout the model, examples are typeset in BANK GOTHIC to avoid having to quote them. The numeral naming an example, which is not part of the example, is typeset in the same Times New Roman that is used for the normal text.

The ambiguity types are presented in the following order: lexical, analytical, attachment, coordination, referential, elliptic, modifier, and plural ambiguities. Also presented are the ambiguity phenomenon of vagueness, generality, and subconscious disambiguation.

## **2.1 Lexical Ambiguity**

Two words are homonymous if they have identical spelling, but different meaning.

*Definition:*

A lexical ambiguity occurs when a homonymous or polysemous word occurs in a sentence and these words have multiple meanings.

*Examples:*

1. Bank

In Example 1 the word bank has at least two different meanings. It can mean a financial institution or the edge of a river.

## 2. Green

In Example 2, the word green could describe either the colour of an object; an emotion such as green with envy; or youth, vitality, or inexperience.

Usually context tells you which choice of a homonymy or a polysemy is meant.

*Resolution:*

To avoid lexical ambiguity, a writer could ensure that enough context is provided to clarify which is the intended meaning.

## 2.2 Analytical Ambiguity

*Definition:*

An analytical ambiguity occurs when the role of the elements in a phrase or sentence is ambiguous.

*Example:*

### 3. The French history teacher

Example 3 can be interpreted as either The teacher of French history or The history teacher who happens to be French. Even French history is analytically ambiguous, as it could mean history of France or history of the French language. Many of these ambiguities are subtle and difficult to resolve.

*Resolution:*

To avoid analytical ambiguity, a writer could rewrite with additional words to make clear the intent.

### **2.3 Attachment Ambiguity**

*Definition:*

An attachment ambiguity occurs when either a prepositional phrase (PP) or relative clause (RC) can be syntactically attached to more than one part of a single sentence and renders different interpretations.

*Examples:*

4. The police shot the rioters with guns. [4]

Example 4 has two possible interpretations based on the two syntactically possible attachments for the PP, with guns. The first attachment is to shot, and the second attachment is to rioters. The first interpretation is that the police, with their guns, shot the rioters. The second interpretation is that the police shot rioters who had guns themselves.

5. The organization has opened a cleaning center in Seward.

Some PPs do not produce different interpretations for the different attachments, as shown in Example 5. The first attachment option for Seward is to a cleaning center and another is to the organization. Both attachments lead to the same interpretation. Therefore, this PP attachment ambiguity is considered innocuous.

6. ... the lamp near the painting in the house that was damaged in the flood... [37]

In Example 6, the RC that was damaged in the flood can be attached to any of the lamp, the painting, or the house.

*Resolution:*

To avoid attachment ambiguity, a writer could rewrite with additional words to make clear the intent.

## **2.4 Coordination Ambiguity**

*Definition:*

A coordination ambiguity occurs in a sentence with either more than one conjunction or a modifier and a conjunction.

*Examples:*

7. I saw Jane and Calvin and Jack saw me.

Example 7 may be interpreted as either I saw Jane and Calvin, and Jack saw me or I saw Jane, and Calvin and Jack saw me.

8. Young man and woman.

Example 8 may be interpreted as either young man and young woman or woman and young man.

*Resolution:*

To avoid coordination ambiguity, a writer could use line breaks and indentation,

as in this sentence, to show the structure of the coordination,<sup>1</sup>

use punctuation,<sup>2</sup>

use additional words,<sup>3</sup> or

change the wording<sup>4</sup>.

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<sup>1</sup> An example of this usage is shown in the resolution.

<sup>2</sup> An example of this usage is shown in the interpretation of example 7.

<sup>3</sup> An example of this usage is shown in the first interpretation of example 8.

## 2.5 Modifier Ambiguity

Some grammar books [38, 39] promote the rule that a modifier should be placed immediately preceding what it modifies; this placement of a modifier is called “correct placement”<sup>5</sup>. Nevertheless, the typical native English speaker places the modifier before the main verb of the containing sentence regardless of what the modifier is intended to modify [4, 40-42]. Appendix A, Section A.1 and Appendix B, Section B.1 contain usage frequency studies with empirical evidence that the typical native English speaker commonly places modifiers before the main verb more often than placement after the main verb. Modifier placement before the main verb is called “standard placement”<sup>6</sup>.

Occasionally, standard placement may be correct placement, but exclusive or even frequent use of standard placement causes ambiguity, as the reader cannot determine what is intended to be modified.

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<sup>4</sup> An example of this usage is shown in the second interpretation of example 8.

<sup>5</sup> The concept of correct placement is a new addition to the 16th edition of the Chicago Manual of Style published in 2010. The preceding editions, the 15th published in 2003, the 14th published in 1993, and the 13th published in 1982, do not include correct placement. The Cambridge grammar of the English Language published in 2003 includes correct placement and the ambiguities that standard placement creates.

<sup>6</sup> In linguistics the concept of standard English refers to following the grammatical rules of English. In this thesis, standard placement refers to the placement that is commonly used.

If most of the modifiers in a document are placed other than before the main verb, then the reader who is aware of the difference between the placements can assume that an occasional placement before the main verb is intentional, because the writer of the document seems to be aware of the dangers of standard placement.

*Definition:*

A modifier ambiguity occurs when a sentence contains a modifier and there is more than one possible element that the modifier could be modifying.

*Examples:*

9. I go grocery shopping only on Wednesdays.

Example 9 has a correct placement, on the assumption that the intended meaning is that the only day of the week that I go grocery shopping is Wednesday. Since the placement of only is non-standard, the aware reader can assume that the placement is intentional because the writer seems to be aware of the dangers of standard placement.

10. I only nap in the afternoon.

There are circumstances in which placing the modifier before the verb is correct: when the intended interpretation is to use the modifier to modify the verb and not to modify anything else in the sentence.

In Example 10, *only* is placed before the verb *nap*. As written, this sentence means that the only thing I do is nap in the afternoon.

If the writer intended to say that he or she does not take naps at any time of the day other than the afternoon, then the correct placement of *only* is *I nap only in the afternoon*.

There are circumstances where the literal interpretation is contrived, and with context there is a salient interpretation.

11. I only ate vegetables.

Example 11 means that I didn't wash, buy, or cook the vegetables, I only ate them.

This is a contrived interpretation, and a large majority of people would not interpret this sentence this way. There is a clearly preferred interpretation, namely I ate only vegetables, regardless of the fact that the syntactical interpretation is different. An ambiguity with a highly viable interpretation, in most cases, is innocuous.



While not common, placing the modifier after what it modifies is incorrect placement and may create ambiguity if the modifier occurs also before something else in the sentence. The reader's interpretation will be that the modifier modifies what immediately follows the modifier, even though the writer's intended interpretation is that the modifier modifies what immediately precedes it.

When the modifier is placed at the very end of a sentence, then the sentence is unambiguous, because the modifier can modify only what precedes it.

12. I nap in the afternoon only.

In Example 12, the modifier *only* cannot modify what follows it, because it is the last word in the sentence. So it must modify the phrase that precedes it, which is the afternoon. The interpretation for this example is I nap in only the afternoon. Example 12 is unambiguous.

*Resolution:*

To avoid modifier ambiguity, a writer could ensure that each modifier placement is immediately preceding what is to be modified.

## 2.6 Referential Ambiguity

In English, a pronoun refers to a noun that appears earlier in the text and a determiner precedes a noun and provides context for determining the referent of that noun in the discourse. Pronouns and determiners are not interpreted semantically on their own; rather, their interpretation is dependant on the set of possible referents.

### *Definition:*

A referential ambiguity occurs when a pronoun or determiner can refer to more than one referent.

### *Examples:*

13. Bob said to Joe that he must leave.

Example 13 has three possible interpretations. The pronoun he could refer to either Bob, Joe or someone else, e.g. Josh.

Example 13 could have been written unambiguously by having the pronoun replaced by the noun that the writer intends to be the referent, as shown in Example 14.

14. Bob said to Joe that Joe must leave.

15. They kidnapped my dog.

Example 15 has three possible interpretations:

1. They could refer to some specific plural noun previously given, such as in three thieves came to my house or three friends came to my house.
2. They could mean an indeterminate number of people such as in Some people kidnapped my dog.
3. They could also mean a person of indeterminate gender such as in Someone kidnapped my dog.

The acceptance in common usage of third-person plural pronouns they, their, them, or themselves as singular is still heavily debated, and has a long history dating back to Middle English [43]. Regardless of its acceptance, the common usage causes ambiguity because a third person pronoun can refer to either a singular or a plural noun referent, even though the associated verb is in plural form. This uncertainty in the number of the referent of They adds ambiguity, as the referent can no longer be assumed to be plural, even when there is a feasible plural potential referent. The reader is left uncertain as to whether the writer is following the rules and intending a plural interpretation, or not following the rules and intending a singular interpretation.

A demonstrative pronoun is particularly problematic because of its popular use in referring to a whole idea instead of a simple noun, as shown in Example 16.

16. This prevents security breaches.

In Example 16, this is a demonstrative pronoun, for which the preceding text is required to determine its referent. The referent could be identified anywhere in the text preceding the sentence. The referent may not even be any particular word or phrase; it may be the idea embodied by whole or multiple sentences. When a demonstrative pronoun is followed by a noun, it becomes a demonstrative determiner and is less likely to be ambiguous, as shown in Example 17.

17. This encoding scheme prevents security breaches.

There are possessive pronouns and determiners, and there are demonstrative pronouns and determiners. In both cases, the use of a determiner is less ambiguous than the use of a pronoun.

*Resolution:*

To avoid referential ambiguity, a writer could use the referent noun instead of a pronoun.

## 2.7 Elliptic Ambiguity

Ellipsis is quite complex, warranting a separate section because despite its similarity to reference, the two are significantly different. Ellipsis can be viewed as a form of reference: reference by empty string. Whereas a reference replaces an element with another element, an ellipsis is the elision of an element. The elements that may be elided include verbs, nouns, and clauses.

### *Definition:*

An elliptic ambiguity occurs when an element has been elided, and there is more than one possible element from the discourse that the elided element could be.

Elliptical ambiguity is particularly problematic to identify because it is sometimes hard to determine what has been elided.

### *Example:*

18. Perot knows a man richer than Trump. [4]

In Example 18, the verb at the end of the sentence has been elided. The reader does not know if the elided verb is knows or is, each of which provides a different interpretation: Perot knows a man richer than Trump knows or Perot knows a man richer than Trump is.

*Resolution:*

To avoid elliptical ambiguity, a writer could avoid ellipsis and write the elided word.

## **2.8 Conditional Clause Reference Ambiguity**

Conditions are part and parcel of RSs. Frequently, the different users, systems or sub-systems provide inputs or outputs that are based on conditions. A conditional clause reference includes the reference elements so or not. In natural language these elements occur most often following *if*, and occasionally following *assuming* or *suppose* [44].

*Definition:*

A conditional clause reference ambiguity occurs when a conditional clause can refer to more than one condition.<sup>7</sup>

*Example:*

In an RS, a sentence of the form *if x, y* is a conditional clause with *x* being the condition and *y* being what is done if the condition, *x*, is true. When writers write only *if*

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<sup>7</sup> In linguistic terms, conditional clause reference is classified as conditional clause substitution. Linguists distinguish substitution as separate from reference regardless of the fact that each has an element that refers to another element. For simplicity, in this model I choose to classify conditional clause as referential.

not, z or if so, z, instead of writing the specific condition, it can be ambiguous what not or so refers to.

An if not or if so condition is ambiguous because the not or so can reference any of the previous conditions, or all of the previous conditions, or some combination of the previous conditions.

Example 19 is from a televised show [45].

19. Person A sends a text message:

“If you’ re coming to the party, bring cupcakes.

If not, no problem.”

Person B reads the text out loud and says to person C

“What does that mean?

It’ s no problem if I don’ t go or its no problem if I don’ t bring cupcakes?

And if I don’ t go then there’ s no cupcakes.

Or will someone else bring them?

And if someone else is bringing them why is she even asking me?”

Example 19 shows a clausal reference ambiguity, where the element not can refer to either of the clauses coming to the party or bring cupcakes, in the previous sentence.

The if not conditional clause in Example 19 changed to an if so conditional clause such as If so, great., is also ambiguous. It is not clear which of the two clauses in the previous sentence so refers to. If there are other preceding sentences, additional interpretations may be possible, shown in Example 20.

20.

- I. When a user requests a book with an available status, assign book to user.
- II. When the user requests a book with a checked-out status, place a hold on the book for the user.
- III. If so, increase the book's number-of-user-requests counter.

In Example 20 So may refer to the first clause in the first sentence or the first clause in the second sentence or it may refer to both. Examples 19 and 20 show the meaning of so or not may go back further than the convention of going to the most recent referential element.

*Resolution:*

To avoid conditional clause reference ambiguity, a writer could write the specific clause in a conditional clause instead of writing the reference elements so or not.



## 2.9 Plural Ambiguity

*Definition:*

A plural ambiguity occurs when a sentence contains a plural subject and or object and it is unclear whether the object or subject complement refers to a collective or a distributive interpretation.

A collective interpretation occurs when the subject or object is interpreted as designating a set. A distributive interpretation occurs when the subject or object is interpreted as designating each of the elements of a set.

*Examples:*

21. Two men lift a table. [46]

In Example 21, the collective interpretation is: Two men lift a single table together and the distributive interpretation is Each of two men lifts his own table.

There are situations in which there is a clearly preferred interpretation, and a salient interpretation exists. Even when a salient interpretation exists ambiguity might exist.

Example 21 contains a plural subject noun phrase. A plural noun phrase in the argument position of any verb can have both a collective interpretation and a distribu-

tive interpretation. Collective and distributive interpretations are possible whenever a plural noun phrase is a subject, or as a direct or indirect object.

22. John lifted three tables. [46]

In Example 22, if John lifted three tables as a set, he had to lift also each table, that is the collective interpretation has a distributive sub-entailment. There are exceptions to the distributive sub-entailment, as shown in Example 23, in which the direct object is possibly ambiguous.

23. She summarized the proposals. [47]

The collective interpretation of Example 23 is that the proposals were not summarized individually, but they were summarized as a whole. The distributive interpretation of Example 23 is that the proposals were not summarized as a whole, but each proposal was individually summarized.

There is a compounding in the number of possible interpretations when a sentence contains more than one plural noun phrase, as in Example 24.

24. Two men lift three tables. [46]

In Example 24, each of the two noun phrases has a collective and distributive interpretation, creating four possible interpretations. With both noun phrases interpreted collectively there is a total of three tables. With the subject noun phrase interpreted distributively, there are up to six tables.

Another cause of a collective and a distributive interpretation is the usage of quantifiers. Quantifiers are inherently ambiguous. Some quantifiers are syntactically plural, yet they are often used singularly. Quantifiers indicate cardinality of the subject and object relationship. Possible interpretations include the following relationships: one to one, one to many, many to one, or many to many. This relationship ambiguity could cause costly errors in software engineering.

25. Many bring their dogs. [4]

26. Few bring their dogs. [4]

27. Many bring their dog.

Examples 25 to 27 are syntactically correct, yet they are also ambiguous. In each example the reader cannot decipher how many dogs each person brings. Examples 25 and 26 can be interpreted as either a many to many relationship or a many to one relationship. Example 27 can be interpreted as either a many to one relationship or a one to one relationship. The many to one interpretation is possible if multiple people all share the same dog.

28. All lights in the room are connected to a single switch. [4]

Example 28 is ambiguous, with two possible interpretations. The collective interpretation is all lights in the room are connected to a single shared switch. The distributive interpretation is each light in the room has its own unshared single switch.

The syntactically singular use of the quantifiers *each*, *every*, and *any* results in a distributive interpretation. When these quantifiers are used as the subject, due to subject verb agreement, the verb must also be singular, which syntactically results in a distributive interpretation of the complement.

Often people use these quantifiers as a plural rather than as a singular [48-50]. Appendix A, Section A.2 and Appendix B, Section B.2 contain usage frequency studies with empirical evidence that the typical native English speaker uses plural rather than singular when talking about what each member of a set does. This semantically plural usage of these quantifiers makes it difficult for the reader to know the writer's intention, and leads to ambiguity.

29. Every light has their switch [4]

The distributive interpretation of 29 is each light has its own switch. The collective interpretation of 29 is all the lights share a single switch.

*Resolution:*

To avoid plural ambiguity for a collective interpretation, a writer could use a singular noun naming the collection, as shown in Examples 30 and 31.

To avoid plural ambiguity for a distributive interpretation, a writer could use an adverb such as *each* or *individually*, to refer to each item as being identified separately, as shown in Examples 32 and 33.

30. A group of two men lifts a table.

31. A pair of men lifts a table.

32. Two men each lifts a table. Or Each of the two men, lifts a table.

33. Two men individually lifts a table.

## **2.10 Vagueness Phenomenon**

*Definition:*

Vagueness occurs when a sentence contains a subjective noun phrase and results in more than one interpretation.

*Example:*

34. tall

In Example 34, the word tall is vague, as different people define tall differently. Also what is being classified as tall has an effect on how tall is defined. One might define a person as being tall if that person is over two meters in height, but the same definition of tall would not be applied to a tall glass of water. Also among basketball players, two meters is not tall, while among jockeys, even one and a half meters is tall.

*Resolution:*

To avoid vagueness, a writer could avoid using subjective noun phrases and use more specific noun phrases as shown in Example 35.

35. He was over 6 feet tall.

## **2.11 Generality Phenomenon**

*Definition:*

Generality occurs when a sentence contains a general non-specific noun phrase and results in more than one interpretation.

*Example:*

36. cousin

In Example 36, *cousin* describes a person who is related in a particular way, but in English, it does not specify if the cousin is male or female.

*Resolution:*

To avoid generality, a writer could avoid using general noun phrases and use more specific noun phrases as shown in Example 37.

37. My cousin Elaine is getting married next year.

## **2.12 Subconscious Disambiguation Phenomenon**

As mentioned in Section 1.2, SD occurs when an ambiguous sentence is interpreted as being unambiguous, having only one possible interpretation. All ambiguity types may result in SD, but some types are more likely than others to result in SD.

My approach is to focus on the ambiguities of which people are likely unaware. The typical person commonly uses language that introduces ambiguity, indicating that he or she is unaware of the ambiguity introduced by his or her common usage. Further evidence of the pervasiveness of ambiguity induced by common usage includes the writing of this thesis. I, myself, succumbed to standard modifier placement, common reference usage, and common plural usage despite being aware of the dif-

ferent ambiguity types and trying to avoid this placement and usages. In response to my standard modifier placement, I decided to ensure that I used correct placement. In response to my common reference usage, I decided to risk overcompensating and use a determiner and a noun in particular instances rather than a more natural sounding pronoun; For example, I would use *this usage* rather than *this*. In response to my common plural usage, I decided to use the singular usage for each subject when possible.

People are more likely to subconsciously disambiguate when they are unaware of ambiguity types that occur due to common usage. People unaware of ambiguity resulting from common usage cannot identify that another interpretation exists.

The following ambiguity types occur because of common usage: modifier, reference, elliptical, conditional clause reference, and plural [3, 4, 51]. Persistent ambiguity (introduced and defined in Section 1.2) comprises these ambiguity types. Appendix C contains for each persistent ambiguity type an example that is a requirement. The ambiguity model details the common usage, that causes ambiguity, by ambiguity type.



## CHAPTER THREE

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# RESEARCH METHODS

This chapter describes the methods used in the following procedures: the collection method for the requirements data; the strategy for dealing with the size explosion problem in the amount of ambiguity to inspect; the persistent ambiguity identification method; the strategy to further reduce the amount of ambiguity to inspect; the strategy used to rank the ambiguities for review by the chief requirements engineer according to those that are most likely to cause damage; and the interview method for the review by the chief requirements engineer that determines the damage resulting from the ambiguities identified. The data collected from these procedures answer the research questions posed in Section 1.1.

In addition, this chapter discusses the resulting validity of the study. The types of validity discussed are: external validity, construct validity, and internal validity.

### **3.1 Requirements Data Collection**

A major company, which shall remain anonymous<sup>8</sup>, has supplied high quality RSs for three major CBSs that have been successfully implemented. Real-life data is difficult to attain, as most companies don't publically share their RSs. The number of documents available is probably not enough for statistically significant results. However, each document is quite lengthy, averaging over 4,000 complex requirements, and the time required to carefully inspect the ambiguity in these documents manually is significant. Future research could increase the total sample data and strengthen the results of this study.

The software was developed in house. The company developed the software to run their business and gain a competitive advantage over other companies in the same business by providing better service to their customers. The company's software provides automated and semi-automated services to their customers.

The company is serious about RE. The company stays in the RE phase of the SDLC until it is completed. The company follows the waterfall model's SDLC and they allocate enough time to develop a system correctly.

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<sup>8</sup> Due to a non disclosure agreement.

The company staffs a project with enough people to do the job, fewer for smaller projects and more for larger projects. Team sizes range from 5 people to 15 people with a median at 10 people. Projects take 1 year to 2 years with a median at 18 months.

### **3.2 Identification of Ambiguity in the Requirements**

The requirements inspector is the author of this thesis and was a Computer Science PhD candidate whose research area is software engineering. She is also a native English speaker. The inspector has no *a priori* knowledge of these RSs. Ignorance of the later histories of the RSs makes the inspector akin to a normal domain-ignorant inspector. A domain-ignorant inspector is someone not involved in the project, specifically chosen for one's ignorance, and therefore more likely to interpret what the RS actually says and not what people involved in the project think it says.

In most RSs, if all types of ambiguity were to be identified in each of the requirements, the resulting data set would be too large and expensive to manually inspect. This data size explosion problem has been dealt with in different ways and my unique strategy is detailed in the following strategy.

### ***3.2.1 Strategy for Dealing with the Data Size Explosion Problem in the amount of Ambiguity***

As detailed in Section 1.1, both de Bruijn and Filippo resorted to random sampling as a way to cut down the amount of ambiguity. In both studies, few defects were identified that were associated with ambiguity; however, de Bruijn himself concluded that the reason he did not identify more defects related to ambiguity was his strategy of random sampling.

When conducting an empirical study such as the one in this thesis or those of de Bruijn or Filippo, the number of ambiguities must be cut down to a manageable size. My study includes three projects totalling 12,054 requirements, which is 43 times more data than in de Bruijn's research and almost 59 times more data than in Filippo's research. While both de Bruijn and Filippo use random sampling, a probability sampling method, to reduce the number of ambiguities, this study uses strategic and purposive sampling because expensive ambiguities may be too infrequent to catch with a random sample.

My strategic and purposive sampling is a non-probability sampling method. Deviant case sampling is a special type of purposive sampling in which the cases chosen substantially differ from the dominant cases. The deviant cases I chose to sample are the persistent ambiguity types (defined in Section 2.12), those that I believe people are unaware of and are therefore most likely to result in SD. The basis for this decision is that I believe that because people are aware of the types of ambiguity defined

in Sections 2.1, 2.2, 2.3, and 2.4 (lexical, analytical, attachment, and coordination ambiguity, respectively), these types would likely have been resolved through communication between the various requirements engineers involved in the project. On the other hand, the ambiguities people are unaware of are most likely to cause expensive problems that require repairing late in the SDLC. I believe this strategy to deal with the size explosion problem is more likely to identify an ambiguity that is expensive to repair that was not detected.

The purpose of my strategy that focuses on persistent ambiguity is to attempt to identify ambiguities that were overlooked by requirements engineers in the requirements analysis discussions. These persistent ambiguities may have led to a false sense of project success because hidden defects not yet identified may yet cause expensive damage.

### ***3.2.2 Persistent Ambiguity Identification Method***

The identification method for each persistent ambiguity type is outlined in detail in this Section.

#### **3.2.2.1 Modifier Ambiguity**

Table 1. Modifier Cue Words

Modifier Cue Words
Only

Also
Just
Even

1. Search for instances of the cue words listed in Table 1.
2. For each instance identified, determine all the possible viable interpretations from the discourse, while ignoring any contrived interpretations.
3. Check each interpretation to ensure that it is unique.

### 3.2.2.2 Referential Ambiguity

RSs and other technical documents are unlikely to contain first person singular or plural, and second person singular or plural pronouns and determiners. Thus, the following pronouns and determiners are excluded from the referential cue words: I, me, mine, my, you, yours, your, we, us, ours, and our<sup>9</sup>. Referential cue words include the following demonstrative third person singular and third person plural pronouns and determiners, see Table 2. These pronouns and determiners are investigated because they are the ones that are likely to be found in RSs<sup>10</sup>.

Table 2. Referential Cue Words

Referential Cue Words				
Pronouns			Determiners	
Personal	Demonstrative	Possessive	Demonstrative	Possessive
It	This	Its	This + noun	Its + noun
They	That	Theirs	That + noun	Their + noun

<sup>9</sup> In the three RSs inspected, zero first person singular or plural, and second person singular or plural pronouns and determiners were found.

<sup>10</sup> In the three RSs inspected, zero third person singular pronouns were found.

Them	Those	-	Those + noun	-
He and him	These	His	These + noun	His + noun
She	-	Hers	-	Her + noun

1. Search for instances of the cue words listed in Table 2.
2. For each instance identified, determine all the possible viable referents from the discourse, while ignoring any contrived interpretations.
  - a. Possible referents include:
    - i. A simple noun
    - ii. A phrase
    - iii. An idea embodied by whole or multiple requirements
3. Check each interpretation to ensure that it is unique.

### 3.2.2.3 Elliptic Ambiguity

Table 3. Elliptic Cue Words

Elliptic Cue Words
Than
From

1. Search for instances of the cue words listed in Table 3.
2. For each instance identified, determine if there is an ellipsis in the requirement.
3. If an ellipsis exists determine all possible viable referents from the discourse, while ignoring any contrived interpretations.
  - a. Possible referents include:
    - i. A simple noun
    - ii. A phrase
    - iii. An idea embodied by whole or multiple requirements
4. Check each interpretation to ensure that it is unique.

### 3.2.2.4 Conditional Clause Reference Ambiguity

Table 4. Conditional Clause Cue Words

Conditional Clause Reference Cue Words
If so,
If not,

1. Search for instances of the cue words listed in Table 4.
2. For each instance identified, determine all the possible viable referents from the discourse, while ignoring any contrived interpretations.
  - a. Possible referents include:
    - i. A simple noun
    - ii. A phrase
    - iii. An idea embodied by whole or multiple requirements
3. Check each interpretation to ensure that it is unique.

### 3.2.2.5 Plural Ambiguity

To identify instances of plural ambiguity, plural cue words include plural nouns and quantifiers. In the ambiguity model in Section 2.9, it is pointed out that the singular quantifiers *each*, *every*, and *any* are often used as plural, which may cause ambiguity.

An instance of these singular quantifiers can be a sign that the requirements engineer is aware of the dangers of plural ambiguity. Therefore, these singular quantifiers are also included as cue words.

For the purposes of this thesis the following numbers are investigated: two to ten.

The number one is excluded because this number is singular. These numbers are chosen because these numbers are commonly written in full as quantifiers of a noun.



Table 5. Plural Cue Words

Plural Cue Words	
Quantifiers	Plural Nouns
Each	
Every	
All	
Any	
Many	
Few	
Both	
Several	
Numbers (two, three, four, five, six, seven, eight, nine, and ten)	

1. Search for instances of the cue words listed in Table 5.
2. For each instance identified, determine the usage of the cue word.
3. If the cue word or cue words is used as the subject and or object, determine if there is a collective interpretation and a distributive interpretation that are not contrived for each cue word.
4. Check each interpretation to ensure that it is unique.

### 3.3 Identification of the Damage Potential of Persistent Ambiguities Identified in the Requirements

The result of the inspection method is a list of persistent ambiguities identified. The chief requirements engineer for each RS reviews this list when interviewed by the inspector.

### ***3.3.1 Strategy for Reducing the Amount of Ambiguity Reviewed by Each Chief Requirements Engineer***

Although a substantial amount of time was spent to obtain the list of persistent ambiguities, the data size remained too large for review by the requirements engineers<sup>11</sup>. Initially, I was very fastidious; each requirement with more than one possible interpretation was recorded as ambiguous. However, each chief requirements engineer would not be able to dedicate the time required to review each ambiguity identified. Out of necessity I had to further reduce the list of ambiguities.

I decided to look for signs of a lack of awareness of ambiguity beyond that captured by persistent ambiguity. In some cases, there were comments showing that the requirements engineers were aware of the ambiguity and they requested further details to disambiguate. In other cases, domain knowledge of the project would likely lead the requirements engineers to disambiguate. In both situations, I decided that it is not worth interviewing them about the particular ambiguities because of these signs of awareness.

As a result, the following strategy for reducing the amount of ambiguity was implemented after the identification of persistent ambiguity in the RSs: For each persistent ambiguity identified, if there were signs of discussion or domain knowledge, the ambiguity was removed from the list of persistent ambiguities.

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<sup>11</sup> Any contrived interpretation was not considered a valid interpretation as its meaning does not make sense.

### ***3.3.2 Strategy for Ranking Persistent Ambiguities According to Damage Potential***

After the reduction of the amount of ambiguity reviewed by the chief requirements engineer is complete, the remaining identified persistent ambiguities are the ones most likely to have been missed and cause damage. Many of these ambiguities have a high number of viable interpretations.

Because the requirements engineer's time is a scarce resource, the ambiguities were ranked from the highest potential damage they could cause to the lowest. In addition, the chief requirements engineers are more likely to review more ambiguities if they prove to be nocuous. This ranking strategy takes this into consideration and will increase the likelihood of answering the research questions.

The ranking strategy purposefully aims to minimize the time required from the people involved in the projects. People are a limited resource and are too busy to take the time to discuss these projects unless something is identified that would interest them. The reason for this strategy is based purely on real-world realities.

### ***3.3.3 Interview with the Chief Requirements Engineer of Each Project***

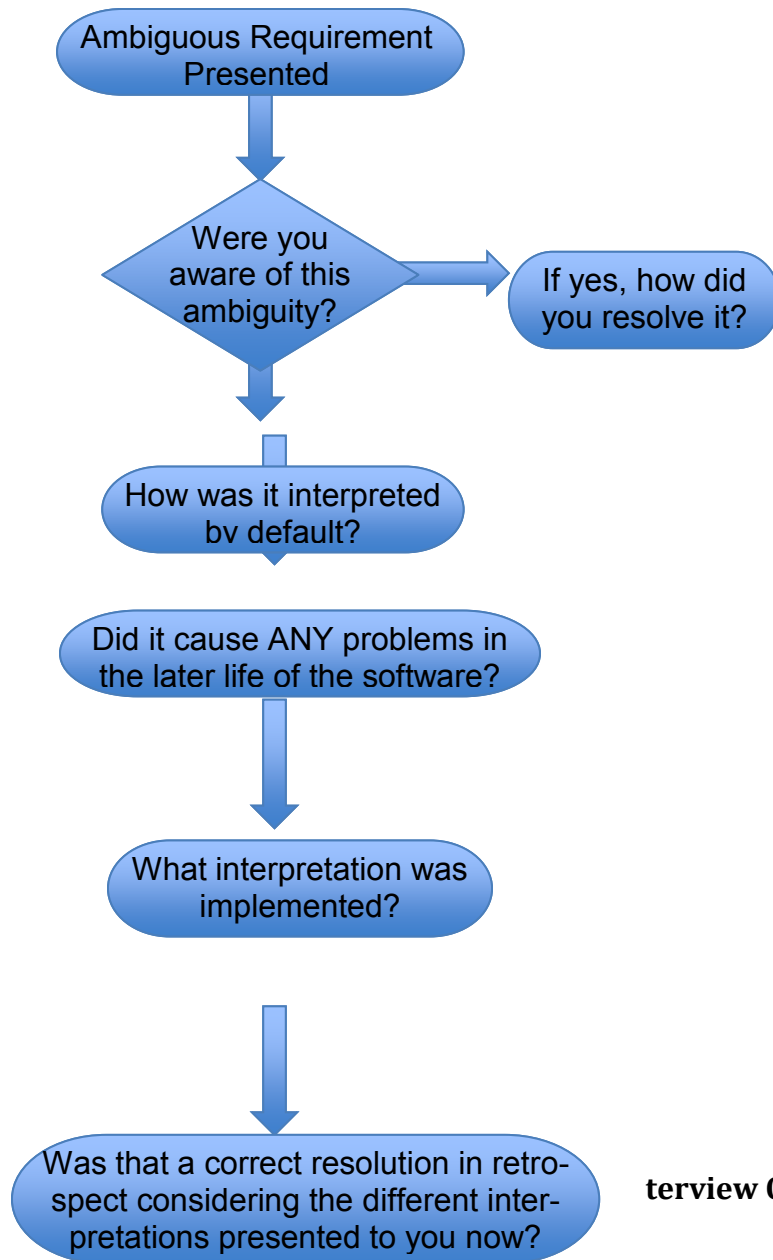
Once the RSs are inspected and the persistent ambiguities ranked, the next step is to interview, the chief requirements engineer for the project, who is familiar with what has happened with the specified system after its implementation.

The interviews are conducted to verify if the ambiguities identified were interpreted incorrectly by the requirements engineers and if any damage has resulted from the ambiguous requirements. Any ambiguous requirements that were implemented incorrectly are considered to be nocuous ambiguities because they have the potential to cause damage. Any ambiguous requirements that were implemented correctly are considered to be innocuous ambiguities because they do not cause damage.

The chief requirements engineer is presented with the requirement ranked most likely to cause damage, along with all the possible interpretations and the questions shown in Figure 1. These questions help identify if the chief requirements engineer is aware of the ambiguity, if the correct interpretation was implemented, and if any damage has resulted from an incorrect interpretation. The chief requirements engineer states the correct interpretation intended and whether the correct interpretation was in fact implemented. If any ambiguity was implemented incorrectly the damage associated to each incorrect implementation is estimated.

If a requirement is interpreted differently from the intended interpretation, this interpretation indicates that the particular requirement could have been implemented incorrectly in the system. If a requirement is interpreted in the exact same way by each of the requirements engineers, this interpretation does not mean the requirement is unambiguous. It is still possible that someone other than the team of requirements engineers could interpret the requirement in a different manner. This could be problematic if the team membership changes. Examples of membership

changes include replacing a member that leaves the company, moves to another project, or takes an extended leave of absence.



**Figure 1 In-**

**terview Questions**

### **3.4 Threats to Validity**

#### ***3.4.1 External Validity***

External validity is the extent to which the results can be generalized to other situations. There are three threats to external validity in this study. The first threat is that the results of empirical case studies are not generalizable and have low external validity. However, this empirical study has a comparable size to real world problems. This study consists of three separate case studies, each using large sets of real world data. Repeated case studies that corroborate the conclusions would provide additional support.

The second threat is that there may be an as of yet unidentified defect with the software that is also a direct result of an ambiguity. However, this possibility is unlikely because the software has been in use for a few years and most defects have likely been identified.

The third threat is that each member of the team of requirements engineers may subconsciously disambiguate persistent ambiguities in a way that matches the intended interpretation, rendering them innocuous with zero damage. However, it is possible that these persistent ambiguities could be interpreted differently by different team members, resulting in damage.

### ***3.4.2 Construct Validity***

Construct validity is the extent to which a study measures what it purports to be measuring. This study measures the prevalence of persistent ambiguity by counting the number of instances of persistent ambiguity per page. In addition, this study measures the impact of persistent ambiguity by calculating the cost to repair damage as a direct result of ambiguity, if any exists. These measures are objective and are easily quantifiable from the project data.

The threat to construct validity in this study is that there could have been persistent ambiguities that were missed in the RS inspection. No manual inspection can detect ambiguity perfectly, and this is a limitation of the study. However, the inspector of the RSs has experience with ambiguity and the inspection is similar to an industrial inspection.

### ***3.4.3 Internal Validity***

Internal validity of a study is the extent to which a purported causal conclusion of a study is valid. There are two threats to the internal validity of this study. The first threat is that unless the documentation of the CBS defects clearly states that ambiguity caused the defect, the cause is debatable. Therefore, the measurement of damage is effected. However, I do not make the assumption that all reported damage is attributable to ambiguity.

The second threat to internal validity is experimenter bias. Experimenter bias occurs when the experimenter unconsciously behaves in a particular way that inadvertently affects the outcome. In this study the experimenter is the inspector of the RSs. Experimenter bias may occur if the inspector is aware of any documented defects in the software. In this case, the inspector may unconsciously conclude that an ambiguity exists due to prior knowledge that a problem exists. However, the inspector is not aware of any documented defects in the software, nor the outcome of the project, eliminating experimenter bias.

### **3.5 Plan for Results Chapters**

Each of Chapters 4-8 is about the results for one kind of persistent ambiguity. It has one subsection for each project reporting on the data for the chapter's type of ambiguity for the project. At any point in these chapters, "ambiguity" means the chapter's kind of ambiguity and "project" means the current subsection's project. Often both the type of ambiguity and the project are left implicit, with both understood from the currently active section and subsection headers.



## CHAPTER FOUR

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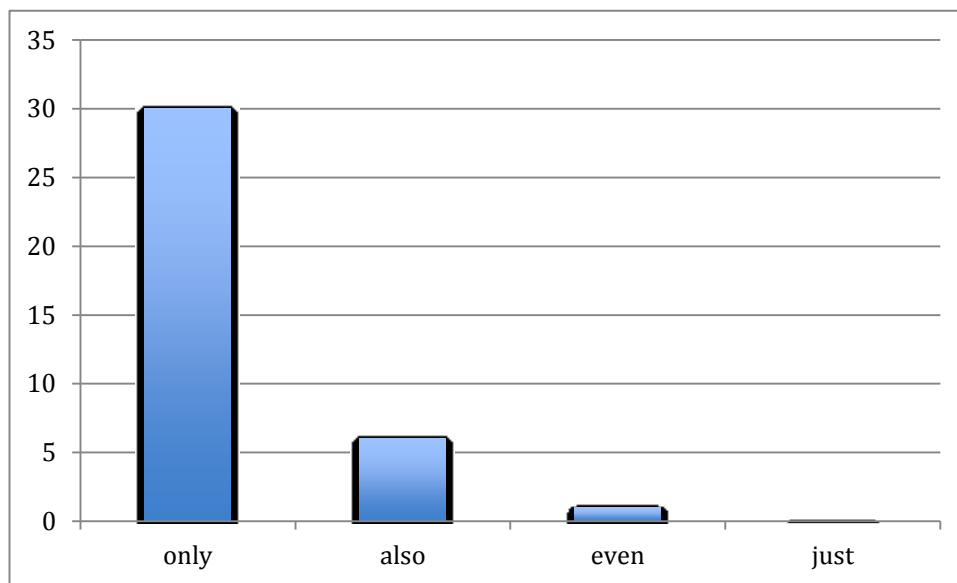
### RESULTS: MODIFIER AMBIGUITY

For each ambiguity type, the results of each of the RSs are discussed separately because different requirements engineers were involved for each project. Also, an analysis of patterns and differences between the three projects is provided. The projects are referred to as P1, P2, and P3.

## 4.1 Project 1

### 4.1.1 Instances of Cue Words

The numbers of instances of modifier cue words of each of only, also, even, and just are 30, 6, 1, and 0, respectively, totalling 37 instances. Figure 2 shows the numbers of instances of each modifier cue word.



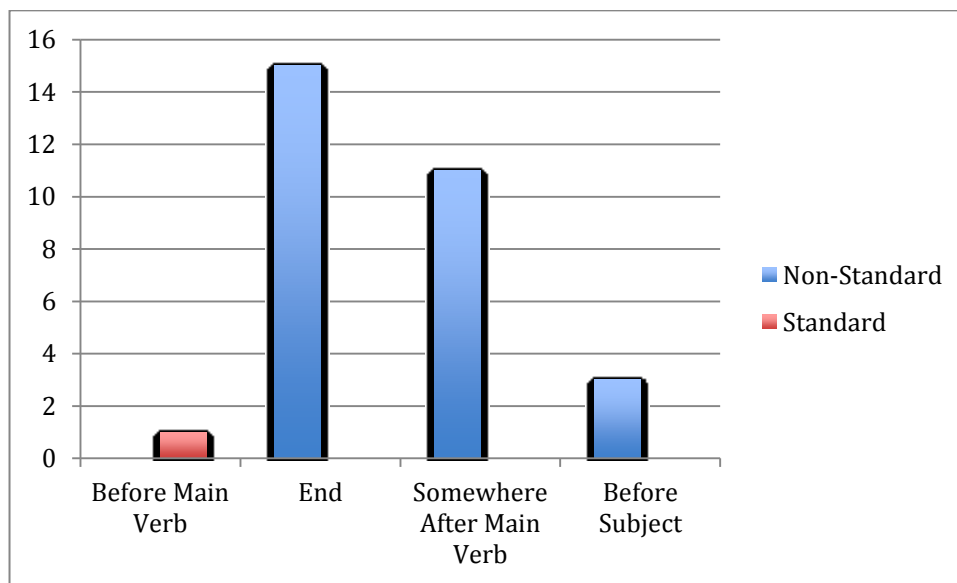
**Figure 2 P1: Instances of Modifier Cue Words**

### 4.1.1.1 Placement Distribution

#### 4.1.1.1.1 Only

Only is placed at the end of a requirement<sup>12</sup> 15 times out of 30. Figure 3 shows the placement distribution of the modifier only.

Only is placed before the main verb only once, before the subject three times, and somewhere after the main verb 11 times.



**Figure 3 P1: Modifier Placement Distribution of only**

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<sup>12</sup> In the ambiguity model, Chapter 2, each example of each ambiguity type is referred to as a sentence, in the results Chapters each sentence is referred to as a requirement.

#### 4.1.1.1.2 Also

Also is placed before the main verb six times out of six.

#### 4.1.1.1.3 Even

Even is used only once, placed somewhere after the main verb.

### ***4.1.2 Instances of Ambiguity***

There are zero instances of ambiguity identified.

There are two instances in the track changes of the Microsoft Word RS in which an only was deleted. The requirements engineer responsible for these changes seems to be aware that only can cause ambiguity.

There are three instances of only before the subject, 11 instances somewhere after the main verb and 15 instances at the end of the requirement. Each of these instances is unambiguous. The requirements engineer responsible for these placements seems to be aware of the dangers of standard placement.

For all cases except one, only is not placed before the main verb and is therefore unambiguous. Since non-standard placement is the most frequent placement, this non-standard placement distribution normally indicates that the author seems to be aware of the dangers of standard placement. However, the literal interpretation of the placement of this modifier is one that does not make sense; the placement that

does make sense is placement somewhere after the main verb. The requirements engineer responsible for this placement seems unaware of the dangers of standard placement.

Each of the six placements of also before the main verb is unambiguous because the literal interpretation is one that makes sense; placement somewhere after the main verb does not make sense considering the context, thus leaving only one possible interpretation. The requirements engineer responsible for these placements seems to be aware of the dangers of standard placement.

The one and only instance of even is placed somewhere after the main verb and is unambiguous. The requirements engineer responsible for this placement seems to be aware of the dangers of standard placement.

For all modifiers, the requirements engineers used non-standard placement 30 times out of 37. Placement at the end of a requirement is unambiguous<sup>13</sup>. Placement at the end of a requirement occurs most often, 15 times out of 37. Placement before the main verb, occurs the least often, seven times out of 37, and they seem to be using this placement in ways that are unambiguous.

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<sup>13</sup> In the ambiguity model, modifier placement at the very end of a requirement is unambiguous, because the modifier can modify only what precedes it.

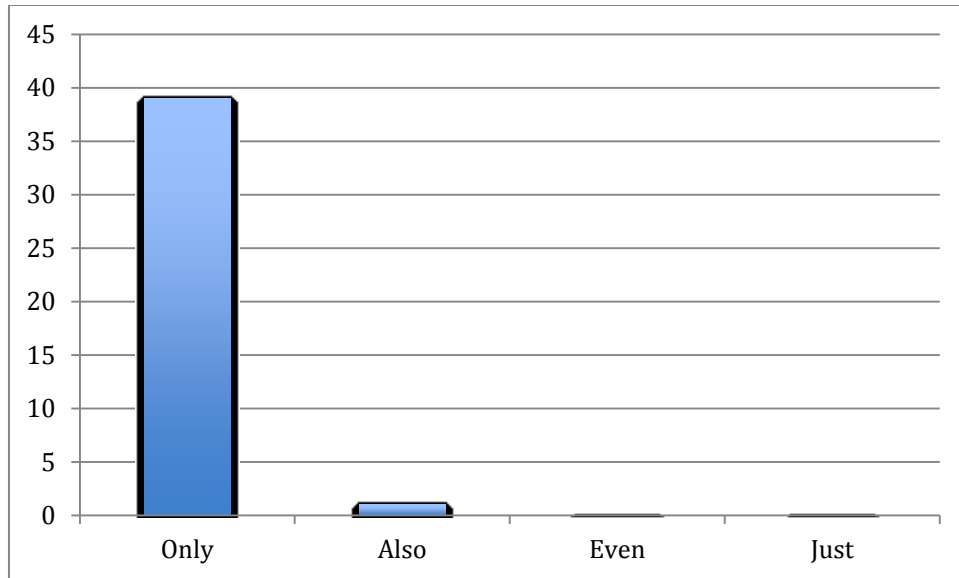
The placement distribution of modifiers is an indication that some requirements engineers were paying attention to the placement of the modifiers and seem to be aware of the dangers of standard placement.

Each of the 37 instances of a modifier cue word is unambiguous. Therefore, despite the prevalence of modifiers, modifier ambiguity does not persist. The reason that modifier ambiguity is not an issue is that the requirements engineers placed modifiers before the main verb sparingly, only seven times out of 37.

## **4.2 Project 2**

### ***4.2.1 Instances of Cue Words***

The numbers of instances of modifier cue words of each of only, also, even, and just are 39, 1, 0, and 0, respectively, totalling 40 instances. Figure 4 shows the numbers of instances of each modifier cue word.



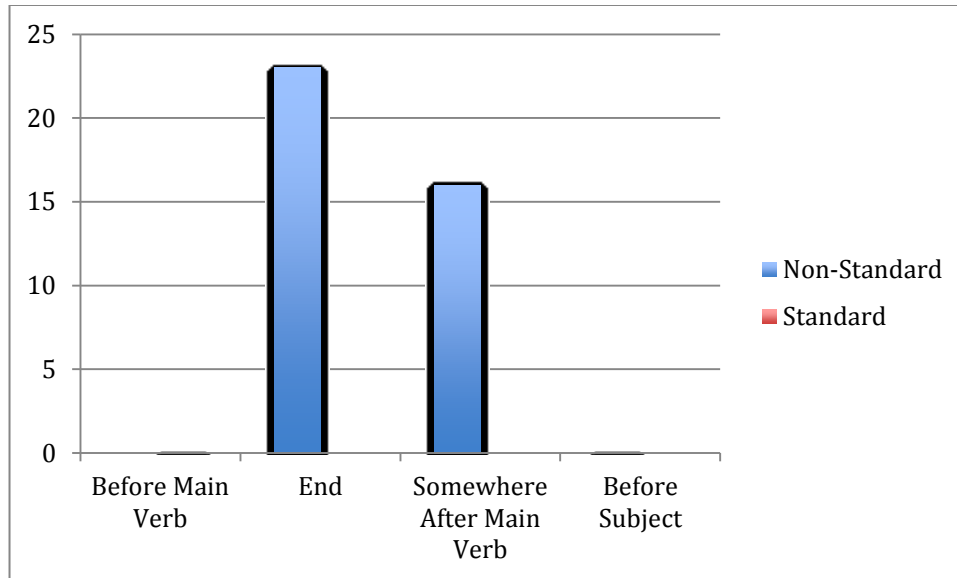
**Figure 4 P2: Instances of Modifier Cue Words**

#### **4.2.1.1 Placement Distribution**

##### 4.2.1.1.1 Only

Only is placed at the end of a requirement 23 times out of 39. Figure 5 shows the placement distribution of the modifier only.

Only is placed before the main verb zero times and somewhere after the main verb 16 times.



**Figure 5 P2: Modifier Placement Distribution of only**

#### 4.2.1.1.2 Also

Also is used only once, placed before the main verb.

#### 4.2.2 Instances of Ambiguity

There are zero instances of ambiguity identified.

Each placement of only is either at the end of a requirement or somewhere after the main verb. There are 16 instances somewhere after the main verb and 23 instances at the end of the requirement. Each of these instances is unambiguous. The requirements engineer responsible for these placements seems to be aware of the dangers of standard placement.



There are zero requirements that place the modifier only before the main verb. The requirements engineer responsible for these placements seems to be aware of the dangers of standard placement.

There is one requirement that places the modifier also before the main verb. The interpretation of only, in which it actually modifies the verb, is one that does not make sense; the placement that does make sense is placement before the subject. The requirements engineer responsible for this placement seems unaware of the dangers of standard placement.

For all modifiers, the requirements engineers used non-standard placement 39 times out of 40. Placement at the end of a requirement is unambiguous. Placement at the end of a requirement occurs most often, 23 times out of 40. Placement before the main verb occurs the least often, only once out of 40.

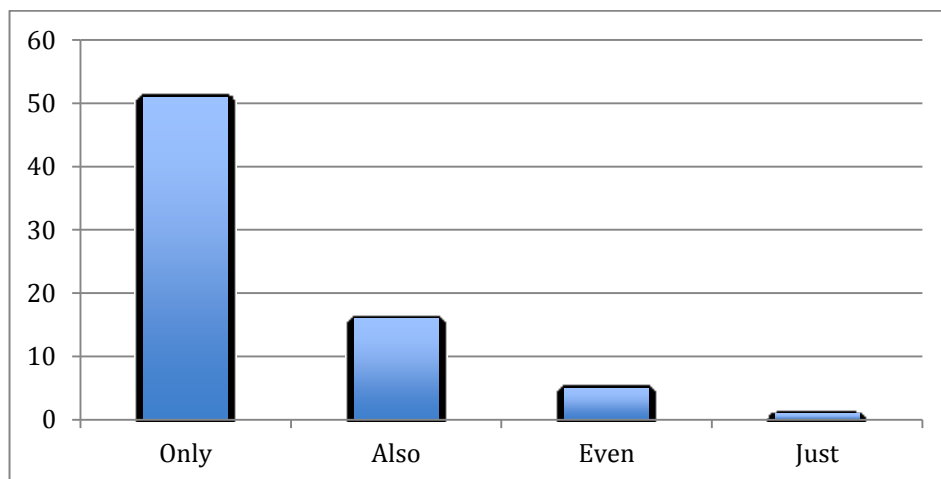
The placement distribution of modifiers is an indication that some requirements engineers were paying attention to the placement of the modifiers and seem to be aware of the dangers of standard placement.

Each of the 40 instances of a modifier cue word is unambiguous. Therefore, despite the prevalence of modifiers, modifier ambiguity does not persist. The reason that modifier ambiguity is not an issue is that the requirements engineers placed modifiers before the main verb sparingly, only one time out of 40.

### 4.3 Project 3

#### 4.3.1 Instances of Cue Words

The numbers of instances of modifier cue words of each of only, also, even, and just are 51, 16, 5, and 1, respectively, totalling 73 instances. Figure 6 shows the numbers of instances of each modifier cue word.



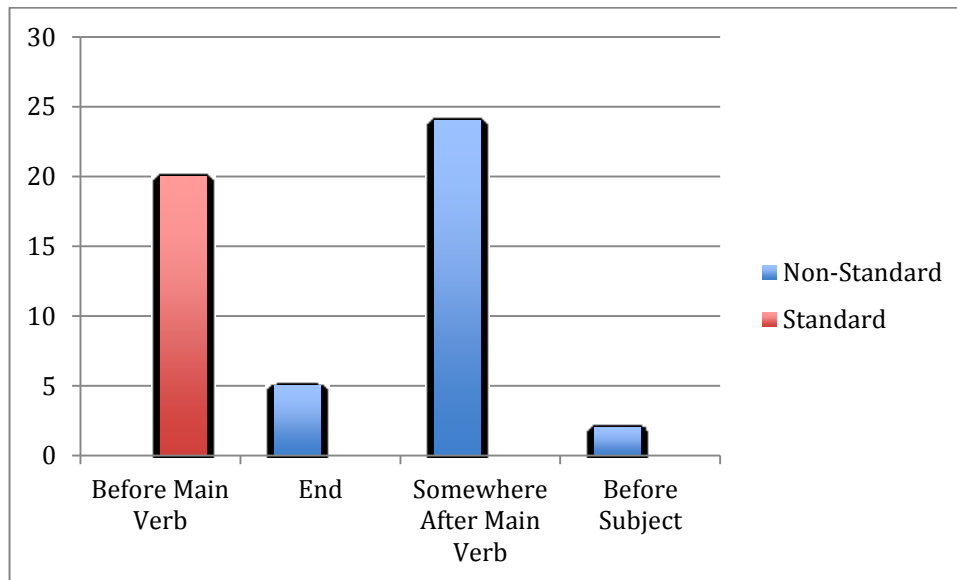
**Figure 6 P3: Instances of Modifier Cue Words**

#### 4.3.1.1 Placement Distribution

##### 4.3.1.1.1 Only

Only is placed at the end of a requirement 5 times out of 51. Figure 7 shows the placement distribution of the modifier only.

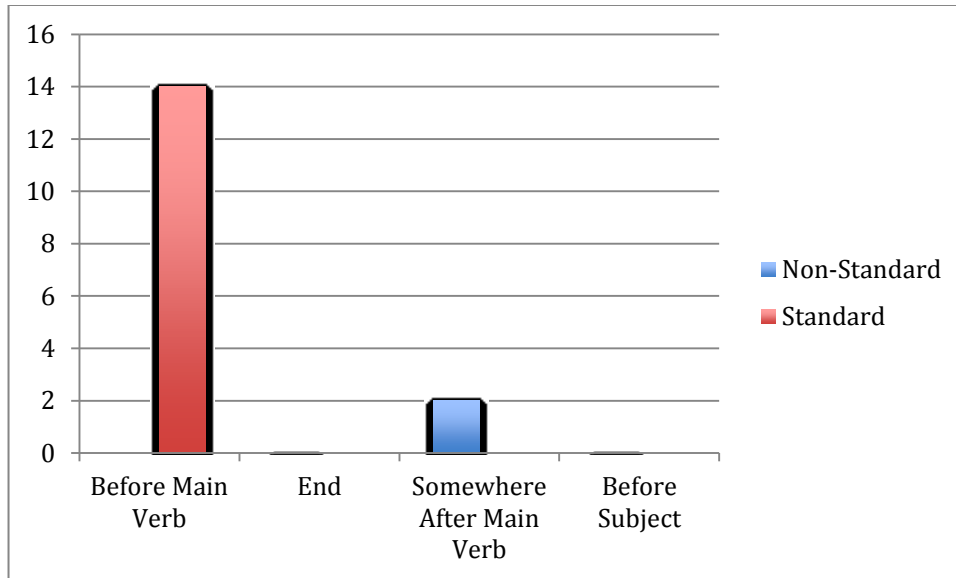
Only is placed before the main verb 20 times, somewhere after the main verb 24 times, and before the subject twice.



**Figure 7 P3: Modifier Placement Distribution of only**

#### 4.3.1.1.2 Also

Also is placed before the main verb 14 times out of 16. Figure 8 shows the placement distribution of the modifier also. Also is placed somewhere after the main verb twice.



**Figure 8 P3: Modifier Placement Distribution of also**

#### 4.3.1.1.3 Even

Even is used five times, placed somewhere after the main verb five times.

#### 4.3.1.1.4 Just

Just is used only once, placed somewhere after the main verb.

### 4.3.2 Instances of Ambiguity

There is one instance of ambiguity identified, and it contains a modifier only placed before the main verb.

Only is placed before the main verb almost as frequently as it is placed somewhere after the main verb. There are 20 requirements with only placed before the main verb and context disambiguated 19 of these requirements.

In almost all cases, also is placed before the main verb and context disambiguates each placement.

For all cases, even and just are placed somewhere after the main verb.

For all modifiers, the requirements engineers used non-standard placement 39 times out of 73. Placement before the main verb occurs the most often, 34 times out of 73. Placement at the end of a requirement occurs the least often, 5 times out of 73.

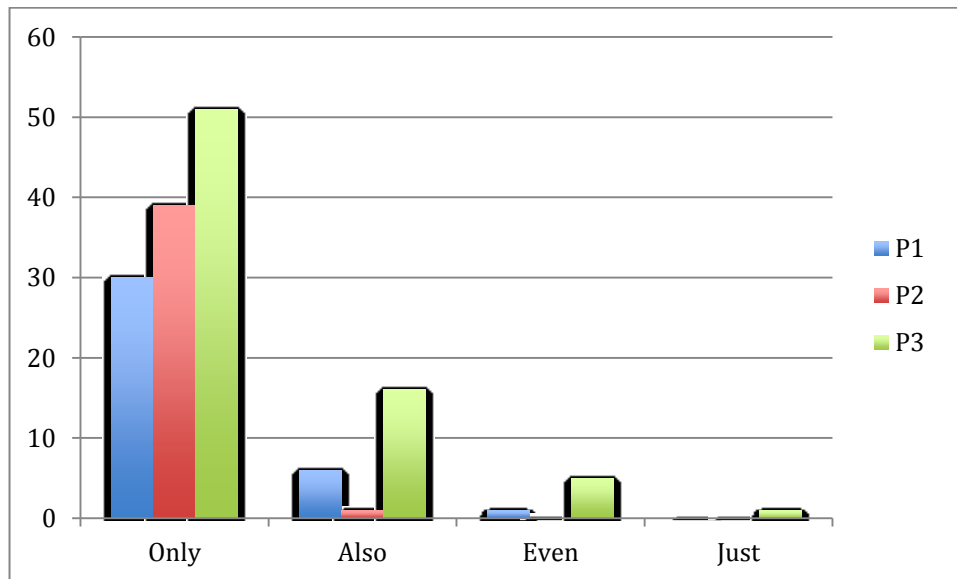
The placement distribution of modifiers is an indication that some requirements engineers were not paying attention to the placement of the modifiers and seem to be unaware of the dangers of standard placement.

All except one of the 73 instances of a modifier cue word are unambiguous. Therefore, despite the prevalence of modifiers, modifier ambiguity does not persist. The reason that modifier ambiguity is not an issue is that the modifiers placed before the main verb context successfully disambiguates 33 times out of 34.

#### 4.4 All Three Projects: A Comparative Analysis of P1, P2, and P3

##### 4.4.1 Instances of Cue Words

The total numbers of instances of modifier cue words of each of only, also, even, and just are 120, 23, 6, and 1, respectively, totalling 150 instances. In each of the three projects, the modifier cue word only has the highest number of instances. Figure 9 shows the numbers of instances of each modifier cue word for each project.



**Figure 9 All Three Projects: Instances of Modifier Cue Words**

#### **4.4.1.1 Placement Distribution**

##### 4.4.1.1.1 Only

Only is placed before the main verb 21 times, only is placed at the end of a requirement 43 times, before the subject five times, and somewhere after the main verb 51 times. Figure 10 shows the placement distribution of each modifier for each project.

##### 4.4.1.1.2 Also

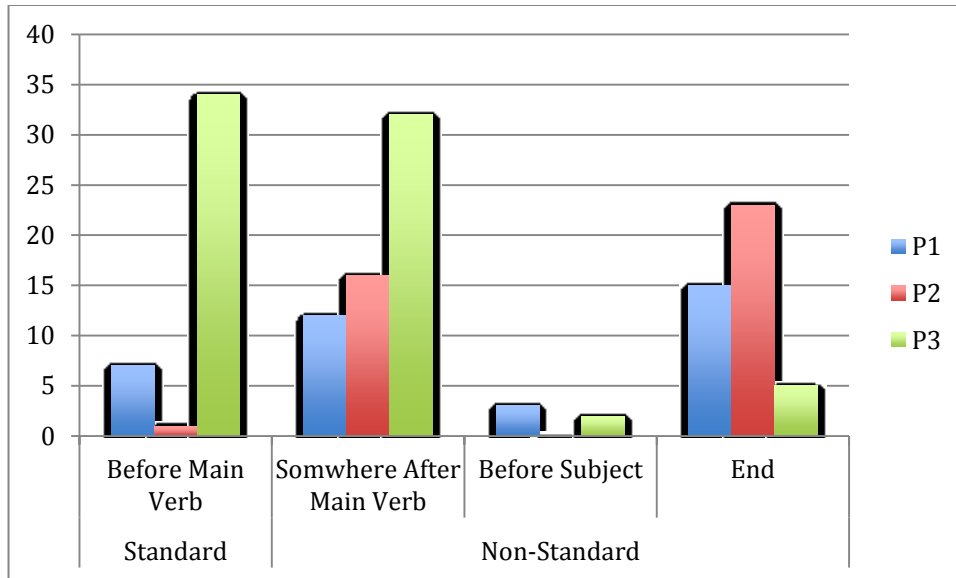
Also is placed before the main verb 21 times and somewhere after the main verb twice.

##### 4.4.1.1.3 Even

Even is placed somewhere after the main verb six times.

##### 4.4.1.1.4 Just

Just is placed somewhere after the main verb only once.

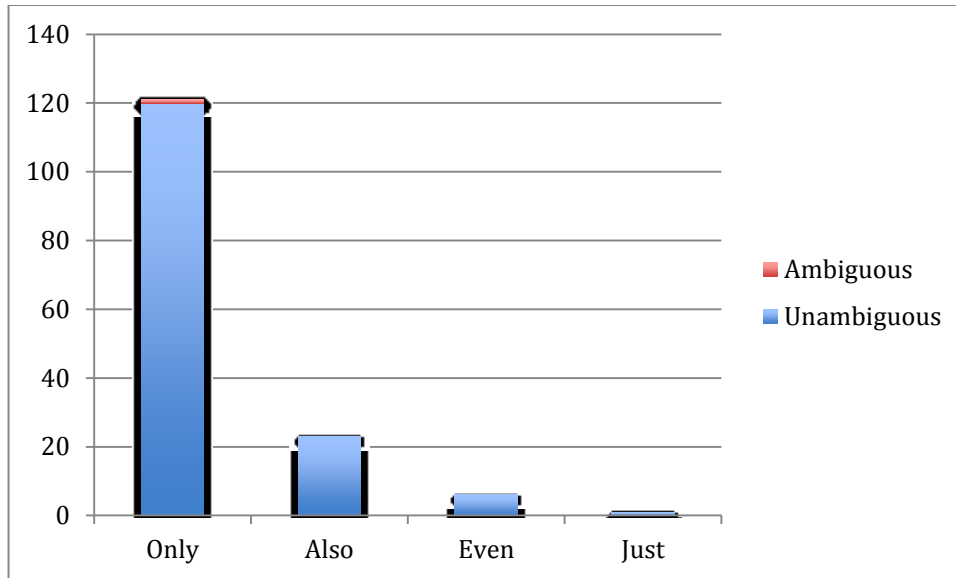


**Figure 10 All Three Projects: Modifier Placement Distribution for Each Project**

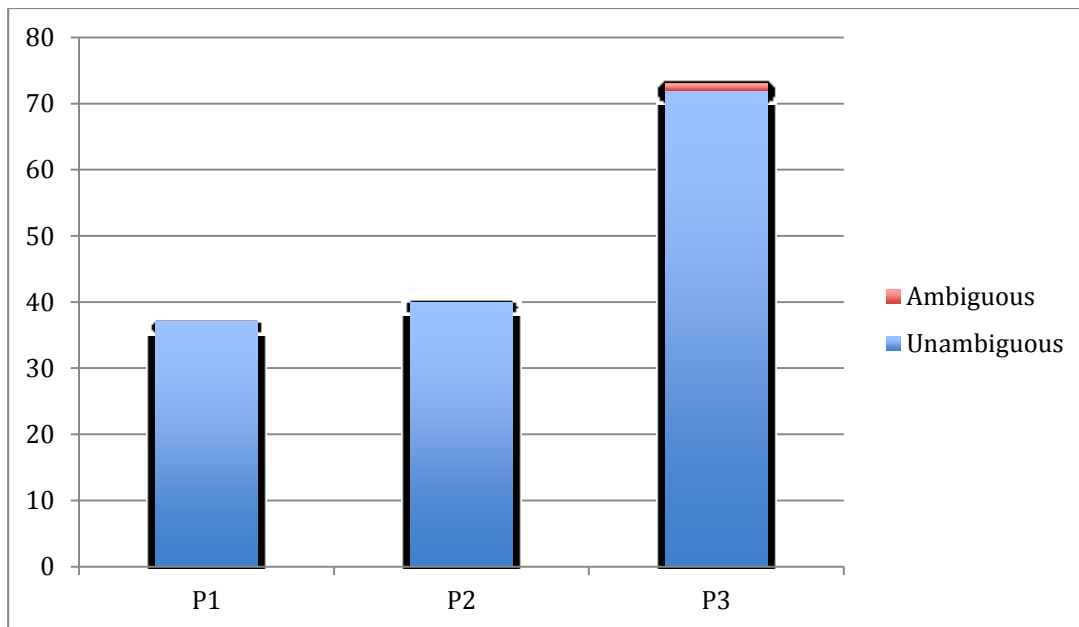
#### ***4.4.2 Instances of Ambiguity***

For all three projects, there is only one instance of ambiguity identified, and it is in P3. Figure 11 shows the instances of ambiguity. Figure 12 shows the instances of ambiguous and unambiguous requirements containing modifiers for each project.



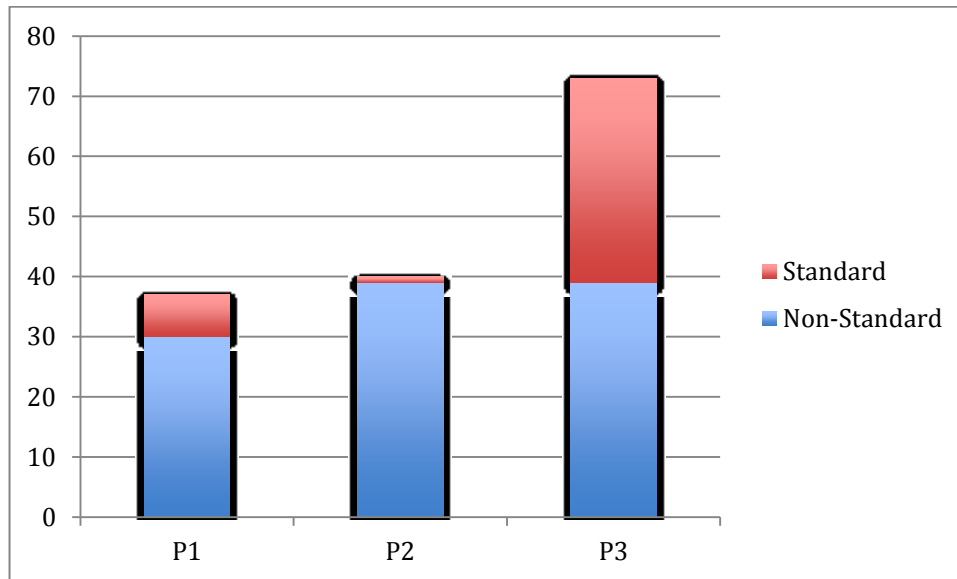


**Figure 11 All Three Projects: Instances of Ambiguous and Unambiguous Requirements for Each Modifier Cue Word**



**Figure 12 All Three Projects: Instances of Ambiguous and Unambiguous Requirements Containing Modifiers for Each Project**

For all modifiers, the requirements engineers used standard placement 42 times out of 150, they seem to be using this placement in ways that are unambiguous. Figure 13 shows the numbers of instances of non-standard and standard placements for each project.



**Figure 13 All Three Projects: Instances of Non-Standard and Standard Modifier Placements for Each Project**

The requirements engineers for P3 used standard placement frequently, 34 times out of 35, while the requirements engineers of P1 and P2 used this placement less often, seven times out of 22 and once out of 24, respectively.

The placement distribution of modifiers for all three projects is an indication that, unlike the requirements engineers for P3, the requirements engineers for P1 and P2

were paying attention to the placement of the modifiers and seem to be aware of the dangers of standard placement.

All except one of the 150 instances of a modifier cue word is unambiguous. Therefore, despite the prevalence of modifiers, modifier ambiguity does not persist for each of the projects. The reason that modifier ambiguity is not an issue is that the requirement engineers placed modifiers before the main verb less often, 42 times out of 150, and when they used this placement context disambiguates successfully 65 times out of 66.

## CHAPTER FIVE

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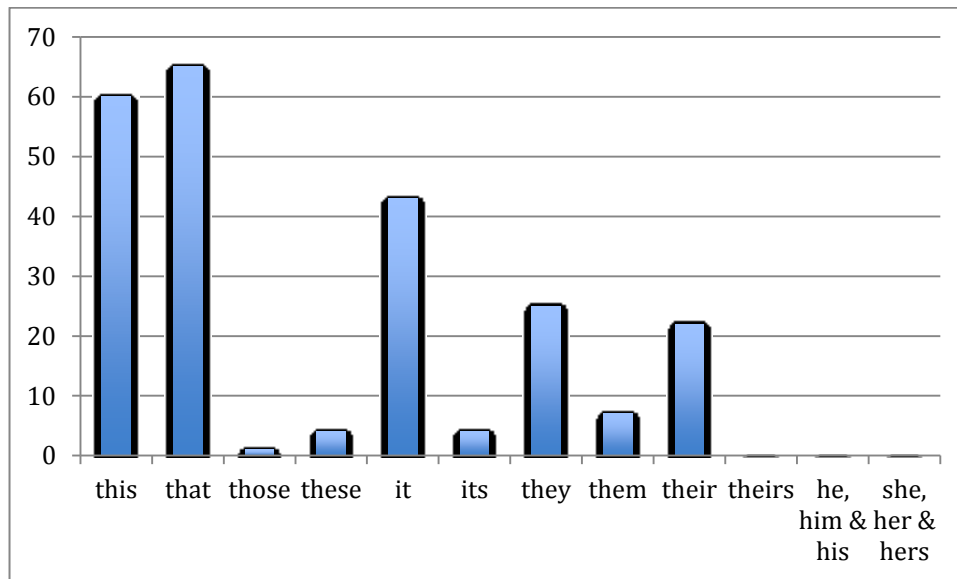
# RESULTS: REFERENTIAL AMBIGUITY

As mentioned in Section 4, for each ambiguity type, the results of each of the RSs are discussed separately because different requirements engineers were involved for each project. Also, an analysis of patterns and differences between the three projects is provided. The projects are referred to as P1, P2, and P3.

## 5.1 Project 1

### 5.1.1 Instances of Cue Words

The numbers of instances of referential cue words of each of this; that; those; these; it; its; they; them; their; theirs; he, him and his; and she, her and hers are 60, 65, 1, 4, 43, 4, 25, 7, 22, 0, 0, and 0, respectively, totalling 231 instances. Figure 14 shows the numbers of instances of each referential cue word.

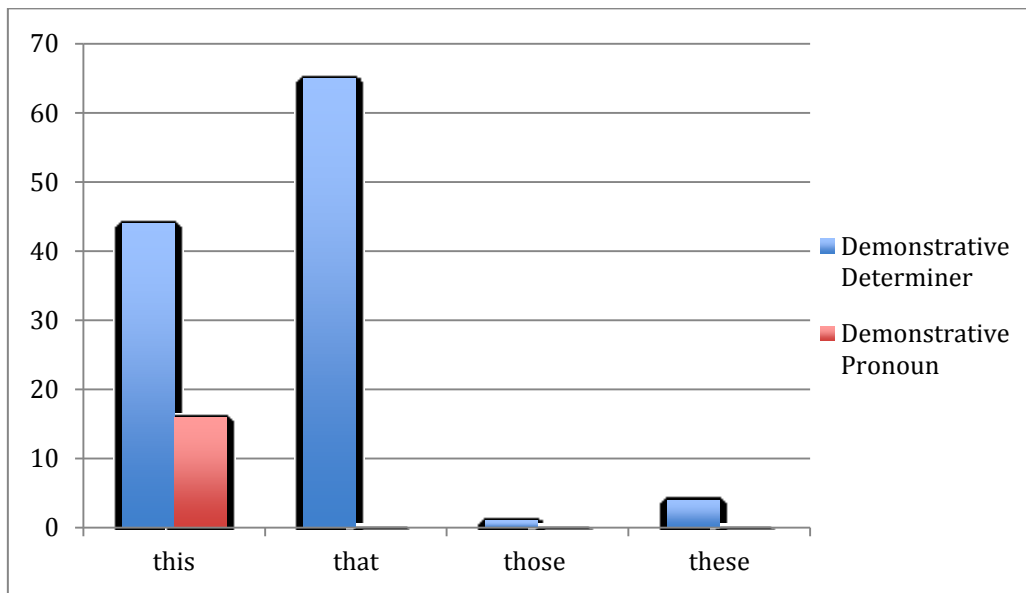


**Figure 14 P1: Instances of Referential Cue Words**

### 5.1.1.1 Usage Distribution of Pronouns and Determiners

#### 5.1.1.1.1 Demonstratives

The usage distribution of demonstrative pronouns of each of this, that, those and these are 16, 0, 0, and 0, respectively, totalling 16 demonstrative pronouns. The usage distribution of demonstrative determiners of each of this, that, those and these are 44, 65, 1, and 4, respectively, totalling 114 demonstrative determiners. Figure 15 shows the usage distribution of demonstratives.

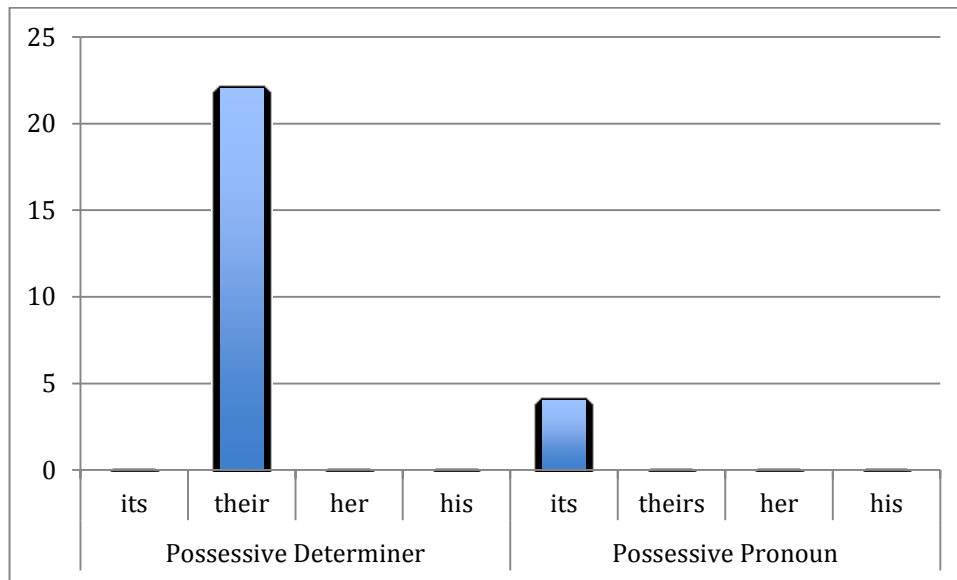


**Figure 15 P1: Usage Distribution of Demonstratives**

#### 5.1.1.1.2 Possessives

The usage distribution of possessive pronouns of each of its, theirs, her, and his are 4, 0, 0, and 0, respectively, totalling 4 possessive pronouns. The usage distribution of

possessive determiners of each of its, their, her, and his are 0, 22, 0, and 0, respectively, totalling 22 possessive determiners. Figure 16 shows the usage distribution of possessives.



**Figure 16 P1: Usage Distribution of Possessives**

### ***5.1.2 Instances of Ambiguity***

There are nine instances of ambiguity identified. Two instances contain the possessive determiner *their*, four instances contain the demonstrative determiner *this*, one instance contain the personal pronoun *they*, one instance contains the personal pronoun *it*, and one instance contains the demonstrative pronoun *this*. This one instance could have been avoided if a demonstrative determiner had been used instead.

There are twice as many ambiguous uses of determiners than uses of pronouns, showing that although determiners may be less ambiguous than pronouns they may still lead to ambiguity.

The requirements engineers used determiners 136 times, and they used pronouns 95 times. The usage distribution of determiners and pronouns is similar between determiners and pronouns and is an indication that some requirements engineers were not paying attention to the use of references and seem to be unaware of the dangers of pronouns.

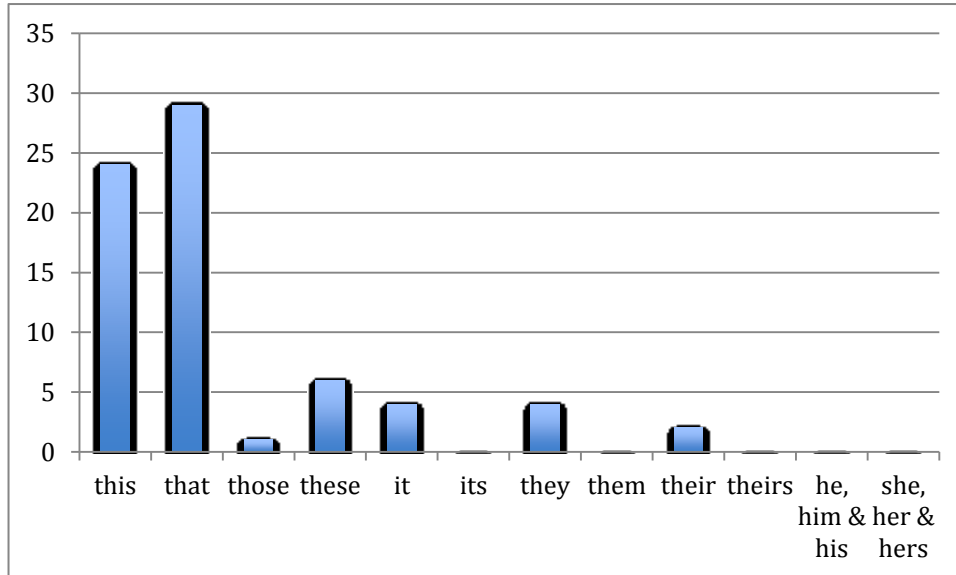
Out of 231 instances of referential cue words, 222 instances are unambiguous. Nevertheless, referential ambiguity does persist. The reason that referential ambiguity is an issue is that the requirements engineers commonly used determiners and pronouns, and context does not disambiguate successfully some of the times.

## **5.2 Project 2**

### ***5.2.1 Instances of Cue Words***

The numbers of instances referential cue words of each of this; that; those; these; it; its; they; them; their; theirs; he, him and his; and she, her and hers are 24, 29, 1, 6, 4, 0, 4, 0, 2, 0, 0, and 0, respectively, totalling 70 instances. Figure 17 shows the numbers of instances of each referential cue word.



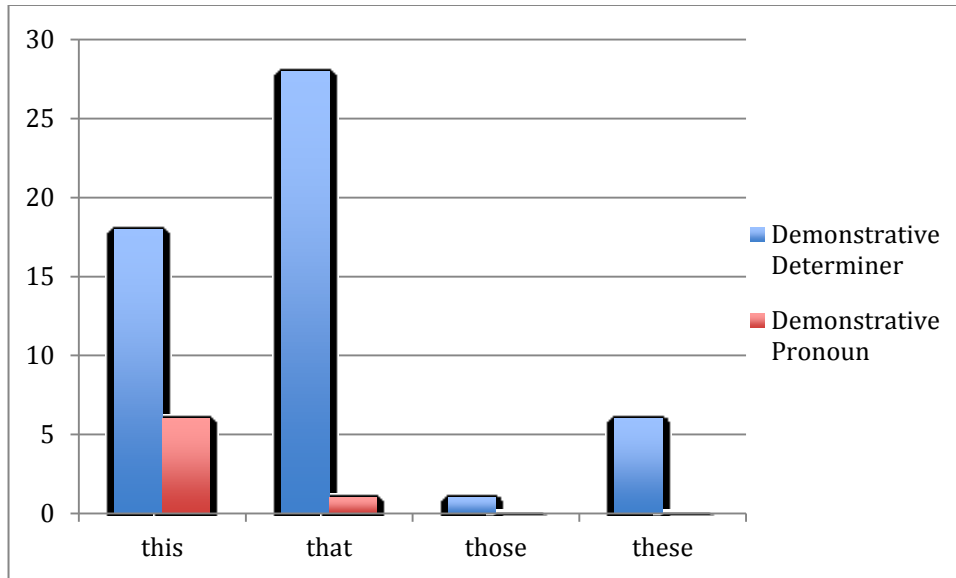


**Figure 17 P2: Instances of Referential Cue Words**

### **5.2.1.1 Usage Distribution of Pronouns and Determiners**

#### 5.2.1.1.1 Demonstratives

The usage distribution of demonstrative pronouns of each of this, that, those and these are 6, 1, 0, and 0, respectively, totalling 7 demonstrative pronouns. The usage distribution of demonstrative determiners of each of this, that, those and these are 18, 28, 1, and 6, respectively, totalling 53 demonstrative determiners. Figure 18 shows the usage distribution of demonstratives.



**Figure 18 P2: Usage Distribution of Demonstratives**

#### 5.2.1.1.2 Possessives

The usage distribution of possessive determiners of each of its, their, her, and his are 0, 2, 0, and 0, respectively, totalling 2 possessive determiners; there are zero possessive pronouns.

#### 5.2.2 Instances of Ambiguity

There is only one instance of ambiguity identified. This instance contains the demonstrative pronoun this. This instance of ambiguity could have been avoided if a demonstrative determiner had been used instead.

The requirements engineers used determiners 55 times, and they used pronouns 15 times. The usage distribution of determiners and pronouns is an indication that

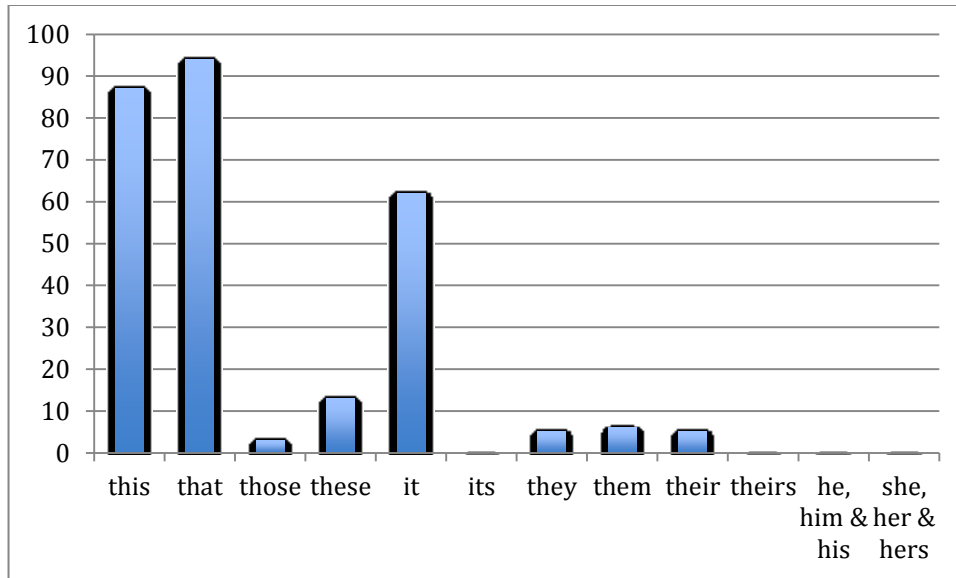
some requirements engineers were paying attention to the use of references and seem to be aware of the dangers of pronouns.

Out of 70 instances of referential cue words, 69 instances are unambiguous. Therefore, despite the prevalence of referential cue words, referential ambiguity does not persist. The reason that referential ambiguity is not an issue is that when the requirements engineers used determiners and pronouns, context does disambiguate successfully most of the times.

### **5.3 Project 3**

#### ***5.3.1 Instances of Cue Words***

The numbers of instances of referential cue words of each of this; that; those; these; it; its; they; them; their; theirs; he, him and his; and she, her and hers are 87, 94, 3, 13, 62, 0, 5, 6, 5, 0, 0, and 0, respectively, totalling 275 instances. Figure 19 shows the numbers of instances of each referential cue word.

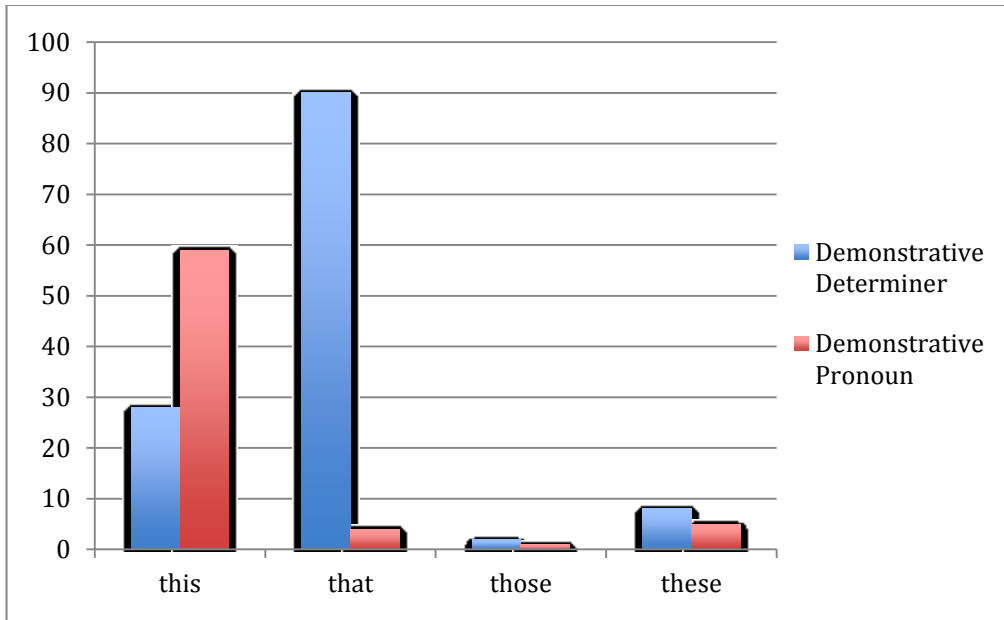


**Figure 19 P3: Instances of Referential Cue Words**

### **5.3.1.1 Usage Distribution of Pronouns and Determiners**

#### 5.3.1.1.1 Demonstratives

The usage distribution of demonstrative pronouns of each of this, that, those and these are, 59, 4, 1, and 5, respectively, totalling 69 demonstrative pronouns. The usage distribution of demonstrative determiners of each of this, that, those and these are 28, 90, 2, and 8 respectively, totalling 128 demonstrative determiners. Figure 20 shows the usage distribution of demonstratives.



**Figure 20 P3: Usage Distribution of Demonstratives**

#### 5.3.1.1.2 Possessives

The usage distribution of possessive determiners of each of its, their, her, and his are 0, 5, 0, and 0, respectively, totalling 5 possessive determiners; there are zero possessive pronouns.

#### 5.3.2 Instances of Ambiguity

There is one instance of ambiguity identified. This instance contains the demonstrative pronoun this. This instance of ambiguity could have been avoided if a demonstrative determiner had been used instead.

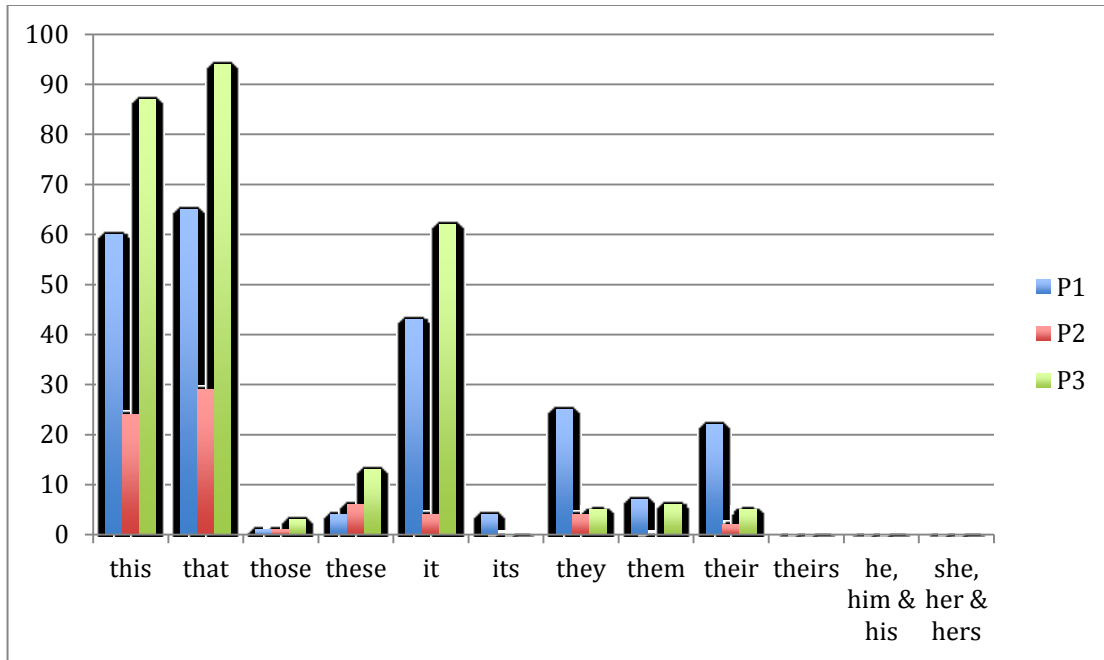
The requirements engineers used determiners 133 times, and they used pronouns 142 times. The usage distribution of determiners and pronouns is an indication that some requirements engineers were not paying attention to the use of references and seem to be unaware of the dangers of pronouns.

Out of 275 instances of referential cue words, 274 are unambiguous. Therefore, despite the prevalence of referential cue words, referential ambiguity does not persist. The reason that referential ambiguity is not an issue is that when the requirements engineers used determiners and pronouns context does disambiguate successfully most of the times.

#### **5.4 All Three Projects: A Comparative Analysis of P1, P2, and P3**

##### ***5.4.1 Instances of Cue Words***

The total numbers of instances of referential cue words of each of this; that; those; these; it; its; they; them; their; theirs; he, him and his; and she, her and hers are 171, 188, 23, 5, 109, 4, 34, 13, 29, 0, 0, and 0, respectively, totalling 576 instances. In each of the three projects, the referential cue word that has the highest number of instances. Figure 21 shows the numbers of instances of each referential cue word for each project.

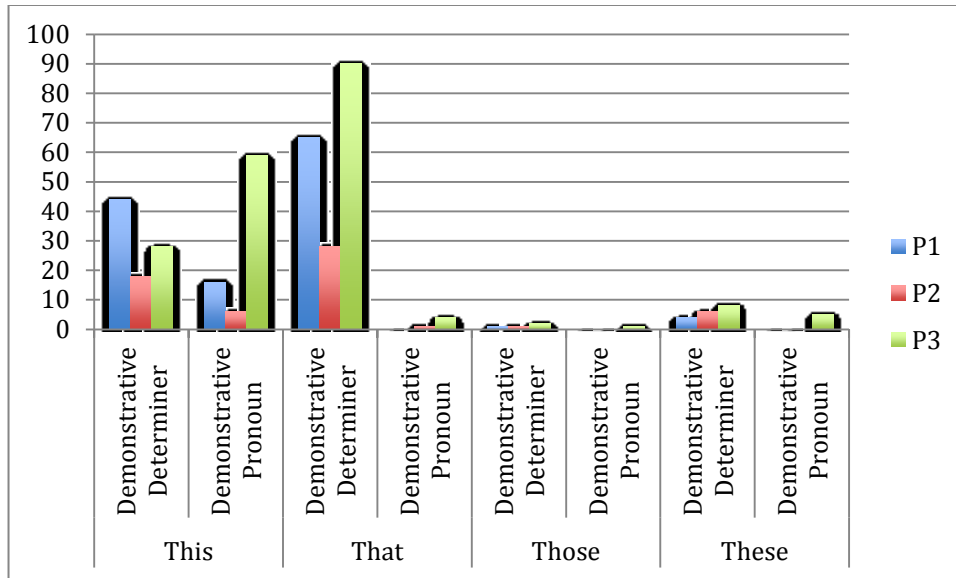


**Figure 21 All Three Projects: Placement Distribution of Pronouns and Determiners for Each Project**

### 5.4.1.1 Usage Distribution of Pronouns and Determiners

#### 5.4.1.1.1 Demonstratives

For all three projects, the usage distribution of demonstrative pronouns of each of this, that, those and these are 81, 5, 1, and 5, respectively, totalling 92 demonstrative pronouns. For all three projects, the usage distribution of demonstrative determiners of each of this, that, those and these are 90, 183, 4, and 18, respectively, totalling 295 demonstrative determiners. Figure 22 shows the usage distribution of demonstratives for each project.



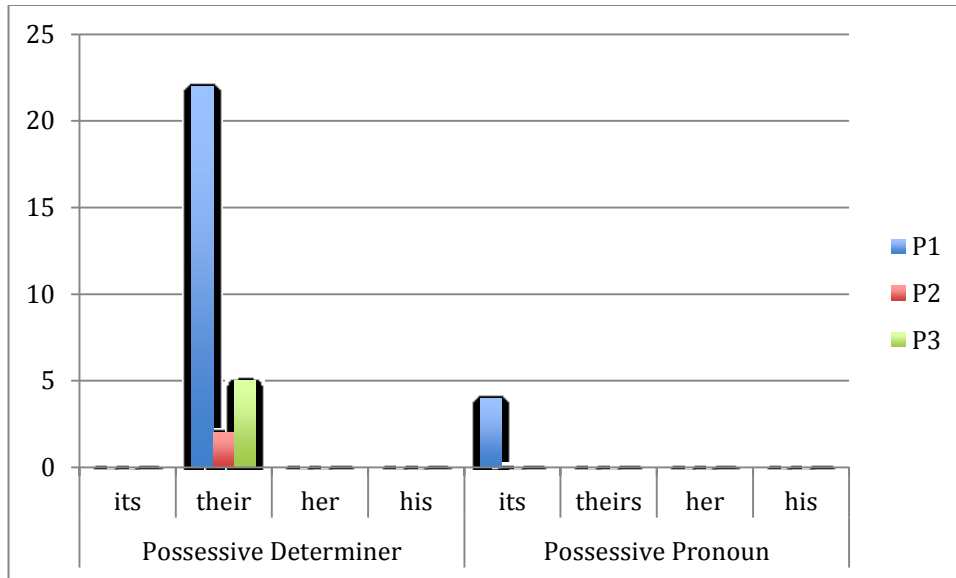
**Figure 22 All Three Projects: Usage Distribution of Demonstratives for Each Project**

#### 5.4.1.1.2 Possessives

For all three projects, the usage distribution of possessive pronouns of each of its, theirs, hers, and his are 4, 0, 0, and 0, respectively, totalling 4 possessive pronouns.

For all three projects, the usage distribution of possessive determiners of each of its, their, her, and his are 0, 29, 0, and 0, respectively, totalling 29 possessive determiners. Figure 23 shows the usage distribution of possessives for each project.





**Figure 23 All Three Projects: Usage Distribution of Possessives for Each Project**

#### **5.4.2 Instances of Ambiguity**

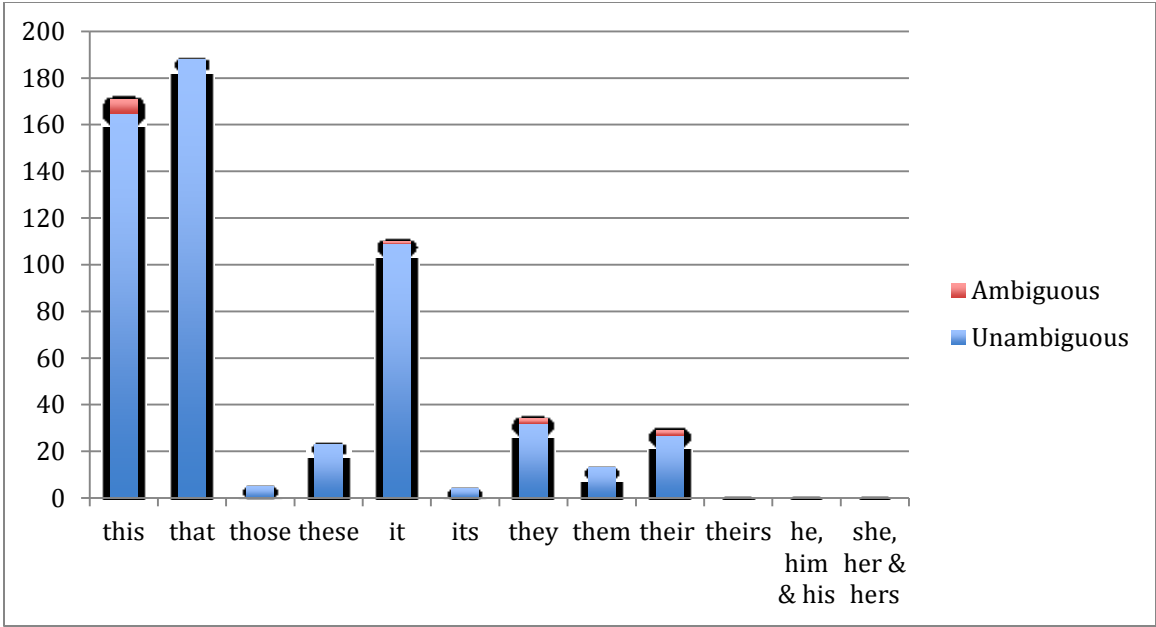
For all three projects, there are 11 instances of ambiguity identified. Four instances contain the demonstrative determiner *this*, two instances contain the possessive determiner *their*, one instance contains the personal pronoun *they*, one instance contains the personal pronoun *it*, and three instances contain the demonstrative pronoun *this*. This one instance of ambiguity containing the demonstrative pronoun *this* could have been avoided if a demonstrative determiner had been used instead.

Figure 24 shows the numbers of instances of ambiguous and unambiguous requirements for each cue word. Figure 25 shows the numbers of instances of ambiguous and unambiguous requirements containing references for each project.

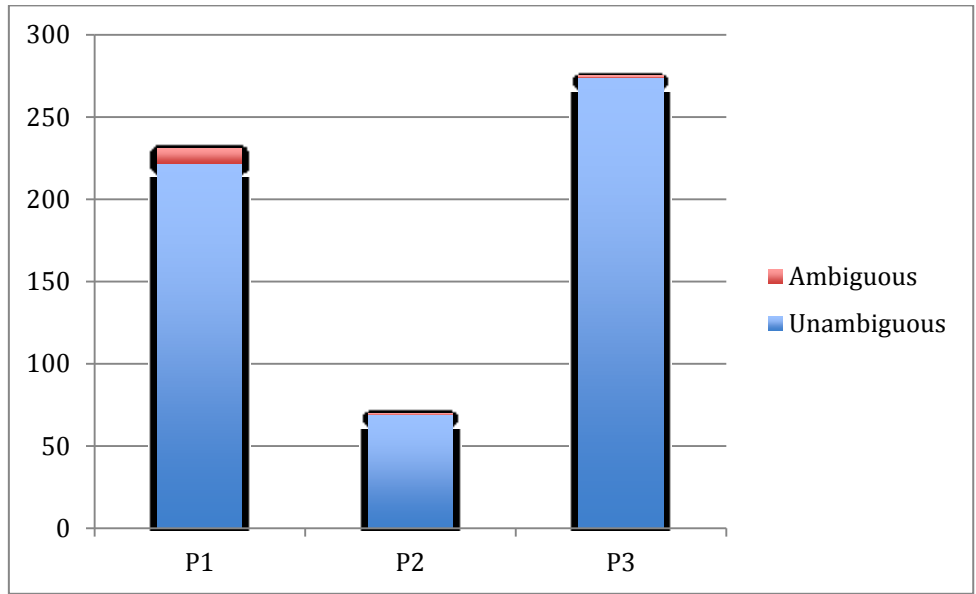
There are nine instances of ambiguity in P1, and one instance of ambiguity in each of P2 and P3. P2 and P3 have a lower number of instances of ambiguity than P1 did.

The requirements engineers for P1 used pronouns slightly more often and used determiners far more often, than P2 and P3.

For all three projects, the usage distribution of pronouns and determiners is an indication that, unlike the requirements engineers for P1 and P3, the requirements engineers for P2 were paying attention to the usage of pronouns and determiners and seem to be aware of the dangers of pronouns.



**Figure 24 All Three Projects: Instances of Ambiguous and Unambiguous Requirements for Each Referential Cue Word**



**Figure 25 All Three Projects: Instances of Ambiguous and Unambiguous Requirements Containing References for Each Project**

The requirements engineers used determiners 324 times, and they used pronouns 252 times. The usage distribution of pronouns and determiners is an indication that some requirements engineers were paying attention to the placement of the references and seem to be aware of the dangers of pronouns.

Out of 576 instances of referential cue words, 565 instances are unambiguous. Nevertheless, referential ambiguity does persist for P1. The reason that referential ambiguity is an issue for P1 is that the requirements engineers commonly used determiners and pronouns, and context does not disambiguate successfully some of the times. Even though the requirements engineers used demonstrative determiners far more often than demonstrative pronouns, demonstrative pronouns may still lead to ambiguity.

## CHAPTER SIX

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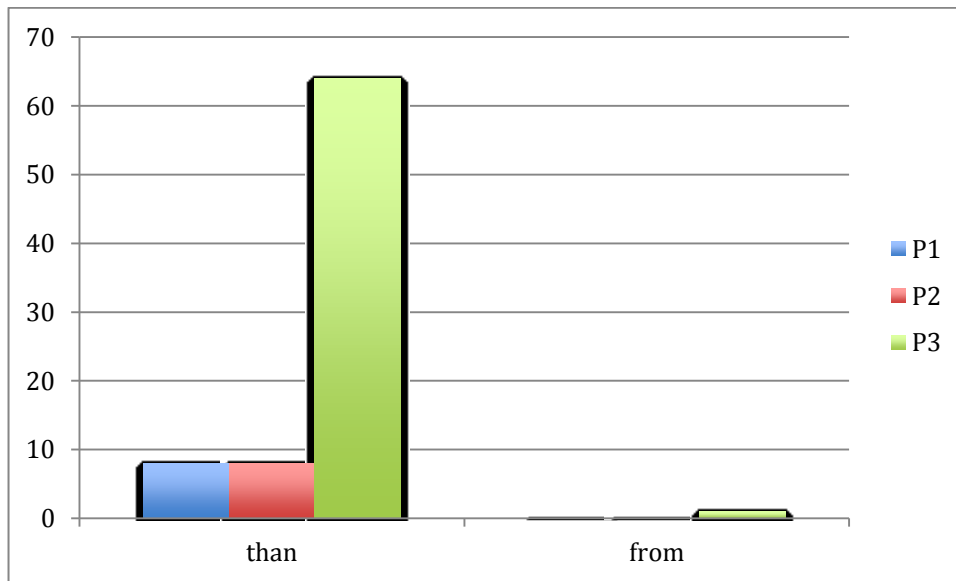
# RESULTS: ELLIPTICAL AMBIGUITY

As mentioned in Section 4, for each ambiguity type, an analysis of patterns and differences between the three projects is provided. The projects are referred to as P1, P2, and P3.

## 6.1 All Three Projects: A Comparative Analysis of P1, P2, and P3

### 6.1.1 Instances of Cue Words

The total numbers of instances of elliptical cue words of each of than and from are 80 and 1, respectively, totalling 81 instances. In each of the projects, the elliptical cue word than has the highest number of instances. Figure 26 shows the numbers of instances of each elliptical cue word for each project. P1 and P2 has few number instances of elliptical cue words, eight and eight, respectively. P3 has the highest number of instances of elliptical cue words, totalling 65 instances.



**Figure 26 All Three Projects: Instances of Elliptical Cue Words**

### ***6.1.2 Instances of Ambiguity***

For all three projects, there are zero instances of ambiguity identified. There are zero instances of elliptical cue words that indicate an actual ellipsis. Thus, the requirements engineers in each of these projects seem to be aware of the dangers of elliptical ambiguity. Elliptical ambiguity does not persist in the three projects inspected.

## CHAPTER SEVEN

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# RESULTS: CONDITIONAL CLAUSE REFERENCE AMBIGUITY

As mentioned in Section 4, an analysis of patterns and differences between the three projects is provided. The projects are referred to as P1, P2, and P3.



## **7.1 All Three Projects: A Comparative Analysis of P1, P2, and P3**

### ***7.1.1 Instances of Cue Words***

The total numbers of instances of conditional clause reference cue words of each of assuming so, assuming not, suppose so, and suppose not, if so and if not are 0, 0, 0, 0, 2, and 2, respectively, totalling four instances. In P1 and P2, there are zero instances of conditional clause reference cue words. In P3, the numbers of instances of conditional clause reference cue words if so and if not are two and two, respectively.

### ***7.1.2 Instances of Ambiguity***

For all three projects, there are zero instances of ambiguity identified. Each of the four instances of conditional clause reference cue words is unambiguous. Thus, the requirements engineers seem to be aware of the dangers of conditional clause reference ambiguity. Conditional clause reference ambiguity does not persist in the three projects inspected.

## CHAPTER EIGHT

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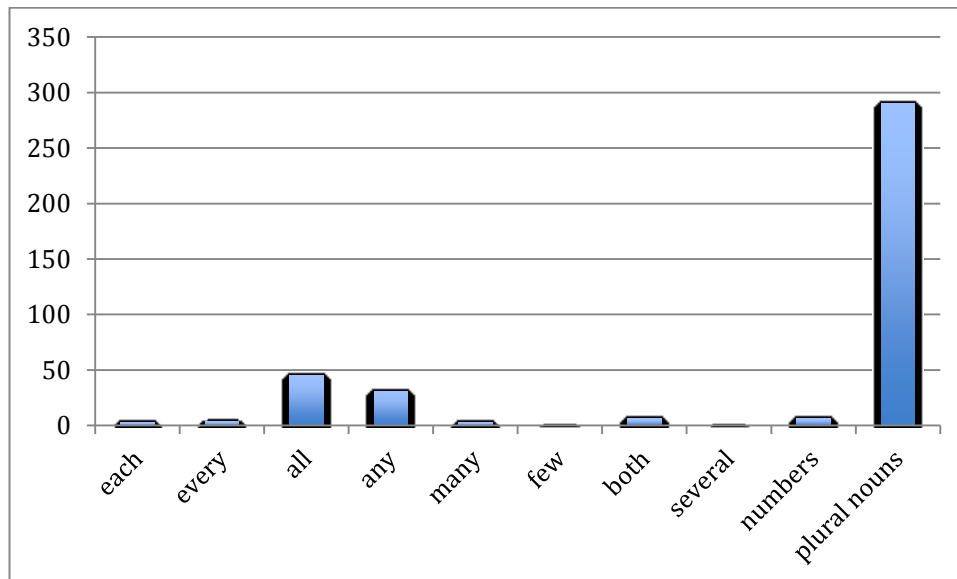
### RESULTS: PLURAL AMBIGUITY

As mentioned in Section 4, for each ambiguity type, the results of each of the RSs are discussed separately because different requirements engineers were involved for each project. Also, an analysis of patterns and differences between the three projects is provided. The projects are referred to as P1, P2, and P3.

## 8.1 Project 1

### 8.1.1 Instances of Cue Words

The numbers of instances of the plural cue words of each of each<sup>14</sup>, every, all, any, many, few, both, several, numbers, and plural nouns are 3, 4, 45, 31, 3, 0, 6, 0, 6, and 290, respectively, totalling 388 instances. Figure 27 shows the numbers of instances of each plural cue word.



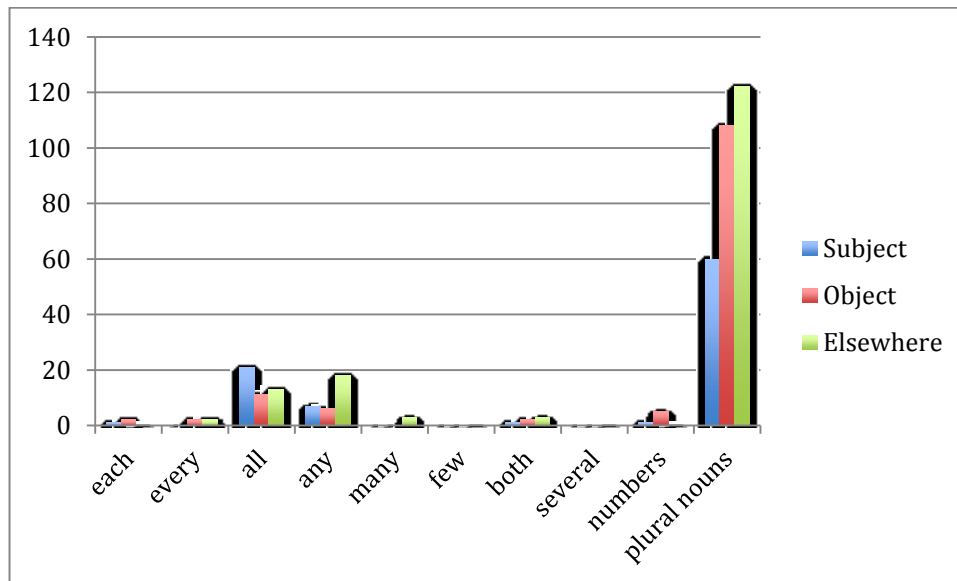
**Figure 27 P1: Instances of Plural Cue Words**

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<sup>14</sup> As noted in Section 3.2.2.5 an instance of the singular quantifiers each, every, and any can be a sign that the requirements engineer is aware of the dangers of plural ambiguity. Therefore, these singular quantifiers are also included as cue words.

### 8.1.2 Usage Distribution of Plurals

The usage distribution of plurals as a subject, an object and elsewhere are 91, 136, and 161, respectively. Figure 28 shows the usage distribution of plurals.



**Figure 28 P1: Usage Distribution of Plurals**

### 8.1.3 Instances of Ambiguity

There are three instances of ambiguity identified. Each instance contains a plural noun. One instance has only a plural object, and two instances have a plural subject and a plural object. The three instances could have been avoided if a singular noun had been used as a subject and as an object instead.

The requirements engineers used plurals slightly more often as a subject and an object than as plurals elsewhere. The usage distribution of plurals is an indication that some requirements engineers were not paying attention to the usage of plurals and seem to be unaware of the dangers of the use of plurals.

Out of 388 instances of a plural cue word, 385 instances are unambiguous. Nevertheless, plural ambiguity does persist. The reason that plural ambiguity does not persist more often is that when the requirements engineers used plurals as a subject and or an object, context disambiguates successfully most of the times<sup>15</sup>.

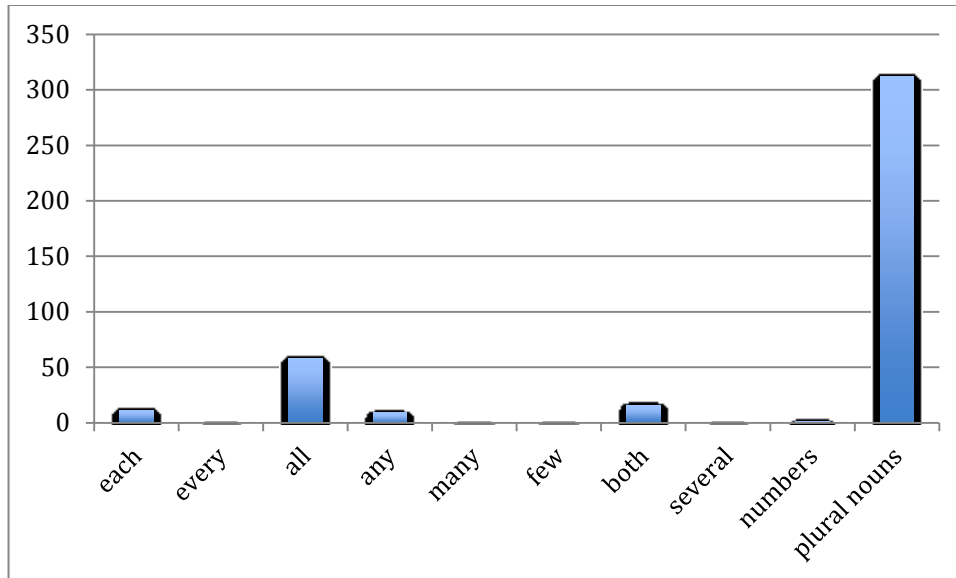
## **8.2 Project 2**

### ***8.2.1 Instances of Cue Words***

The numbers of instances of plural cue words of each of each, every, all, any, many, few, both, several, numbers, and plural nouns are 11, 0, 58, 9, 0, 0, 16, 0, 1, and 312, respectively, totalling 407 instances. Figure 29 shows the numbers of instances of each plural cue word.

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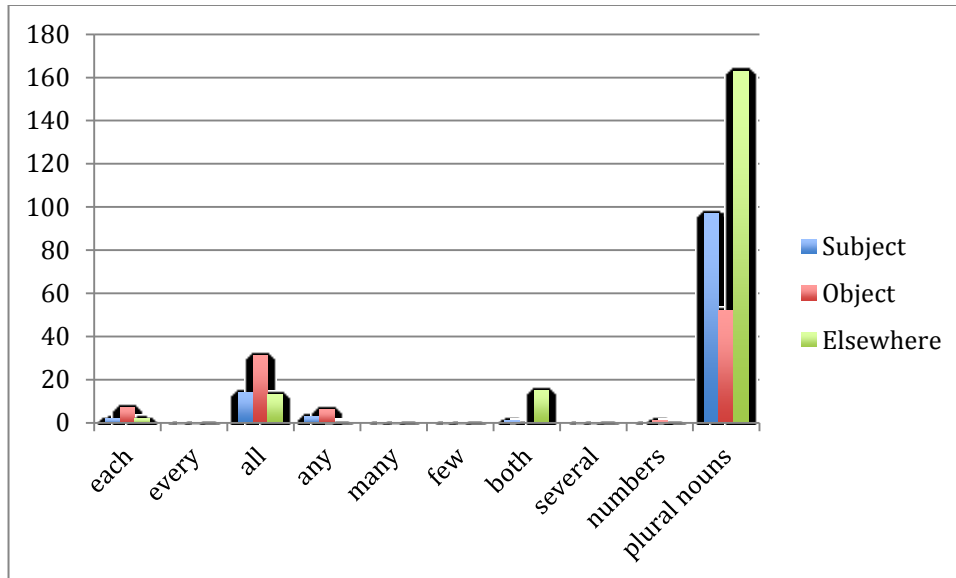
<sup>15</sup> A plural noun can be ambiguous only in the subject and or object position. See Examples 21, 23 and 24 in the Ambiguity Model.



**Figure 29 P2: Instances of Plural Cue Words**

### ***8.2.2 Usage Distribution of Plurals***

The usage distribution of plurals as a subject, an object and elsewhere are 117, 97, and 193, respectively. Figure 30 shows the usage distribution of plurals.



**Figure 30 P2: Usage Distribution of Plurals**

### ***8.2.3 Instances of Ambiguity***

There is one instance of ambiguity identified. This instance contains a plural subject noun phrase. This instance could have been avoided if a singular noun had been used as a subject instead.

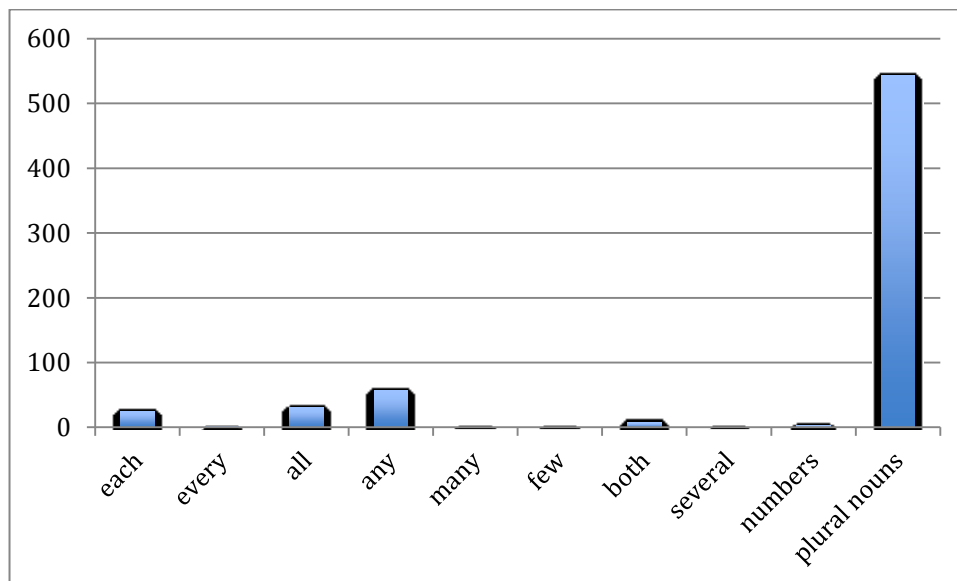
The requirements engineers used plurals slightly more often as a subject and an object than as plurals elsewhere. The usage distribution of plurals is an indication that some requirements engineers were not paying attention to the usage of plurals and seem to be unaware of the dangers of the use of plurals.

Out of 407 instances of plural cue words, 406 instances are unambiguous. Nevertheless, plural ambiguity does persist. The reason that plural ambiguity does not persist more often is that when the requirements engineers used plurals as a subject and or an object, context disambiguates successfully most of the times.

### 8.3 Project 3

#### 8.3.1 Instances of Cue Words

The numbers of instances of quantifier cue words of each of each, every, all, any, many, few, both, several, numbers, and plural nouns are 25, 1, 30, 56, 0, 0, 8, 0, 3, and 544, respectively, totalling 667 instances. Figure 31 shows the numbers of instances of each plural cue word.

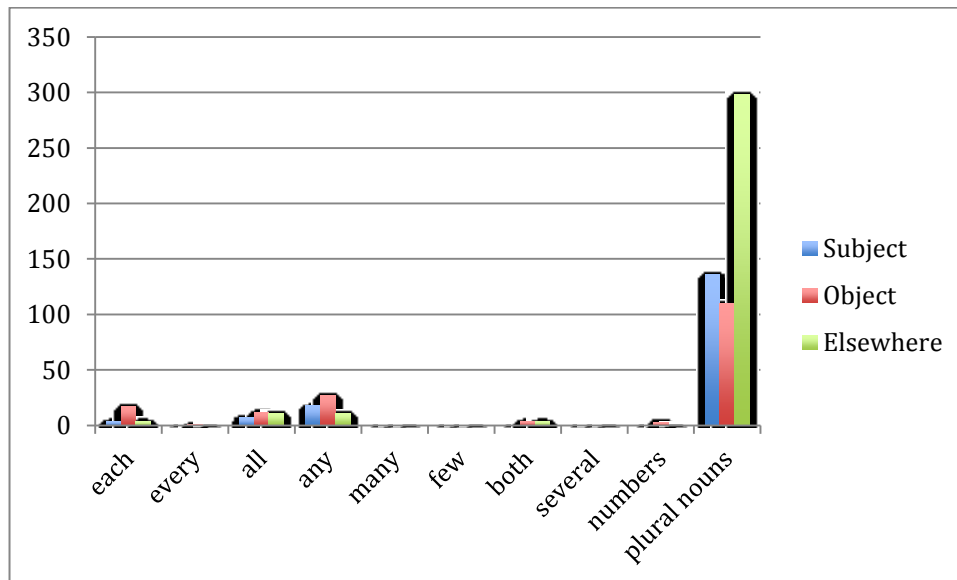




**Figure 31 P3: Instances of Plural Cue Words**

### **8.3.2 Usage Distribution of Plurals**

The usage distribution of plurals as a subject, an object and elsewhere are 165, 174, and 328, respectively. Figure 32 shows the usage distribution of plurals.



**Figure 32 P3: Usage Distribution of Plurals**

### **8.3.3 Instances of Ambiguity**

There are two instances of ambiguity identified. The first instance contains the quantifier all as a subject. The second instance contains a plural subject noun

phrase. The two instances could have been avoided if a singular noun had been used as a subject instead.

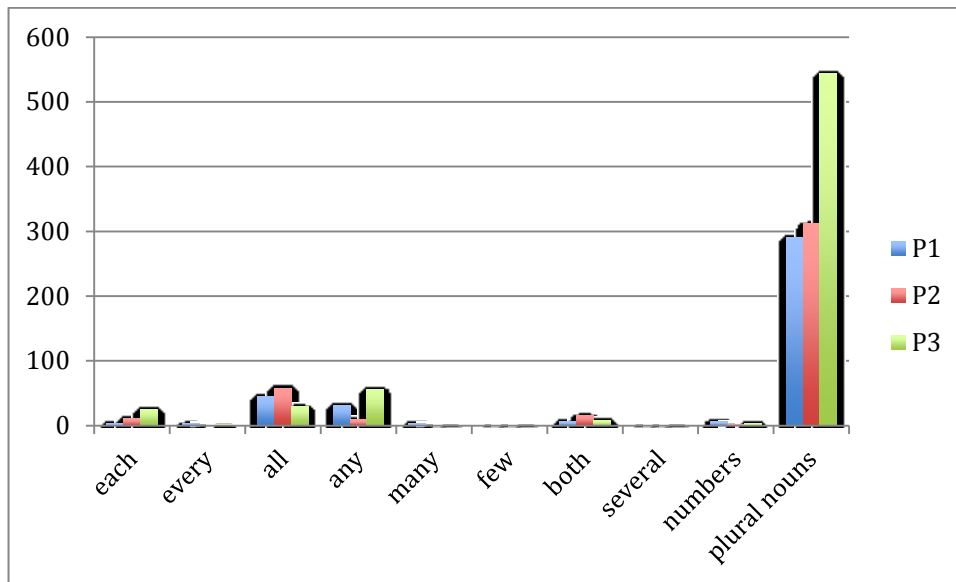
The requirements engineers used plurals slightly more often as a subject and an object than as plurals elsewhere. The usage distribution of plurals is an indication that some requirements engineers were not paying attention to the usage of plurals and seem to be unaware of the dangers of the use of plurals.

Out of 667 instances of plural cue words, 665 instances are unambiguous. Nevertheless, plural ambiguity does persist. The reason that plural ambiguity does not persist more often is that when the requirements engineers used plurals as a subject and or an object, context disambiguates successfully most of the times.

## **8.4 All Three Projects: A Comparative Analysis of P1, P2, and P3**

### ***8.4.1 Instances of Cue Words***

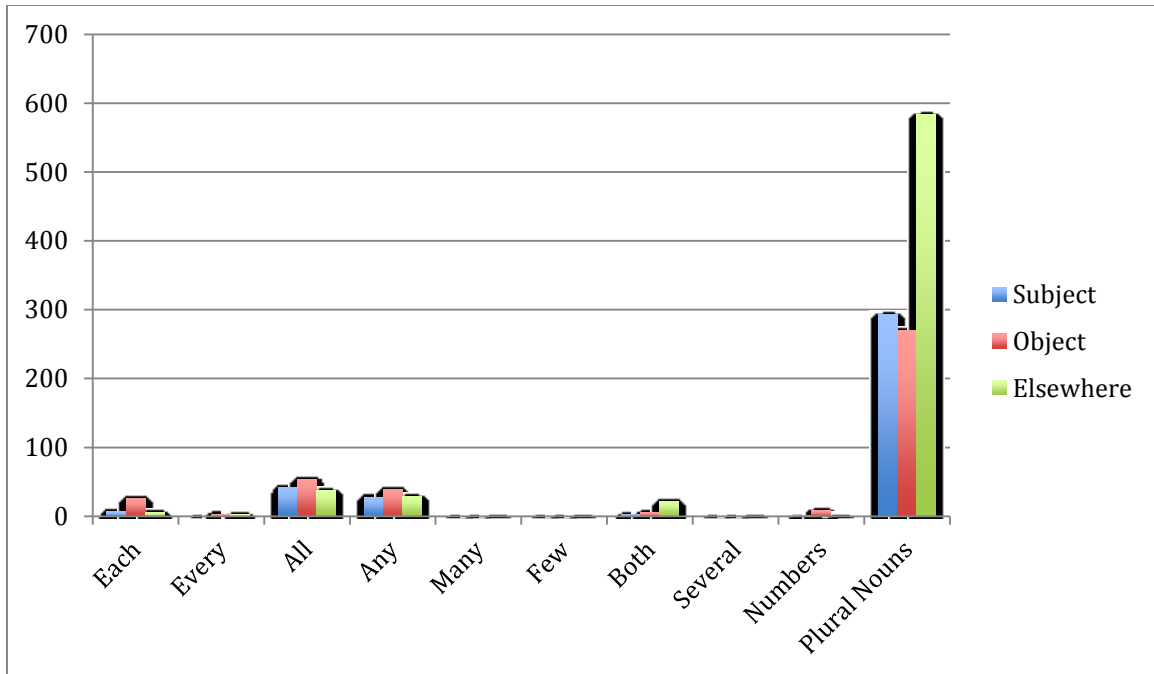
The total numbers of instances of plural cue words of each of each, every, all, any, many, few, both, several, numbers, and plural nouns are 39, 5, 133, 96, 3, 0, 30, 0, 10, and 1146, respectively, totalling 1462 instances. In each of the three projects, the plural noun has the highest number of instances. Figure 33 shows the numbers of instances of each plural cue word for each project.



**Figure 33 All Three Projects: Instances of Plural Cue Words for Each Project**

### ***8.4.2 Usage Distribution of Plurals***

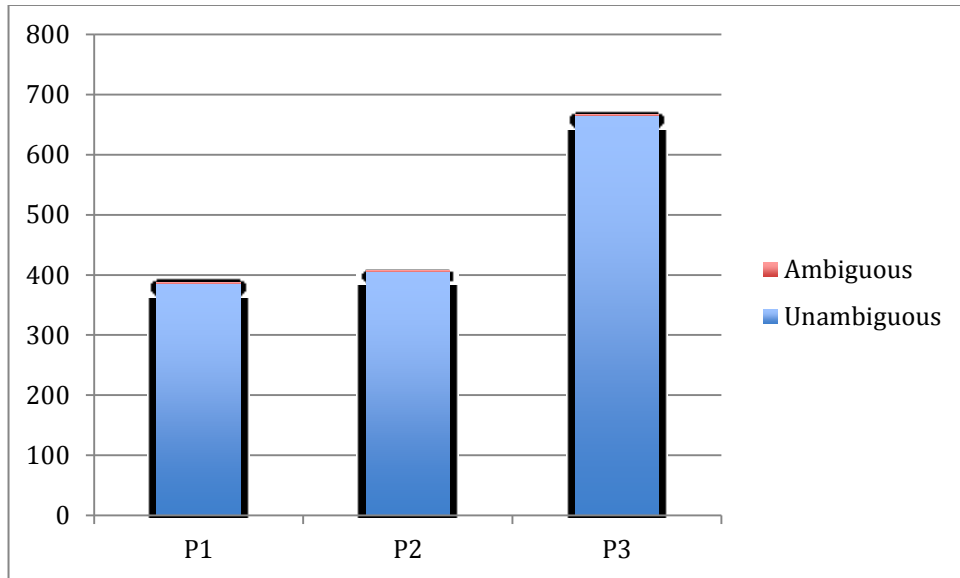
The usage distribution of plurals as a subject, an object and elsewhere are 373, 407, and 682, respectively. Figure 34 shows the distribution of plurals for each project.



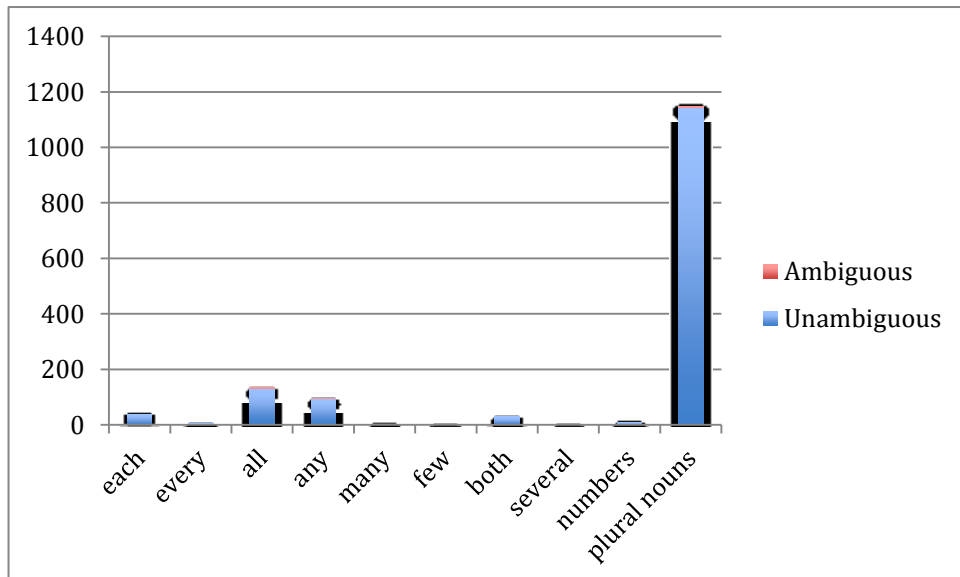
**Figure 34 All Three Projects: Usage Distribution of Plurals for Each Project**

### ***8.4.3 Instances of Ambiguity***

For all three projects, there are six instances of ambiguity identified. One instance contains a quantifier and each of the five instances contains a plural noun. Figure 35 shows the numbers of instances of ambiguous and unambiguous requirements containing plurals for each project. Figure 36 shows the numbers of instances of ambiguous and unambiguous requirements containing plurals for each cue word.



**Figure 35 All Three Projects: Instances of Ambiguous and Unambiguous Requirements Containing Plurals for Each Project**



**Figure 36 All Three Projects: Instances of Ambiguous and Unambiguous Requirements for Each Plural Cue Word**

Instances of ambiguity exist for each project; three instances are in P1, one instance is in P2, and two instances are in P3. P1, P2 and P3 have similar numbers of instances of ambiguity.

For all projects, the requirements engineers used plurals as a subject 373 times, an object 407 times, and elsewhere 682 times. The requirements engineers used plurals slightly more often as a subject and an object than as plurals elsewhere. The usage distribution of plurals is an indication that the requirements engineers were not paying attention to the usage of plurals and seem to be unaware of the dangers of the usage of plurals.

Out of 1462 instances of plural cue words, 1456 instances are unambiguous. Nevertheless, plural ambiguity does persist. The reason that plural ambiguity does not persist more often is that when the requirements engineers used plurals as a subject and or an object, context disambiguates successfully most of the times.

## CHAPTER NINE

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# INTERVIEW RESULTS

The chief requirements engineer of each project was interviewed to determine if any of the identified instances of ambiguity identified caused any problems during the project. Using the author's experience as a software engineer, each project's list of instances of ambiguity was ranked in the order of instances most likely to cause damage or problems, and most likely to have been overlooked. If the chief requirements engineer can dedicate only a small amount of time for the interview, this ranking strategy ensures that if an interview ends before the list is exhausted, the instances of ambiguity most likely to cause problems will have been covered. If the

instances of ambiguity most likely to cause damage are innocuous, then the remaining instances of ambiguities further down the list are most likely innocuous too.

## **9.1 Project 1**

In P1's RS, the instance of ambiguity most likely to cause damage is a referential ambiguity using the pronoun *this*. This instance of ambiguity has two interpretations that affect the data structures that are required. The other instances of ambiguity are referential and plural.

The referential ambiguity mentioned above, was determined to be innocuous by the chief requirements engineer. The chief requirements engineer was not aware of this instance of ambiguity, but the entire team of requirements engineers had subconsciously disambiguated the reference in the same way. The team was dedicated to this software project, and they were familiar and comfortable with the language. The chief requirements engineer was not aware of any problems later in the life of the software that would have been caused by this ambiguity.

## **9.2 Project 2**

P2's RS was well written and there are only two instances of ambiguity in the entire project. The instance of ambiguity most likely to cause damage is a plural ambiguity. This instance is a plural subject, and there are two possible interpretations. The interpretation affects the maximum size of a data structure that is required.



The second most likely instance of ambiguity to cause damage is a referential ambiguity using the pronoun this. This instance has five possible interpretations and affects the implementation of a process.

Each instance of ambiguity was determined to be innocuous by the chief requirements engineer. The chief requirements engineer was not aware of either instance of ambiguity, but the entire team of requirements engineers had subconsciously disambiguated each in the same way. For the instance of referential ambiguity, the chief requirements engineer does not believe that this instance of ambiguity was a problem as the process was implemented correctly. For the instance of plural ambiguity, the chief requirements engineer does not believe that this instance of ambiguity was a problem, as the relevant business process is controlled in other applications, and the instance of ambiguity never presented itself in those applications.

### **9.3 Project 3**

In P3's RS, the instance of ambiguity most likely to cause damage is a plural ambiguity using the plural quantifier all. This instance of ambiguity is a plural subject, and there are two possible interpretations. The interpretation affects the implementation of a process. Other instances of ambiguity in P3 were referential, plural, and modifier ambiguities.

The first plural ambiguity mentioned above, was determined to be innocuous by the chief requirements engineer. The chief requirements engineer was not aware of the instance of ambiguity, but the entire team of requirements engineers had subconsciously disambiguated it in the same way. The chief requirements engineer thought that the team interpreted it correctly either by experience or common sense. The chief requirements engineer did not believe that this instance of ambiguity was a problem, as each member of the team who read the requirements understood how the business operates and did not see any ambiguity.

## CHAPTER TEN

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# DISCUSSION

### **10.1 Prevalence of Persistent Ambiguity**

For the three RSs inspected, there is an average of one persistent ambiguity for every 15.38 pages; P1 has the highest average of one persistent ambiguity for every 3.33 pages, P3 has an average of one persistent ambiguity for every 31.25 pages, and P2 has the lowest average of one persistent ambiguity for every 56 pages.

For each project, the persistent ambiguity identification method identified the existence of persistent ambiguities, and most of these ambiguities went undetected by the requirements engineers, increasing their likelihood of causing damage. For the ambiguities identified, there were no signs of discussion and no domain knowledge. The fact that these persistent ambiguities remain in the RSs after multiple focused inspections is evidence that these ambiguity types are in fact persistent.

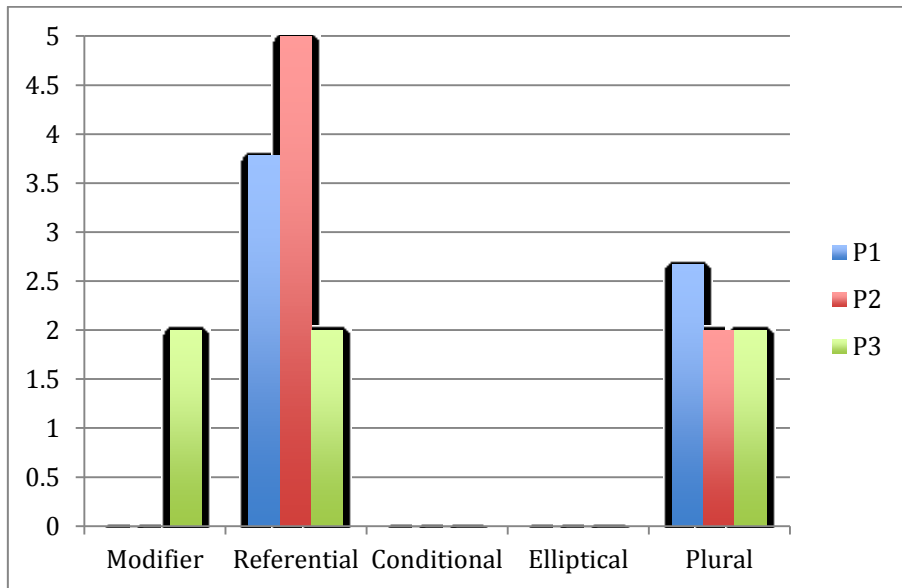
## **10.2 Factors Affecting Persistent Ambiguity**

I had expected three factors would affect ambiguity; however, number of viable interpretations and writing style has an affect on persistent ambiguity and project size does not have an affect on persistent ambiguity. These three factors are likely to be relevant in determining the extent to which inspecting for persistent ambiguity is useful, potentially leading to the avoidance and minimization of persistent ambiguity. Further study of the effect of these factors on persistent ambiguity is recommended.

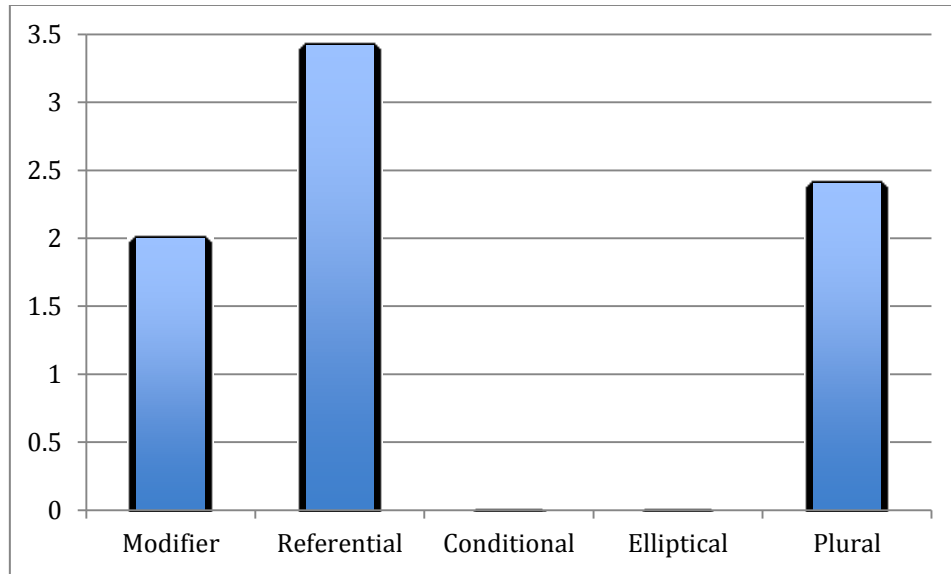
### ***10.2.1 Number of Viable Interpretations***

Some persistent ambiguity types seem more ambiguous than others. Figure 37 shows the average number of interpretations of instances of ambiguity for each persistent ambiguity type for each project. Figure 38 shows the average number of in-

terpretations for each instance of ambiguity for each persistent ambiguity type for all projects. I expected that the referential ambiguity type would be ambiguous more often because of its capacity for a considerable number of interpretations. In fact, the referential ambiguity type does occur 11 times, which is almost twice as often as the second most common ambiguity type to be ambiguous, plural ambiguity.



**Figure 37 Average Number of Interpretations for Each Ambiguity Type for Each Project**



**Figure 38 Average Interpretations for Each Ambiguity Type for All Projects**

### 10.2.2 Writing Style

The writing styles of the requirements engineers involved in each project differ in their usage of the cue words. Particular usages of the cue words may avoid ambiguity.

#### 10.2.2.1 Modifier

Table 6. Average Number of Instances per Page of Modifier Ambiguities and Modifier Placement for Each Project

Project	Ambiguities	Before the Main Verb	Somewhere Else	Before the Subject	At the End of a Requirement
P1	0	0.175	0.3	0.075	0.375
P2	0	0.018	0.143	0	0.205
P3	0.008	0.272	0.256	0.016	0.04

Table 6 shows the modifier placement for each project. P3 is the only project that has a modifier ambiguity. P3 has the highest number of instances of modifiers placed before the main verb and this placement creates uncertainty over whether the literal meaning is intended, particularly if all modifiers are placed before the main verb. P3 has the lowest number of instances of modifiers placed at the end of a requirement, and this placement is unambiguous. The writing style of the requirements engineers of P3 likely resulted in more modifier ambiguity than the writing styles of the requirements engineers of P1 and P2.

#### 10.2.2.2 Reference

Table 7. Average Number of Instances per Page of Referential Ambiguities and Reference Usage for Each Project

Project	Ambiguities	As a Pronoun	As a Determiner
P1	0.23	0.5	3.4
P2	0.009	0.6	0.49
P3	0.008	0.59	1.024

Table 7 shows the reference usage for each project. P1 has the highest number of instances of referential ambiguity. Of all persistent ambiguity types, referential ambiguity has the largest difference in usage among the three projects. Table 7 shows a notably higher number of referential ambiguities in P1 than in the other two projects. In P1, determiners were ambiguous almost seven times as often as pronouns were.

P1 has the highest usage of determiners. The three projects have a very similar usage of pronouns. The writing style of the requirements engineers of P1 likely resulted in more referential ambiguity than the writing style of the requirements engineers of P2 and P3.

#### **10.2.2.3 Elliptical**

Each project has zero instances of elliptical ambiguity. Each project used a low number of instances of elliptical cue words compared to cue words for other persistent ambiguity types. For all three projects, there is a total of 81 instances of elliptical cue words, yet zero instances have an actual ellipsis. The writing style of the requirements engineers of each project avoided the use of ellipses.

#### **10.2.2.4 Conditional Clause Reference**

Each project has zero instances of conditional clause reference ambiguity. P1 and P2 each have zero instances of conditional clause reference cue words. P3 has a total of four instances of conditional clause reference cue words, yet zero of these instances were ambiguous. The writing styles of the requirements engineers of P1 and P2 avoided the use of conditional clause references. The writing style of the requirements engineers of P3 used conditional clause references sparingly.



### 10.2.2.5 Plural

Table 8. Average Number of Instances per Page of Plural Ambiguities and Plural Usage for Each Project

Project	Ambiguities	As a Subject	As an Object	Elsewhere
P1	0.075	2.275	3.4	4.025
P2	0.009	1.045	0.866	1.72
P3	0.016	1.32	1.39	2.62

Table 8 shows the plural usage for each project. P1 has the highest number of instances of plural ambiguity. P1 has the highest usage of plurals in all positions. The use of a plural as a subject is the most ambiguous use, but use as an object may also cause ambiguity. The use of a plural elsewhere in a requirement is unambiguous. The writing style of the requirements engineers for P1 likely resulted in more plural ambiguity than the writing style of the requirements engineers of P2 and P3.

### **10.2.3 Project Size**

There is no good way to quantify project size. Measuring project size by the number of requirements is problematic as the size of a requirement can vary greatly in the total number of words. Therefore, a project's size is measured by the number of standard 8.5 by 11 inch pages the project's RS has.

Table 9. Project Size

Project Number	Number of Pages	Number of Instances of Cue Words	Number of Instances of Ambiguities
P1	40	757	12
P2	112	423	2
P3	125	1835	4

An examination of Table 9 shows that project size is not a factor affecting ambiguity. I expected the number of instances of each of cue words and ambiguity to increase as a project's size increases. Surprisingly, the data disproves this expectation. Project size does not correlate with the number of instances of either cue words or ambiguities. It seems that the key factors affecting the instances of ambiguity in a project are (1) that some persistent ambiguity types are more ambiguous, in terms of number of possible interpretations per instance, than others and (2) the writing style of the requirements engineers.

### 10.3 Impact of Persistent Ambiguity

For each project, the team of requirements engineers subconsciously disambiguated the identified persistent ambiguities in the same way, according to the norms and business processes that everyone understood. This group-wise subconscious disambiguation occurred naturally as a result of the group's continual discussion throughout the project.

The chief requirements engineers of P1 and P3 were each interviewed about one instance of ambiguity and the chief requirements engineer of P2 was interviewed about two instances of ambiguities, totalling four instances.

Each instance of ambiguity, previously ranked most likely to cause damage, was determined innocuous by the chief requirements engineer of each project. Each chief requirements engineer was unaware of the ambiguity in his or her respective project, and reported that the team of requirements engineers had subconsciously disambiguated the ambiguity in the same way.

P2 has only two instances of ambiguities identified for the entire project. The chief requirements engineer was interviewed about both instances, and each instance of ambiguity was reported as innocuous. For P1 and P3, the chief requirements engineers were not interviewed for all instances of ambiguities identified due to limited time.

For P2, it can be concluded that there is zero impact of persistent ambiguity for the entire project. For P1 and P3, it can be concluded that there is zero impact of persistent ambiguity for the instances of ambiguity that the chief requirements engineers were interviewed about, and these instances were the most likely among the ambiguities identified to have an impact.

## 10.4 Cost Benefit Analysis of Persistent Ambiguity: Initial Identification versus Repair of Any Damage Caused Later in the SDLC

### 10.4.1 Inherent Strengths and Weaknesses of Each Approach

Table 10 gives the inherent strengths and weaknesses of initial identification of persistent ambiguity versus repairing any damage caused later in the SDLC.

Table 10. Strengths and Weaknesses of Approaches

Approach	Strengths	Weaknesses
Initial Identification	<ul style="list-style-type: none"> <li>• Increased confidence in project success.</li> <li>• Potential prevention of damage and resulting decreases in repair costs.</li> </ul>	<ul style="list-style-type: none"> <li>• Increase in implementation time and associated labour costs.</li> </ul>
Repair of Any Damage Caused Later in the SDLC	<ul style="list-style-type: none"> <li>• Decrease in implementation time and associated labour costs.</li> </ul>	<ul style="list-style-type: none"> <li>• Decreased confidence in project success.</li> <li>• Increase in potential repair costs of damage.</li> </ul>

The strengths and weaknesses seem to be exactly counter balanced, yet they are not exactly counter balanced. There is a difference in the costs of early and late repairs. Initial identification can significantly decrease potential repair costs because, as previously noted, the cost to repair a defect increases exponentially with the SDLC phase during which the defect is detected.

#### ***10.4.2 Retrospective Cost Benefit Analysis of the Three Studies***

Not all of the instances of ambiguities were reviewed by the chief requirements engineer in the interview; however, the remaining ambiguities are less likely to cause damage because of the ranking in order of likelihood to cause damage.

In general, the potential cost of repairing any damage caused by persistent ambiguities (i.e., if any ambiguity had been interpreted by any team member differently from the intended interpretation and it turned out to be nocuous) could be quite high as the cost to repair increases exponentially in the later phases of the SDLC. If a nocuous ambiguity had been identified, the least expensive approach would have been the identification of persistent ambiguity.

In retrospect, for the three projects analyzed and the ambiguities reviewed by each chief requirements engineer, it turns out that the less expensive approach would have been to forego initially identifying persistent ambiguity.

As none of the ambiguities reviewed by the chief requirements engineer of each project turned out to be nocuous, there is no damage caused resulting in no repair costs.

## 10.5 Cost Benefit Analysis of Identifying Persistent Ambiguity versus All Ambiguity Types

Whenever there is an ambiguous requirement, there is a possibility that a team member will subconsciously disambiguate it differently from other team members of the project team. A major goal of this research is to identify ambiguities that people are unaware of, persistent ambiguities, and to focus on awareness of persistent ambiguity types so that it can be determined through cost benefit analysis whether identification early in the SDLC and the resulting reduction in damage is an effective and efficient approach.

The persistent ambiguity identification method is successful in identifying undetected ambiguities remaining in the RSs after multiple inspections. This means that my strategy focused attention on those ambiguities that could have been subconsciously disambiguated incorrectly. In particular, the persistent ambiguity identification method successfully identified modifier, referential, and plural ambiguities. Referential ambiguity is found in all three projects and is the most commonly identified ambiguity; of the types studied, referential ambiguity is shown to have the highest number of viable interpretations leading to ambiguity.

There is a high cost to identifying *all* ambiguity as it requires multiple focused inspections that are time consuming. Conversely, the *persistent* ambiguity identification method is less expensive because it cuts down the inspection time by cutting down the number of ambiguity types to identify.

This method is a new strategy that recognizes the potential for minimizing re-sources should be spent inspecting for ambiguity if a project has a good RE process in which the requirements are thoroughly discussed, for example the RE process at the company that implemented these three projects. Therefore, the persistent ambiguity identification method is potentially the basis of a cost effective inspection method.

## CHAPTER ELEVEN

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# CONCLUSIONS

### **11.1 Summary**

A comprehensive ambiguity model based on linguistic ambiguity and its application to RE is presented. The model was developed and subsequently analyzed to determine the ambiguity types likely to result in subconscious disambiguation and therefore likely to persist, defined in this research as persistent ambiguity.



The research goal was to identify persistent ambiguity, quantify any resulting damage, and conduct a cost benefit analysis of approaches to identify ambiguity. Two approaches were analyzed: identification of persistent ambiguity versus repairing any resulting damage and identification of persistent ambiguity versus identification of all ambiguity. Current research is questioning the value of identifying ambiguity because it has been suggested that ambiguities are resolved through continual discussion. However, by definition persistent ambiguity has the potential to remain in the RSs after multiple inspections and continual discussion.

A method was developed for inspecting for persistent ambiguity in RSs and three RSs were inspected for instances of persistent ambiguity as defined in the model. Each chief requirements engineer verified whether the persistent ambiguities likely to have the greatest impact on each project were indeed interpreted ambiguously, and if so, what the impact was.

The first research question asked "What is the prevalence of persistent ambiguity?" In the three requirements specifications inspected there is an average of one persistent ambiguity for every 15.38 pages; P1 has the highest prevalence with an average of one persistent ambiguity for every 3.33 pages, P3 has a prevalence of an average of one persistent ambiguity for every 31.25 pages, and P2 has the lowest prevalence with an average of one persistent ambiguity for every 56 pages.

The second research question asked “What is the impact of persistent ambiguity?” In the three projects, none of the persistent ambiguities reviewed by the chief requirements engineer caused expensive damage. The team of requirements engineers in each project were unaware of each instance of persistent ambiguity but seemed to subconsciously disambiguate the ambiguities in the same way. This consistent group-wise SD was likely the result of everyone’s understanding of the norms and business processes.

This research provides additional support for both de Bruijn’s and Filippo’s findings, that ambiguity in RSs does not have a significant impact on the development of a CBS. I conducted a purposive sampling focused on persistent ambiguity in all of the requirements whereas they conducted a random sampling of the requirements focused on all ambiguity. The purposive sampling failed to find the disproof, and thus ended up strengthening de Bruijn’s and Filippo’s findings.

The third and final research question asked “Which approach has the lower cost: identifying persistent ambiguities in an RS during RE or repairing the damage caused by undetected ambiguities in later phases of the SDLC?” For the three projects analyzed and the persistent ambiguities reviewed by each chief requirements engineer, the least expensive approach would have been to forego initially identifying persistent ambiguity in these three projects. Nonetheless, each project failed to identify its specification’s persistent ambiguities; although each of the three projects was successfully implemented and had a good RE process, persistent ambiguity re-

mained in each project even after multiple focused requirements inspections. Each of the persistent ambiguities identified has the potential to cause damage. In mission critical systems, such as a nuclear power plant, damage may be very expensive and potentially cost lives. Especially for these systems, a thorough requirements review including the identification and removal of persistent ambiguities should be considered. In fact, any project, regardless of how good its RE process is, could potentially benefit from the identification of persistent ambiguities in an RS during RE.

The first main conclusion is that, as expected, persistent ambiguity remained undetected by the teams of requirements engineers despite intense continual discussion. The second main conclusion is that the process used by these particular RE teams for these particular projects is enough to prevent damage. The third main conclusion is that the identification of persistent ambiguity is potentially more effective and efficient than identifying all ambiguity in RSs.

## **11.2 Contributions**

This research presents a comprehensive state-of-the-art ambiguity model for RSs, combining research from computational linguistics, linguistics, and RE. This model covers all ambiguity types and includes a special focus on persistent ambiguity, that is, instances of types that are most likely to result in SD and remain undetected despite continual discussions among RE team members and the resulting resolution of defects. In addition, a method is presented to identify persistent ambiguity in RSs.

In fact, persistent ambiguity was identified in each of the projects analyzed suggesting that persistent ambiguity does remain undetected.

My strategy is potentially cost effective because it reduces the amount of ambiguity to inspect by focusing on ambiguity that might not be resolved through continual discussion because the requirements engineers are unaware of it. The identification of persistent ambiguity in RSs is potentially an effective and efficient strategy for minimizing damage caused by ambiguity precisely because of its focus on ambiguity that remained undetected due to lack of awareness. Current research suggests that a focus on *all* ambiguity is not cost effective because continual discussion of RSs results in implementations with no ambiguity related defects. Therefore, the persistent ambiguity inspection strategy is a scalable lower cost RS ambiguity inspection method.

The strengths and weaknesses of initial ambiguity identification versus repair of any damage caused later in the SDLC are not counter balanced. Although avoiding an initial identification of persistent ambiguity may decrease implementation time and associated labour costs, initial identification can significantly decrease potential repair costs because the cost to repair a defect increases exponentially in the later SDLC phases. While all systems could potentially benefit from the identification of persistent ambiguity, for mission critical systems in particular, damage may be very expensive and potentially cost lives. These systems could especially benefit from a

thorough requirements review including the identification and removal of persistent ambiguities.

Finally, software engineers and requirements engineers could use knowledge of persistent ambiguity to produce higher quality RSs and decrease software defects by writing RSs differently.

### **11.3 Future Work**

Any empirical study may be better supported with additional studies. The three studies on the prevalence and impact of persistent ambiguity can be extended in various ways.

#### ***11.3.1 Ambiguity Types Investigated for Persistent Ambiguity***

Persistent ambiguity was investigated in five ambiguity types chosen because I assumed that these types are more likely to result in ambiguities that people subconsciously disambiguate due to their lack of awareness. This inability to perceive that ambiguity exists may result in persistent ambiguity remaining in an RS even after continual discussion about the RS and its known ambiguities. Two ambiguity types studied, elliptical and conditional clause reference, did not result in persistent ambiguity in the three studies conducted. Further study is necessary to assess if these types chosen are indeed the types that people are likely to be unaware of. This research would determine if the other types not investigated result in persistent am-

biguity. In addition to the relationship between ambiguity type and persistent ambiguity, further research is necessary to determine the effect of other factors on their relationship.

### ***11.3.2 Prevalence of Persistent Ambiguity***

In the three studies that were situated in one company, industry, and three different teams, an average of one persistent ambiguity was identified for every 15.38 pages. However, additional and larger studies are necessary to determine the prevalence of persistent ambiguity in different contexts. The three aspects of context likely to have an effect are companies, industries, and people involved.

### ***11.3.3 Impact of Persistent Ambiguity***

This research found that persistent ambiguity did not have an impact in the three studies conducted. Due to the limited time each chief requirements engineer could dedicate to the interview, the number of ambiguities reviewed for their resulting impact was small. In my opinion as a domain-ignorant inspector I was surprised that these persistent ambiguities identified were subconsciously disambiguated in the same way by each of the requirements engineers. On the other hand, the company is known to be serious about RE and doing a thorough job of requirements analysis. In such a serious analysis, people tend to come to a consensus more often. Therefore, additional and larger studies are necessary to determine the impact of persistent ambiguity in different companies, industries, and people involved.

#### ***11.3.4 Cost Benefit Analyses of Persistent Ambiguity***

Further cost benefit analyses are necessary for both initially inspecting for persistent ambiguity versus repairing any damage caused by persistent ambiguity later in the SDLC, as well as inspecting for persistent ambiguity versus inspecting for all ambiguity. These analyses will aid in determining the most effective and efficient allocation of resources to the problem of ambiguity in RSs.

#### ***11.3.5 Factors Affecting Persistent Ambiguity***

It would be valuable to further investigate the factors affecting persistent ambiguity. The findings of the three studies have potential significance in industry, and software engineers and requirements engineers can benefit from knowledge of the factors that affect persistent ambiguity. The factors investigated in this research include the number of interpretations for each ambiguity, writing style, and project size. Further study of these three factors in different contexts is necessary to determine further their effect on (1) persistent ambiguity and its prevalence, as well as on (2) its potential impacts.

However, additional factors may affect persistent ambiguity and its potential significance in industry. Software engineers and requirements engineers can benefit from knowledge of all the factors that affect persistent ambiguity. Further study is necessary to determine what factors affect persistent ambiguity and its prevalence, as well as its potential impacts. Potential factors include people's backgrounds and other stakeholders.

Because persistent ambiguity is immune to the normally beneficial affects of discussion, a key factor in its impact is whether or not people subconsciously disambiguate an instance of persistent ambiguity in the same way. Potential factors affecting how people subconsciously disambiguate include aspects of the backgrounds of people involved in the project. With internationalization of businesses and specifically the globalization of software development [52], more and more people are involved from different parts of the world, and outsourcing has also become common. In some cases there may be involvement from interdepartmental teams.

People from such varied backgrounds may have differences in terminology, work environment, and perspective that can result in differing assumptions that affect how they subconsciously disambiguate. Further study of projects embedded in complex environments will shed light on the affect of people's backgrounds on persistent ambiguity.

Another potentially relevant aspect of a person's background is their native language background. For example, English as a second language speakers may subconsciously disambiguate differently from native English speakers, and this may depend on their experience in and facility with English. Ironically, a non-native English speaker whose original language's standard placement of modifiers is correct placement may have an easier time avoiding and spotting modifier misplacement.



Finally, depending on the software project there may be other stakeholders involved, for example, clients or experts from different industries. Software engineers and requirements engineers through training and the nature of their work with requirements may subconsciously disambiguate differently from other stakeholders. A deeper understanding of this factor would be useful for software engineers and requirements engineers when working with other stakeholders in the development of software.

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## APPENDIX A

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# USAGE FREQUENCY STUDY

A usage frequency study was conducted with various usage queries using the Google search engine. This usage study is a quick way of comparing usage frequencies. In addition, the output of Google queries allows for examining the context of the queried phrase.

A list of queries to assess different modifier placements was created by pairing the modifier only with each of the five most commonly used verb forms, which are listed below. The modifier only is the most frequently used modifier and the only modifier

to cause ambiguity in the three RSs. For this reason, only is the modifier chosen to conduct the usage frequency queries for modifiers.

A list of the five verbs that are the most commonly used with the modifier only in the RSs was created. These verbs were identified using word frequency counts, using the three RSs as input data. The five verbs identified are: be, add, change, send, and record.

A list of queries to assess different plural usages was created by pairing each of the quantifiers each and all with each of the five most commonly used verb forms, which are listed below. These quantifiers were chosen for the plural queries because they can demonstrate examples of the usage of plural quantifiers when the intended interpretation is distributive.

A list of the five verbs that are the most commonly used with the quantifiers all and each in the RSs is created in a similar manner, using word frequency counts, and the three RSs as input data. The five verbs identified are: identify, support, approve, impact, and request.

### **A.1 Modifier Placement Usage Frequency Examples**

Modifier placement is indicative of people's awareness of modifier ambiguity.

The study reveals that overall, for each of the 5 verb forms studied, the modifier *only* is placed before the main verb 267,010,000 times and is placed after the main verb 39,634,000 times. Thus, *only* is placed before a verb 6.7 times more often than after a verb, supporting the assumption that before the main verb is the placement used frequently.

Query 1, *only be*, shows that the modifier *only* is placed before the main verb 245,000,000 times. See Figure 39. Query 2, *be only*, shows that *only* is placed after the main verb only 35,300,000 times. See Figure 40. Thus, *only be* occurs 6.9 times more frequently than *be only*.

Query 3, *only send*, shows that the modifier *only* is placed before the main verb 6,710,000 times. See Figure 41. Query 4, *send only*, shows that *only* is placed after the main verb only 595,000 times. See Figure 42. Thus, *only send* occurs 11.3 times more frequently than *send only*.

Query 5, *only add*, shows that the modifier *only* is placed before the main verb 6,170,000 times. See Figure 43. Query 6, *add only*, shows that *only* is placed after the main verb only 615,000 times. See Figure 44. Thus, *only add* occurs 10 times more frequently than *add only*.

Query 7, *only change*, shows that the modifier *only* is placed before the main verb 6,110,000 times. See Figure 45. Query 8, *change only*, shows that *only* is placed after the main verb only 2,590,000 times. See Figure 46. Thus, *only change* occurs 2.5 times more frequently than *change only*.

Query 9, *only record*, shows that the modifier *only* is placed before the main verb 3,020,000 times. See Figure 47. Query 10, *record only*, shows that *only* is placed after the main verb only 534,000 times. See Figure 48. Thus, *only record* occurs 5.7 times more frequently than *record only*.

The verb **be** is a highly irregular verb and it seems to have an idiomatic use with the modifier **only**. With **be**, **been**, and **being** there is a preference for placement before the verb form 6.2 times more often than after the verb form. With the other five forms of **be** (**am**, **is**, **are**, **was**, and **were**) there is a preference for placement after the verb form 9.2 times more often than before the verb form. The difference could be because of **be**'s usage as an auxiliary verb more often than is the case with other verbs. The queries include when each of the verb forms is either a main verb or an auxiliary verb. When the verb form **am**, **is**, **are**, **was**, or **were** is used as an auxiliary verb then the placement of the **only** is after this verb form, which means that the **only** is placed before the main verb because the main verb follows the auxiliary verb. Table 11 shows the results of the queries with the different forms of the verb **be**.

Table 11. Usage Frequency of Modifier Queries with the Verb **be**

Query	Usage Frequency
only be	245,000,000
be only	35,300,000
only been	40,600,000
been only	6,200,000
only being	16,800,000
being only	7,140,000
only am	646,000
am only	15,300,000
only is	48,100,000
is only	436,000,000
only are	23,200,000
are only	197,000,000
only was	14,300,000
was only	148,000,000
only were	5,630,000
were only	45,800,000

The screenshot shows a Google search results page for the query "only be". At the top, the Google logo is on the left, the search bar contains "only be", and the name "Cristina" is visible on the right. Below the search bar are navigation tabs for "All", "Videos", "Images", "News", "Maps", "More", and "Search tools". The results section indicates "About 245,000,000 results (0.55 seconds)".

The first result is "Words That Can Only Be Your Own" from [wordsthatcanonlybeyourown.blogspot.com/](http://wordsthatcanonlybeyourown.blogspot.com/), dated Feb 9, 2016. The snippet says: "Finally, 'myself' should **only be** used when there's also an 'I' in your sentence. For example: 'I bought myself some new Lush goodies.'"

The second result is "KANYE WEST on Twitter: 'My album will never never never ...'" from <https://twitter.com/kanyewest/status/699376240709402624>, dated 2 days ago. The snippet says: "My album will never never never be on Apple. And it will never be for sale... You can only get it on Tidal. Retweets 33,727; Likes 47,410; Daniel ..."

The third result is "Urban Dictionary: 'there can only be one'" from [www.urbandictionary.com/define.php?term=%22there+can...be...](http://www.urbandictionary.com/define.php?term=%22there+can...be...). The snippet says: "'there can **only be** one'. A commonplace quote from character Duncan McCloud in the TV series The Highlander which preceded the decapitation of his ..."

The fourth result is "There can only be one - 9GAG" from [9gag.com/gag/agVgjmX/there-can-only-be-one](http://9gag.com/gag/agVgjmX/there-can-only-be-one). The snippet says: "There can **only be** one - 9GAG has the best funny pics, GIFs, videos, memes, cute, wtf, geeky, cosplay photos on the web. We are your best source of happiness ..."

The fifth result is "Stevie Wonder - I Can Only Be Me Lyrics | MetroLyrics" from [www.metrolyrics.com/i-can-only-be-me-lyrics-stevie-wonder.html](http://www.metrolyrics.com/i-can-only-be-me-lyrics-stevie-wonder.html). The snippet says: "Lyrics to 'I Can **Only Be** Me' by Stevie Wonder. Butterflies begin from having been another / As a child is born from being in a mother's womb / But how many."

The sixth result is "Annihilator - Only Be Lonely Lyrics | MetroLyrics" from [www.metrolyrics.com/only-be-lonely-lyrics-annihilator.html](http://www.metrolyrics.com/only-be-lonely-lyrics-annihilator.html). The snippet says: "Lyrics to '**Only Be** Lonely' by Annihilator. We've been apart a long time, it feels like years / The memories bring tears / Good times, I think of all the good."

The seventh result is "EVA CASSIDY LYRICS - I Can Only Be Me - A-Z Lyrics" from [www.azlyrics.com/lyrics/evacassidy/i-can-only-beme.html](http://www.azlyrics.com/lyrics/evacassidy/i-can-only-beme.html). The snippet says: "Lyrics to 'I Can **Only Be** Me' song by EVA CASSIDY: Butterflies begin From having been another As a child is born, from being in a mother's womb But how..."

The eighth result is "Perforce Public Knowledge Base - Client can only be used ..." from [answers.perforce.com/articles/KB/3412](http://answers.perforce.com/articles/KB/3412). The snippet says: "The 'Host:' field of the client workspace specification is optional: it can be changed to the new hostname or even removed. Please be aware that by default, ..."

The ninth result is "'There can be only one' or 'there can only be one'?" from [painintheenglish.com/case/5147](http://painintheenglish.com/case/5147), dated Jul 15, 2013. The snippet says: "'there can **only be** one ultimate cause of rational change in general' ... can **only be** one" (although the difference is less in British English)."

The tenth result is "PSA: The Dominion Icon could only be obtained if you had ..." from [https://www.reddit.com/.../psa\\_the\\_dominion\\_icon\\_could\\_only\\_be\\_obta...](https://www.reddit.com/.../psa_the_dominion_icon_could_only_be_obta...), dated 14 hours ago. The snippet says: "It's super annoying because me and my friends were actually playing more and more dominion and if I had one more day I ..."

The eleventh result is "'Singletons that pass quality control can only be validated ...'" from <https://plus.google.com/.../posts/8WVQUv9npj> by Fiona Whelan, dated Aug 8, 2014. The snippet says: "'Singletons that pass quality control can **only be** validated ecologically" - Sue Huse #STAMPS14"

The twelfth result is "I really like some of the points made in this article, especially ..." from <https://plus.google.com/.../posts/3RMBbiNVSkL> by Fiona Whelan, shared privately.

Figure 39 Modifier Query 1: "only be"



GOOGLE "be only" Cristina

All Images News Videos More Search tools

About 35,300,000 results (0.52 seconds)

**Be Only: Les bottes de pluie trendy**  
[www.be-only.com/](http://www.be-only.com/) Translate this page  
 Découvrez le site officiel de **Be Only**, la marque numéro 1 des bottes de pluie revisitées.  
 Be fashion, Be proud, **Be Only**.

**BRAND**  
 Be Only is a reference brand for rubber boots. Away from its ...

**Home | Be-Only**  
 Home · Press · Partners.  
 COLLECTIONS. Children news ...

**Collection**  
 nouveautés enfant · collections enfant. nouveautés femme ...

**Points de vente**  
 Be Only est présent dans une vingtaine de pays en Europe et ...

**Women collections**  
 Women Collections. Cavaliere. size from 36 up to 41. Kimi. size ...

**Fr**  
 Découvrez les collections Femme de nos bottes de pluie revisitées.

[More results from be-only.com »](#)

Images for "be only" Report images



[More images for "be only"](#)

**Be Only shoes: All Be Only shoes on Sarenza | Free delivery**  
[www.sarenza.co.uk/be-only](http://www.sarenza.co.uk/be-only)  
 Rating: 4.4 - 1,281 votes  
 Sarenza, official **Be Only** stockists. Choose from a wide range of **Be Only** shoes. Delivery and returns are always free!

**B.O.Y ( Be Only You ) | Free listening on SoundCloud**  
<https://soundcloud.com/boytillwedie>  
<http://officialboy.com/about>. Atlanta. 7 Tracks. 237 Followers. Stream Tracks and Playlists from B.O.Y ( **Be Only You** ) on your desktop or mobile device.

**Highlander (film) - Wikipedia, the free encyclopedia**  
[https://en.wikipedia.org/wiki/Highlander\\_\(film\)](https://en.wikipedia.org/wiki/Highlander_(film))  
 ... spin-offs. Its tagline, "There can **be only one**", has carried on throughout the franchise, as have the songs provided for the film by the rock band Queen.

**BOY - Be Only You - Facebook**  
<https://www.facebook.com/BOY.BeOnlyYou/>  
 BOY - **Be Only You**. 3501 likes · 10 talking about this. B.O.Y. (**Be Only You**)

**Urban Dictionary: "there can only be one"**  
[www.urbandictionary.com/define.php?term=%22there+can...be...](http://www.urbandictionary.com/define.php?term=%22there+can...be...)  
 Commonly misquoted reference to the Highlander movies and TV series. The actual line is "There can **BE ONLY** one."

Searches related to "be only"

- [only lyrics](#)    [only rentals](#)
- [only nicki minaj](#)    [joey's only](#)
- [only download](#)    [only hope](#)

Figure 40 Modifier Query 2: "be only"

The screenshot shows a Google search results page for the query "only send". The search bar at the top contains the text "only send" and the name "Cristina" is visible on the right. Below the search bar, there are navigation tabs for "All", "Images", "Maps", "Videos", "News", "More", and "Search tools". The search results are listed below, starting with "About 6,710,000 results (0.46 seconds)".

The first result is titled "I want to only send as an imessage, never as a ..." from Apple Support Communities, dated May 6, 2012. It describes a user's issue with sending messages to friends and family in Europe. Other results include a video titled "11 Stress Texts You Only Send During Finals Week" from BuzzFeed, dated Nov 30, 2016; a post from a community forum titled "I can only send/receive picture messages from other ..." dated Mar 16, 2013; a Facebook post titled "i only send request to people i know, and i get blocked ..." dated Sep 13, 2011; a forum post titled "Can only send photos in iMessage | MacRumors Forums" dated Aug 19, 2012; a post titled "SMTP Authentication-I Can Only Send Email to My Domain ..." dated Sep 13, 2011; a YouTube video titled "Texts You Only Send Your Best Friend - YouTube" uploaded on Oct 27, 2014; a support article titled "Will a contact on 2 or more of my email lists receive ..." dated support2.constantcontact.com/articles/FAQ/1679; a MailChimp article titled "How MailChimp Pricing Plans Work | MailChimp.com: KB ..." dated kb.mailchimp.com/accounts/billing/how-mailchimp-pricing-plans-work; and a post from StackExchange titled "I can I set Mail to only send from one email address ..." dated Jan 18, 2012.

At the bottom of the search results, there is a section titled "Searches related to 'only send'" with the link "how to only send imessages".

Figure 41 Modifier Query 3: "only send"

The screenshot shows a Google search results page for the query "send only". The search bar at the top contains the text "send only" and the name "Cristina" is visible on the right. Below the search bar are navigation tabs for "All", "Videos", "Images", "News", "Maps", "More", and "Search tools". The results section shows approximately 595,000 results in 0.37 seconds. The first few results are:

- How to configure a Send-Only account in Outlook - CodeTwo**  
www.codeltwo.com > Knowledge Base  
Feb 6, 2009 - To have a **Send-Only** account, the is one from which mail will never be downloaded, you need to do the following: in Outlook choose Tools, ...
- Exclude account from receiving (send only account ...**  
www.msoutlook.info/question/308  
Exclude account from receiving (**send only** account). I've got several POP3 accounts configured in Outlook. One account I only use for sending (someone else ...
- Stave Off Distractions with a Send-Only Email Account**  
lifehacker.com/\_stave-off-distractions-with-a-send-only-email-account  
Jun 24, 2011 - We all need email for work, but if you'd like to send emails without getting distracted by your overflowing inbox, weblog TUAW recommend ...
- Send Only Account - Office Mac Help Site - MVPs.org**  
www.office.mvps.org > accounts  
A **Send Only** Account is used when you don't want your actual email address shared. An example of this would be posting on a newsgroup where your email ...
- How to create a send-only POP3 account - Slipstick Systems**  
www.slipstick.com > Outlook > Configure and Maintain  
Jul 21, 2014 - How to create an email account that will be used only to send email from a forwarded email address.
- How do I change my Outlook.com account from Send only? - ...**  
answers.microsoft.com/\_51b229f9-7e84-4276-aac3-4d688805b97e?...  
Nov 16, 2015 - Hi. If you have multiple email accounts, you can receive, read, and respond to mail from other email accounts right from your Hotmail account.  
How to I change a gmail account from **Send only** to 6 Nov 2015  
How do I delete a "**send only**" account in Outlook ? 3 Nov 2015  
**Send Only** feature in Windows Live Mail 30 Oct 2015  
How do I set up an email account to be **send only** and not receive ... 4 Oct 2013  
More results from answers.microsoft.com
- Use Mailsmith to create a "send-only" email account**  
www.engadget.com/\_use-mailsmith-to-create-a-send-only-email-accou...  
Jun 18, 2011 - How many times have you gone to send an email, only to be distracted or even derailed by something that you found in your inbox? I found a ...
- Helpcentral | SLN26524 - Send-only addresses in Yahoo Mail**  
https://help.yahoo.com/kb/SLN26524.html  
Add a **send-only** address to your Yahoo Mail so you can send from that address without switching accounts.
- Outlook.com Tip: Send Email from Another Account ...**  
winsupersite.com > Cloud > Outlook.com  
May 3, 2013 - From this page, click the "Add a send-and-receive account" button under Add an email account. Note: Do not choose "Add a **send-only** account" ...
- How To Install and Configure Postfix as a Send-Only SMTP ...**  
https://www.digitalocean.com/\_how-to-install-and-configure-postfix-as-...  
Jan 23, 2015 - Postfix is an MTA (Mail Transfer Agent), an application used to send and receive email. In this tutorial, we will install and configure Postfix so ...

Searches related to "send only"

- postfix send only
- sendmail send only
- how to send only imessages
- nservicebus send only

Figure 42 Modifier Query 4: "send only"

GOOGLE "only add" Cristina

All Images Videos News Maps More Search tools


About 6,170,000 results (0.32 seconds)

**Using jQuery only, add to all links with the class "external ...**  
<https://teamtreehouse.com/.../using-jquery-only-add-to-all-links-with-the-...>  
 Using jQuery **only**, add to all links with the class "external", the target attribute with the value of "\_blank". \$external.attr("external", "\_blank"); ...

**how do i add people to my group who are not on my friends ...**  
<https://www.facebook.com/help/community/question/?id...>  
 Hi Mandie, For standard Facebook groups, you can **only add** people you're friends with but other people can request to join the group. You can learn more about ...

**Add more than one image at a time to a post without having ...**  
<https://www.facebook.com/help/community/question/?id...>  
 I can **only add** one at a time to another page. Posted about 10 months ago by Jim Rohn. This totally does not work!!!! Posted about 10 months ago by Pippa ...

**Images for "only add"** Report images



**More images for "only add"**

**Can only add one song at a time to a playlist - The Spotify ...**  
<https://community.spotify.com/t5/Help...only-add...at.../1041428>  
 6 posts  
 Solved: I found yesterday instead of being able to select a whole album, or even everything an artist has I can now **only add** one song at a time to a.

**WordPress › Support › Can only add one item to each group ...**  
<wordpress.org › WordPress › Support › Plugins and Hacks>  
 I think the plugin is great, however why is it that I can **only add** one item to each group? I have dozens of pages to restrict access to over numerous user roles.

**Is there a way to search for and display only add-on items ...**  
[https://www.reddit.com/.../is\\_there\\_a\\_way\\_to\\_search\\_for\\_and\\_display\\_o...](https://www.reddit.com/.../is_there_a_way_to_search_for_and_display_o...)  
 Sep 8, 2015 - Customer Service questions, shipping, products, reviews, customer images, questionable packaging or odd/poorly related items. All things ...

**a day at the supermarket | Codecademy**  
<https://www.codecademy.com/forum.../543d1c8a282ae3fac0025fa>  
 Make the following changes to your compute\_bill function: While you loop through each item of food, **only add** the price of the item to total if the item's stock

**Only add a file if it's absent. - Puppet Cookbook**  
<www.puppetcookbook.com/posts/only-create-file-if-absent.html>  
**Only add** a file if it's absent. Challenge. You only want puppet to add a file if the file isn't already present. Once it's added, or if it's already there, you want to leave ...

**Opinion: Only add people you really know on Facebook ...**  
<bcgavel.com › Opinions › Beyond Campus>  
 Mar 20, 2013 - Sorting through Facebook friend requests can be a tedious process. There are the obvious denials – Dad's crazy cousin Bob who taught you to ...

Searches related to "only add"

Figure 43 Modifier Query 5: "only add"

GOOGLE "add only" Cristina

All Images Videos News Maps More Search tools

About 615,000 results (0.42 seconds)

**Add Only**  
[addonly.com/](#)  
**Add Only** India's No.1 local search engine provides comprehensive updated information on all B2B and B2C Products and Services. Services available in all ...

**DS2502 1Kb Add-Only Memory - Maxim**  
<https://www.maximintegrated.com/en/products/digital/.../DS2502.html>  
 The DS2502 1Kb **Add-Only** Memory identifies and stores relevant information about the product to which it is associated. ... The DS2502 consists of a factory-lasered registration number that includes a unique 48-bit serial number, an 8-bit CRC, and an 8-bit Family Code (09h) plus 1Kb of ...

**[PDF] DS2502/5-UNW UniqueWare Add-Only Memory - Maxim ...**  
<https://datasheets.maximintegrated.com/.../DS2502-UNW-DS2505-UNW...>  
 Device is an "**add only**" memory where additional data can be programmed into. EPROM without disturbing existing data. • Reduces control, address, data, ...

**Git add only all new files, not modified files - Stack Overflow**  
[stackoverflow.com/.../git-add-only-all-new-files-not-modified-files](https://stackoverflow.com/.../git-add-only-all-new-files-not-modified-files)  
 Apr 2, 2013 - This question already has an answer here: git: stage only new files 7 ... Maybe git add \$(git ls-files -o --exclude-standard). git ls-files lets you list ...

**commit - git add only modified changes and ignore ...**  
[stackoverflow.com/.../git-add-only-modified-changes-and-ignore-untrac...](https://stackoverflow.com/.../git-add-only-modified-changes-and-ignore-untrac...)  
 Aug 19, 2011 - This worked for me: #!/bin/bash git add `git status | grep modified | sed 's/(.\*modified:.\*\$)/'`. Or even better: \$ git ls-files --modified | xargs git add ...

**git-add only whitespace changes? - Stack Overflow**  
[stackoverflow.com/questions/27489189/git-add-only-whitespace-changes](https://stackoverflow.com/questions/27489189/git-add-only-whitespace-changes)  
 Dec 15, 2014 - You can try the following "trick": git add -A git diff --cached -w | git apply --cached -R. This basically adds everything to the index, then unstages all ...

**Using SUMIF to add up cells in Excel that meet certain criteria**  
[fiveminutelessons.com/.../using-sumif-add-cells-excel-meet-certain-criter...](https://fiveminutelessons.com/.../using-sumif-add-cells-excel-meet-certain-criter...)  
 Is there a way to use sumif when I want to **add only** specific cells in a column (not a range)? When I reference the cells in the sumif formula it tells me I have too ...

**add only load? | Qlik Community**  
<https://community.qlikview.com/thread/53171>  
 May 12, 2012 - This code "**add only** load "; select lastname firstName from customer" What does "**add only** load" means and what is the purpose of.

**Can I add only one product on my site? | Ecwid Help Portal**  
<https://help.ecwid.com/.../1113353-can-i-add-only-one-product-on-my-s...>  
 Nov 19, 2015 - The answer is Yes. If you're selling one or only a few items, you can insert them alone without embedding the whole catalog. Ecwid offers two ...

**EPROM Add-Only Memory Button | RS Components**  
[uk.rs-online.com](https://uk.rs-online.com) › Home › Semiconductors › Memory Chips  
 Products 1 - 7 of 7 - Shop our range of EPROM **Add-Only** Memory Button supplies & accessories. Free Next Day Delivery. Browse our latest EPROM **Add-Only** ...

Searches related to "add only"

[git add all modified files only](#)    [git add multiple files](#)  
[git add untracked files](#)    [undo git add](#)  
[git add all new files](#)    [git commit changes](#)  
[git commit all](#)    [git unadd](#)

Figure 44 Modifier Query 6: "add only"

GOOGLE "only change" Cristina

All Images Videos News Maps More Search tools

About 6,110,000 results (0.35 seconds)

**the only thing you can change :mnmlist**  
[mnmlist.com/small-changes/](http://mnmlist.com/small-changes/)  
 You can't change your entire life. You can **only change** your next action. —. You can't change a relationship with a loved one. You can **only change** your next ...

**The Only Thing You Can Really Change Is Yourself**  
[www.huffingtonpost.com/.../the-only-thing-you-can-re\\_b\\_5939608.htm...](http://www.huffingtonpost.com/.../the-only-thing-you-can-re_b_5939608.htm...)  
 Oct 7, 2014 - "You can't change other people; you can **only change yourself**" is one of those lessons I've had to learn over and over again. And then ...

**You Can Only Change Yourself | World of Psychology**  
[psychcentral.com/blog/archives/2008/.../you-can-only-change-yourself/](http://psychcentral.com/blog/archives/2008/.../you-can-only-change-yourself/)  
 Nov 14, 2008 - One of life's hardest lessons to learn is that you can **only change** yourself. ... Yet we don't think about it when we have an emotional reaction to someone else's behavior or words. ... We react and respond emotionally to emotional needs of our own, rather than in a logical, rational ...

**You can only change yourself — Depressed Optimism**  
[depressedoptimism.com/blog/2013/11/.../you-can-only-change-yourself/](http://depressedoptimism.com/blog/2013/11/.../you-can-only-change-yourself/)  
 Nov 17, 2013 - Most of what we think and do have a deeper emotional tie. Changing these emotional ties requires internal changes. If you consider how hard it ...

**AL JARREAU LYRICS - (If I Could Only) Change Your Mind**  
[www.azlyrics.com/lyrics/aljarreau/ificouldonlychangeyourmind.html](http://www.azlyrics.com/lyrics/aljarreau/ificouldonlychangeyourmind.html)  
 Lyrics to "(If I Could **Only**) Change Your Mind" song by AL JARREAU: So you say it's over - you turn and walk away And love is like a stranger Who is running out ...

**Only Change is Forever!**  
[joelchung.blogspot.com/](http://joelchung.blogspot.com/)  
 Sep 4, 2015 - Have seen 'Inside Out' and 'M15 – Rogue State' recently, Pixar produced a great one this time. The movie was entertaining though it didn't hit ...

**Above Only - Change lyrics | LyricsMode.com**  
[www.lyricsmode.com/lyrics/a/above\\_only/change.html](http://www.lyricsmode.com/lyrics/a/above_only/change.html)  
 New! Read & write lyrics explanations. Highlight lyrics and explain them to earn Karma points. Above **Only – Change** lyrics. Good intentions never get me too far

**Only change in Dallas mayor's Exxxotica stance is who's ...**  
[dallasmorningviewsblog.dallasnews.com/.../only-apparent-change-in-ma...](http://dallasmorningviewsblog.dallasnews.com/.../only-apparent-change-in-ma...)  
 Feb 8, 2016 - Opinion Blog. **Only change** in Dallas mayor's Exxxotica stance is who's pulling the strings. Mike Hashimoto Follow @MikeHashimoto Email ...

**Above Only - Change [HD] - YouTube**  
<https://www.youtube.com/watch?v=iH-SNK7rKDM>  
 Jan 12, 2014 - Uploaded by MontageRock  
 Oldie, love it though. Check out the artist's pages!  
 ▶ 4:02 <http://www.facebook.com/aoband> <http://www.myspace.com> ...

**Is change the only constant thing? - Quora**  
<https://www.quora.com/Is-change-the-only-constant-thing>  
 ... memories the 4d object seems like a moving 3d object. So what change in our worldview results from this? The **only change** is that everything is constant.

Searches related to "only change"

- [only change is constant](#)
- [above only change](#)
- [only change is permanent](#)

Figure 45 Modifier Query 7: "only change"

GOOGLE "change only" Cristina

All Images Videos News Maps More Search tools

About 2,590,000 results (0.30 seconds)


**"Change only the text size" greyed out - Microsoft Community**  
[answers.microsoft.com/.../change-only...c11c4344-ccba-4889-8f50-84e...](#)  
 Aug 4, 2013 - I want to change the text size only in windows 8. When I go to control panel/display the option to "Change only the text size" dialog boxes are greyed out. ... Verify if you are using the smaller display under change the size of all items and then try changing the "Change only the text ...  
 How to "change only the text size" permanently? 7 Mar 2015  
 Change the text size only is not working 2 Jun 2013  
 Change only ONE bullet type in a list 7 Jan 2012  
 More results from answers.microsoft.com

**Why is the "change only text size" greyed out? - Windows 10 ...**  
[www.tenforums.com/Windows-10-Forums/General-Discussion](#)  
 Aug 16, 2015 - I'm logged in an admin account and it's greyed out.... Click on "set a custom scaling level" and change it to say 125%. ... You should be able to change the Text Size.  
 Solved Change only text size greyed out. 28 Sep 2015  
 Title Bar Text Size - Change in Windows 10 25 Aug 2015  
 More results from www.tenforums.com

**angularjs - Change only one view on state change in ui ...**  
[stackoverflow.com/.../change-only-one-view-on-state-change-in-ui-route...](#)  
 Jun 11, 2014 - When the state changes, all the new state's views and those of any ancestor state will be loaded. So if you want view A to remain unchanged while ...

**jquery - How to change only text node in element - Stack ...**  
[stackoverflow.com/questions/.../how-to-change-only-text-node-in-eleme...](#)  
 Mar 31, 2012 - I have next html: <label for="user\_name"> <abbr ... If you use contents() method it will also return text nodes. Since jQuery doesn't have text node ...

Images for "change only" Report images



More images for "change only"

**The Science For Climate Change Only Feeds The Denial ...**  
[www.ifscience.com/.../science-climate-change-only-feeds-denial-how-d...](#)  
 The Science For Climate Change Only Feeds The Denial: How Do You Beat That?  
 January 29, 2016 | by John Cook. Photo credit: The frilly forms of corals and ...

**Change only the year component of a date in Microsoft ...**  
<https://www.youtube.com/watch?v=bqzaXlBUfZo>  
 Jul 9, 2013 - Uploaded by Tecexpertz  
 Change only the year component of a date in Microsoft Excel.  
 Tecexpertz. SubscribeSubscribedUnsubscribe ...

**how to change the font size in a plot (only for the axes ...**  
[www.mathworks.com/.../151945-how-to-change-the-font-size-in-a-plot...](#)  
 as you can see in the attached image i need to change only the size of the numbers not the title or the colorbar how can i do this? thank you ...

**Is it possible to change ONLY the Glass? - Samsung Galaxy ...**  
<https://www.ifixit.com/.../Is-it-possible-to-change-ONLY-the-Glass>

Hi, I'd like to know if it is possible to exchange the top glass of the Galaxy Nexus I9250. The screen on my device is working OK only the glass has cracked.

**Real change only happens when you want... - Coach Scott ...**  
<https://www.facebook.com/CoachScottAbel/posts/417484081596147>  
 Real change only happens when you want it - and want it a lot more than you fear it - and want it a lot more than you fear staying right where you are now - till ...

Figure 46 Modifier Query 8: "change only"

The screenshot shows a Google search interface with the query "only record" entered in the search bar. The search results are displayed below the search bar, showing various links and snippets related to the query. The results include:

- Index-only Record . Previous Posts (1695) . Getting Started ...**  
ancestryforums.custhelp.com/posts/4e2a5164dd -  
Jan 20, 2015 - Summary: What does this mean? Content: When I look up birth records I get an "index-only record" with no visibility to the record. What is this?
- Option to record ONLY game audio - Raptr Support**  
support.raptr.com/support/discussions/topics/5000050636 -  
Please add the ability to **only record** the game's audio. I often listen to music in the background, or watch TV / youtube / whatever in a browser on another monitor ...
- Here's the Only Record of Daniel Holtzclaw Left in ... - Jezebel**  
jezebel.com/heres-the-only-record-of-daniel-holtzclaw-left-in-the-o-175... -  
Feb 1, 2016 - Earlier this week, the Oklahoma Department of Corrections removed former cop and convicted rapist Daniel Holtzclaw from their online system. ... Holtzclaw isn't listed at all in the Oklahoma Department of Corrections inmate lookup. A record of him still exists of him, sort of, in one ...
- can only record the program I am watching? - Sky Community**  
helpforum.sky.com > Archive -  
Mar 1, 2014 - Solved: hello all, wondered if someone can help? I have sky plus hd but have noticed if I have a planned recording and I am watching something.  
Can **only record** program I'm watching, turning off ... - Page 2 ... 14 Jan 2016  
New sky plus box. How do you record a programme an... 13 Jan 2016  
Why will my Sky + HD box **only record** 1 program and... 9 Jan 2016  
Sky+ will **only record** the channel being watched 31 Jan 2014  
More results from helpforum.sky.com
- I can only record 1 second | Open Broadcaster Software**  
obsproject.com > ... > OBS Multiplatform Support > Windows Support -  
Nov 30, 2015 - 1 post - 1 author  
I **CAN ONLY RECORD** ! SECOND!!! PLZ HELP ASAP I want to record minecraft! It only records 1 second! LAST LOG FILE:...
- The Only Record Store in Mauritania | VICE | Canada**  
www.vice.com/en\_ca/video/the-only-record-store-in-mauritania -  
We passed through Nouakchott, Mauritania, while filming in Africa so we decided to stop in at the country's **only record** store, Saphir D'or. Turns out, it rules!
- Record Audio Only - Movavi**  
img.movavi.com/online-help/screencapturemad/.../record\_audio\_only.ht... -  
Movavi Screen Capture can help you not **only record** any screen activity, but it can also function as a sound recorder to record online music, radio broadcasts, ...
- The Only Record In The World - Discogs**  
www.discogs.com/ARTOnly-Band-In-The-...Only-Record.../2337992 -  
Rating: 3.8 - 4 votes  
Find a ART, The Only Band In The World - The **Only Record** In The World first pressing or reissue. Complete your ART, The Only Band In The World collection.
- Starting To Record Visitors · Hotjar**  
docs.hotjar.com/docs/starting-to-record-visitors -  
... our Recording User Input article for more information). **Only record** sessions with click and scroll activity. **Only record** sessions that are longer than 30 seconds.
- Recording Notes / Scores - Image-Line**  
https://www.image-line.com/support/FLHelp/html/recording\_scores.htm -  
You can **only record** into one pattern at a time. NOTE: You have the following two options as to how to record your MIDI data: In Pattern mode - MIDI data will be ...

Figure 47 Modifier Query 9: "only record"



GOOGLE "record only" Cristina

All Videos Images News Maps More Search tools

About 534,000 results (0.39 seconds)

**To Record Only Water for Ten Days - Wikipedia, the free ...**  
[https://en.wikipedia.org/wiki/To\\_Record\\_Only\\_Water\\_for\\_Ten\\_Days](https://en.wikipedia.org/wiki/To_Record_Only_Water_for_Ten_Days)  
 To **Record Only** Water for Ten Days is the third solo album by American musician John Frusciante, released in 2001 through Warner Music Group. Unlike his ...  
**Recorded:** 2000 **Producer:** John Frusciante  
**Released:** February 13, 2001 **Length:** 42:20

**John Frusciante - To Record Only Water For Ten ... - YouTube**  
<https://www.youtube.com/watch?v=igE2iriAM8I>  
 May 8, 2013 - Uploaded by JohnFrusciantetv  
 2001 Warner Bros. Records "To **Record Only** Water For Ten Days" by John Frusciante, available now. Track ...

**Murderers - To Record only Water for Ten Days - John ...**  
<https://www.youtube.com/watch?v=wfeNtA5ptuo>  
 Feb 7, 2012 - Uploaded by Guillermo Sufgráfiez Pérez  
 "Murderers" instrumental del disco "To **Record only** Water for Ten Days" de John Frusciante (2001)

**To Record Only Water for Ten Days - John Frusciante ...**  
[www.allmusic.com/.../to-record-only-water-for-ten-days-mw00011757...](http://www.allmusic.com/.../to-record-only-water-for-ten-days-mw00011757...)  
 Rating: 8/10 - Review by Melissa Giannini  
 With the opening kick of a simple but loud drum machine beat and multiple full-throttle guitar wails over the top, it quickly becomes apparent that John Frusciante has also given a swift kick to his heroin addiction. ... To **Record Only** Water for Ten Days, however, is made up of 15 ...

**Reviews for To Record Only Water For Ten Days by John ...**  
[www.metacritic.com/music/to-record-only-water-for-.../john-frusciante](http://www.metacritic.com/music/to-record-only-water-for-.../john-frusciante)  
 Rating: 66% - 6 reviews  
 Metacritic Music Reviews, To **Record Only** Water For Ten Days by John Frusciante, The third solo release from former Red Hot Chili Peppers guitarist John ...

**Camtasia (Windows): Record only audio – TechSmith Support**  
<https://support.techsmith.com/.../203728588-Camtasia-Windows-Record-...>  
 Jan 20, 2015 - Camtasia Studio 5 and Earlier To record audio without any video, use Camtasia Audio Editor in Camtasia Studio 5 and earlier. This...

**Camtasia To Record Only My Webcam - 0 - TechSmith**  
<https://feedback.techsmith.com/.../camtasia-to-record-only-my-webcam>  
 Mar 24, 2015 - Camtasia To **Record Only** My Webcam. Question; Updated 3 months ago. 4. Me Too. 10. Follow. Unfollow. Problem with camtasia recording my ...

**John Frusciante - To Record Only Water For Ten Days at ...**  
[www.discogs.com/John-Frusciante-To-Record-Only-Water-For-.../9322](http://www.discogs.com/John-Frusciante-To-Record-Only-Water-For-.../9322)  
 Rating: 4.3 - 79 votes  
 Find a John Frusciante - To **Record Only** Water For Ten Days first pressing or reissue. Complete your John Frusciante collection. Shop Vinyl and CDs.

**NME Reviews - John Frusciante : To Record Only Water For ...**  
[www.nme.com/reviews/artist/Keyname/4042](http://www.nme.com/reviews/artist/Keyname/4042)  
 John Frusciante : To **Record Only** Water For Ten Days. Thankfully not the sound of a dripping tap... Share Tweet Share Share. 12th September 2005. Thankfully ...

**JOHN FRUSCIANTE - To Record Only Water for Ten Days ...**  
[www.amazon.com](http://www.amazon.com) > Music > Alternative Rock > Indie & Lo-Fi > Lo-Fi  
 Rating: 4.5 - 102 reviews  
 JOHN FRUSCIANTE - To **Record Only** Water for Ten Days - Amazon.com Music.

Figure 48 Modifier Query 10: "record only"

## A.2 Plural Usage Frequency Examples

The use of a singular subject is indicative of people's awareness of plural ambiguity. The study reveals that overall, for each of the 5 verb forms studied, people write plural rather than singular when talking about what each member of a set does, supporting the assumption that plural quantifiers are commonly used when the intended interpretation is distributive warranting the use of a singular quantifier use instead.

Query 1, all support, shows that the quantifier all is used with the plural verb support 5,560,000 times. See Figure 49. Query 2, each supports, shows that the quantifier each is used with the singular verb supports only 214,000 times. See Figure 50.

Thus, all support occurs 26 times more frequently than each supports.

Query 3, all request, shows that the quantifier all is used with the plural verb request 498,000 times. See Figure 51. Query 4, each requests, shows that the quantifier each is used with the singular verb requests only 16,500 times. See Figure 52. Thus, all request occurs 30.2 times more frequently than each requests.

Query 5, all impact, shows that the quantifier all is used with the plural verb impact 462,000 times. See Figure 53. Query 6, each impacts, shows that the quantifier each is used with the singular verb impacts only 13,400 times. See Figure 54. Thus, all impact occurs 34.5 times more frequently than each impacts.

Query 7, all identify, shows that the quantifier all is used with the plural verb identify 183,000 times. See Figure 55. Query 8, each identifies, shows that the quantifier each is used with the singular verb identifies only 29,400 times. See Figure 56. Thus, all identify occurs 6.2 times more frequently than each identifies.

Query 9, all approve, shows that the quantifier all is used with the plural verb approve 95,100 times. See Figure 57. Query 10, each approves, shows that the quantifier each is used with the singular verb approves only 1,340 times. See Figure 58. Thus, all approve occurs 71 times more frequently than each approves.

The screenshot shows a Google search results page for the query "all support". The search bar at the top contains the text "all support" and the user's name "Cristina" is visible on the right. Below the search bar, there are navigation tabs for "All", "Images", "Videos", "News", "Maps", and "More", along with a "Search tools" button. The search results are displayed below, starting with "About 5,560,000 results (0.46 seconds)".

The first result is "All Support Team - League of Legends Community" with a link to a forum thread. The second result is a YouTube video titled "League of Legends - Trolling - All Support Team (WIN ...)". The third result is "Acute Lymphocytic Leukemia (ALL) Support Group ...". The fourth result is "ALL SUPPORT SERVICE INC | LinkedIn". The fifth result is "Support | Dell US". The sixth result is "HP Customer Support for Desktops & All-in-One PCs | HP ...". The seventh result is "All Support Groups Posts | Support Groups". The eighth result is "Support | One For All | Global". The ninth result is "Support | Dell Canada". The tenth result is "Xbox support".

At the bottom of the search results, there is a section titled "Searches related to 'all support'" with a grid of related search terms: support lenovo, support apple, support oracle, support asus, support dell, support mmbb, support hp, and support sap.

Figure 49 Plural Query 1: "all support"

The screenshot shows a Google search results page for the query "each support". The search bar at the top contains the text "each support" and the user's name "Cristina" is visible on the right. Below the search bar, there are tabs for "All", "Images", "News", "Videos", "Maps", "More", and "Search tools". The search results are listed below, starting with "Each Support Analyst Jobs | Indeed.com" and "Each Support Agent Jobs | Indeed.com". There are also several physics-related results, including "How much upward force does support 1 and support 2 exert o...", "Solution Hw2 - Mechanical and Mechatronics Engineering", "Physics 2514 Lecture 37 - University of Oklahoma", "Is there a reference site to see what each support does? - J ...", "How many heart points does each support level require ...", and "No search on each support forum is counter intuitive". At the bottom of the page, there is a pagination bar with numbers 1 through 10 and a "Next" button.

Figure 50 Plural Query 2: "each supports"

GOOGLE "all request" Cristina

All Images Videos News Maps More Search tools


About 499,000 results (0.45 seconds)

**All Request - Wikipedia, the free encyclopedia**  
[https://en.wikipedia.org/wiki/All\\_Request](https://en.wikipedia.org/wiki/All_Request)  
The introduction to The Carpenters' version of Calling Occupants of Interplanetary Craft features a fictional dialogue between the disc jockey of an **all request** ...

**All Request Lunch - OZFM**  
[ozfm.com/allrequestlunch/](http://ozfm.com/allrequestlunch/)  
Join Stephanie O'Brien every weekday from 12-2pm for the **All Request Lunch!** It's two hours of nothing but the songs you want to hear, so tell her what to play!

**All Request Weekend - OZFM**  
[ozfm.com/allrequestweekend/](http://ozfm.com/allrequestweekend/)  
Your weekend just got a whole lot better! Tell us what to play all weekend long with OZFM's **All Request Weekend**, brought to you by Metrobus! Hosted by Hugh ...

Images for "all request" Report images



More images for "all request"

**Request a song**  
[www.boom973.com/requests.aspx](http://www.boom973.com/requests.aspx)  
Boombx **All Request Lunch**. Is there a certain song that you just can get out of your head and need a little help with? Do you just need something to crank up ...

**104.5 CHUM FM – Toronto :: All Request Power Lunch**  
[www.chumfm.com/AllRequestPowerLunch.aspx](http://www.chumfm.com/AllRequestPowerLunch.aspx)  
It's all new! And the music is up to you! Every weekday from noon to 1, Ingrid Schumacher plays your requests. Whether it's a back in the day classic, a brand ...

**All Request Live: Ween: Amazon.ca: Music**  
[www.amazon.ca](http://www.amazon.ca) > ... > Live Albums > Hardcore & Punk  
Ween and their touring band, recorded live in the studio, doing songs requested by their fans. "**All Request Live**" was recorded in 2003 and features tracks from ...

**Virgin Radio 96 :: All Request Lunch**  
[montreal.virginradio.ca/Shows/AllRequestLunch.aspx](http://montreal.virginradio.ca/Shows/AllRequestLunch.aspx)  
Dec 15, 2015 - It's Virgin Radio's **All Request Lunch!** Send us your song requests by using the form below, by texting them to 99999 or by using the #VirginARL ...

**Live 88.5 FM|All Request Fridays**  
[www.live885.com/inside.asp?mn=8&id=12&cc=13](http://www.live885.com/inside.asp?mn=8&id=12&cc=13)  
Every Friday afternoon, Jen Traplin takes you into the weekend with her **All Request** Friday show. From 2:00pm-6:00pm, listeners can call in their requests for ...

**All Request Saturday Night | 101.5 The Wolf**  
[www.thewolf.ca/all-request-saturday-night/](http://www.thewolf.ca/all-request-saturday-night/)  
Send a Request via Email Your Name:Your Email:Artist Na ...

Searches related to "all request"  
[request npm](#) [request php](#)

Figure 51 Plural Query 3: "all request"

GOOGLE "each requests" Cristina

All Images Videos News Maps More Search tools

About 15,600 results (0.55 seconds)

[How to insert delay between each requests in Jmeter - Stack ...](#)  
 stackoverflow.com/questions/22009999/...each-requests-in.../22010760  
 Feb 25, 2014 - Create a transaction controller in Thread group; put all your http requests under this transaction controller; add constant timer (with value as 2 ...

[load - Scheduling each requests in a jmeter threadgroup ...](#)  
 stackoverflow.com/...scheduling-each-requests-in-a-jmeter-threadgroup  
 Jun 12, 2015 - You can run the thread group at specific time. Once the thread group is started, you can use only timers to delay the requests inside the thread group.

[Connections not released after each requests ? · Issue #50 ...](#)  
 https://github.com/davidmoten/rxjava-jdbc/issues/50  
 Dec 11, 2015 - rxjava-jdbc - Efficient execution and functional composition of database calls using jdbc and rx-java Observables.

[Computational Logistics: Second International Conference, ...](#)  
 https://books.google.ca/books?isbn=3642242642  
 Jürgen W. Bose, Hao Hu, Carlos Jahn - 2011 - Computers  
 ... of different vehicles can be linked by OR, since they are independent of each other (provided the auctioneer ensures that **each requests** is just assigned once).

[FAQ - Plex Requests](#)  
 plexrequests.8bits.ca/faq/  
 ... ease of entry. A local token is also saved for future visits. Administrators can see who has submitted **each requests**, while users are not shown this information.

[XML and Web Technologies for Data Sciences with R](#)  
 https://books.google.ca/books?isbn=1461479002  
 Deborah Nolan, Duncan Temple Lang - 2013 - Computers  
 The Web server stores information about the user and **each requests** he or she makes. It then uses the cookie to retrieve this information for each request and ...

[The Code of Federal Regulations of the United States of ...](#)  
 https://books.google.ca/books?id=xDA6AAAIAAJ  
 1966 - Administrative law  
 (c) **Each requests** shall contain a description of the record requested which is sufficiently specific with respect to names, dates, subject matter, and location, ...

[Creating multiple or weekly requests - Exact Software](#)  
 www.exactsoftware.com/docs/DocView.aspx?DocumentID...4153...  
 Creating multiple or weekly requests. Menu paths. Workflow à Entry à Requests à Requests: New; Click Create in the left menu or toolbar, and then select ...

[net-snmp / Mailing Lists - SourceForge](#)  
 sourceforge.net › Browse › net-snmp  
 Currently I am using > > the asynchronous calls in which i open the session using snmp\_sess\_op= en > for **each requests** and do a book keeping for this open ...

[\[PDF\] Guidelines for Donation Requests For Watkins Glen ...](#)  
 https://www.theglen.com/.../FC5B26042FC54149B84E6116A8C24C0Fa...  
 very hard to review **each requests** individually and are happy to be able to support a variety of regional organizations. All requests can be mailed to Watkins ...

1 2 3 4 5 6 7 8 9 10 Next

Figure 52 Plural Query 4: "each requests"

GOOGLE "All impact" Cristina

[All](#) [News](#) [Images](#) [Videos](#) [Maps](#) [More](#) [Search tools](#)

About 467,000 results (0.58 seconds)

**Important message to all Impact supporters | Montreal Impact**  
[www.impactmontreal.com/en/.../important-message-all-impact-supporter...](http://www.impactmontreal.com/en/.../important-message-all-impact-supporter...)  
 Important message to **all Impact** supporters. April 22, 2015 12:43 AM EDT. Next. For anyone who is currently in Mexico to attend the first leg match against Club ...

**show install all - NX-OS CLI Navigator**  
[www.cisco.com/web/techdoc/dc/reference/cli/.../show\\_install\\_all.html](http://www.cisco.com/web/techdoc/dc/reference/cli/.../show_install_all.html)  
 switch# show install **all impact**. This example shows how to display the status of the software installation process: switch# show install all status. There is an ...

**Montreal Impact - Wikipedia, the free encyclopedia**  
[https://en.wikipedia.org/wiki/Montreal\\_Impact](https://en.wikipedia.org/wiki/Montreal_Impact)  
 TVA Sports serves as the official French-language broadcaster of **all Impact** games not broadcast as a part of MLS' contract with the TSN family of networks ...

**How Do We Make Health Care Accessible For All? - Impact ...**  
[www.dal.ca](http://www.dal.ca) > ... > Events > NTE Events Archive > 2015 > March 2015  
 Mar 24, 2015 - NTE Impact Ethics together with the Canadian Centre for Policy Alternatives-Nova Scotia presents a keynote address and an interactive panel ...

**All Impact Evaluations | Global Environment Facility**  
<https://www.thegef.org/gef/Impact%20Evaluations>  
 AIR 2013. Annual Impact Report 2013. The seventh annual impact report (AIR) presents the findings and recommendations of the Climate Change Mitigation ...

**Impact Personnel Services Home**  
[www.impactpersonnel.ca/](http://www.impactpersonnel.ca/)  
**All Impact** temps are regularly monitored while on assignment. An associate from our agency will visit the work facility periodically to ensure 100% customer ...

**Do-All Impact Seal Reactive Targets - YouTube**  
<https://www.youtube.com/watch?v=qbi4itSmhlg>  
 Nov 10, 2012 - Uploaded by bgallaher77  
 Four reactive targets from Do All Outdoors. These were pretty fun. Overall I give them a 4 of 5 stars. Shooting ...

**All Impact Films - Facebook**  
<https://www.facebook.com/allimpactfilms/>  
**All Impact** Films, Troy, MO. 44 likes · 2 were here. Facebook home of **All Impact** Films, Phoenix Garden Studios and AI 360 Publishing. websites coming soon...

**877-941-8635 - All Inventory | Meridian RV**  
[www.meridianrv.com/default.asp?page=xAllInventory&brand=impact](http://www.meridianrv.com/default.asp?page=xAllInventory&brand=impact)  
 Our exclusive king bed "Glide-A-Bed" system is available in **all Impact** fifth wheels.... Learn More... Stock:4417. Colour:CLAY. Location:100 Mile House.

**Do-All Impact Seal Deer Crossing Sign Target | Cabela's ...**  
[www.cabelas.ca/product/.../do-all-impact-seal-deer-crossing-sign-target](http://www.cabelas.ca/product/.../do-all-impact-seal-deer-crossing-sign-target)  
 Do-**All Impact** Seal Deer Crossing Sign Target. This over-sized, unique target allows shooters to legally shoot at the classic deer crossing road sign. Designed ...

Searches related to "All impact"

- [impact thesaurus](#) [impact 2015](#)
- [impact magazine](#) [impact test](#)
- [impact wrestling](#) [impact mma](#)
- [impact radio](#) [impact movie](#)

Figure 53 Plural Query 5: "all impact"



GOOGLE "each impacts" Cristina

All Images News Videos Maps More Search tools

About 13,500 results (0.41 seconds)

**The Differences Between Online, Offline Leads ... - Visual.ly**  
[visual.ly/differences-between-online-offline-leads-and-how-each-impacts-...](http://visual.ly/differences-between-online-offline-leads-and-how-each-impacts-...)  
 Nov 16, 2013 - The Differences Between Online, Offline Leads and How **Each Impacts** Lead Conversions Infographic. Embed this visual. 0 Comments. Sort by.

**9 Types of Reviews on TripAdvisor – and How Each Impacts ...**  
[www.reviewtrackers.com/9-types-reviews-tripadvisor-impacts-business-r-...](http://www.reviewtrackers.com/9-types-reviews-tripadvisor-impacts-business-r-...)  
 Feb 4, 2015 - 9 Types of Reviews on TripAdvisor – and How **Each Impacts** Your Business Reputation. By Migs Bassig on February 4, 2015.

**Ethanol vs. Gasoline: How Each Impacts the Environment ...**  
[www.go60.com/articles/ethanol/ethanol\\_vs\\_gasoline.html](http://www.go60.com/articles/ethanol/ethanol_vs_gasoline.html)  
 One of the greatest debates concerning the future of energy use surrounds the differences between ethanol vs. gasoline. Each of these fuel substances is ...

**b. briefly explain how each impacts treatment decisions. c ...**  
[www.coursehero.com/mississippi-state/ce/ce-8833](http://www.coursehero.com/mississippi-state/ce/ce-8833)  
 b. briefly explain how **each impacts** treatment decisions. c. briefly define any impacts the sludge treatment system can have on the "source" system generating ...

**8833-1 - approach. b. Briefly explain how each impacts ...**  
[www.coursehero.com/mississippi-state/ce/ce-8833](http://www.coursehero.com/mississippi-state/ce/ce-8833)  
 View Class Note - 8833-1 from CE 8833 at Mississippi State. approach. b. Briefly explain how **each impacts** treatment decisions. c. Briefly define any.

**Accidental Injury: Biomechanics and Prevention**  
<https://books.google.ca/books?isbn=1475722648>  
 Alan M. Nahum, John W. Melvin - 2013 - Medical  
 This plate was actually made from eight small load cells 5 cm by 1.2 cm **each. Impacts** with the flat disk were to the temporoparietal region, while the rectangular ...

**Impacts in Mechanical Systems: Analysis and Modelling**  
<https://books.google.ca/books?isbn=354067523X>  
 Bernard Brogliato - 2000 - Science  
 We shall suggest in Sect. 3.3 that (i) the solution include only a finite number of impacts (2.8) per period; (ii) **each impacts** is non-degenerate, i.e. if  $f_j(t)=0$ , then ...

**Knowledge Systems of Societies for Adaptation and ...**  
<https://books.google.ca/books?isbn=3642361439>  
 Sunil Nautiyal, K.S. Rao, Harald Kaechele - 2013 - Science  
 Biodiversity and climate change are closely linked and **each impacts** upon the other. Sustained biodiversity resources can reduce the impacts of climate change ...

**FECA vs. opensecrets.org and how each impacts the ability ...**  
<https://politicalxu.wordpress.com/.../fece-vs-opensecrets-org-and-how-ea-...>  
 Dec 1, 2015 - FECA vs. opensecrets.org and how **each impacts** the ability to organize. It is true: the Federal government has provided American citizens (who ...

**The Differences Between Online, Offline Leads and How ...**  
<https://iammoulde.wordpress.com/.../the-differences-between-online-off-...>  
 Dec 29, 2014 - The Differences Between Online, Offline Leads and How **Each Impacts** Lead Conversions. Standard. In today's sales environment, leads ...

1 2 3 4 5 6 7 8 9 10 Next

Figure 54 Plural Query 6: "each impacts"

The screenshot shows a Google search results page for the query "all identify". At the top, the Google logo is on the left, the search bar contains "all identify", and the user's name "Cristina" is on the right. Below the search bar are navigation tabs for "All", "Images", "Videos", "News", "Maps", "More", and "Search tools". The search results indicate "About 183,000 results (0.43 seconds)".

The first result is titled "14 Expectation Vs. Reality Photos We Can All Identify With" from [www.awesomeinventions.com/expectation-vs-reality-we-all-identify/](http://www.awesomeinventions.com/expectation-vs-reality-we-all-identify/). The snippet reads: "14 Expectation Vs. Reality Photos We Can All Identify With. We all like to make a good impression, and to look good no matter the occasion. However, life ...".

The second result is titled "14 Common Truths We Can All Identify With" from [www.awesomeinventions.com/common-truths/](http://www.awesomeinventions.com/common-truths/). The snippet reads: "14 Common Truths We Can All Identify With. Life experience is different for everyone however there are a few all-encompassing common truths that we all go ...".

Below these results is an "Images for 'all identify'" section with a "Report images" link. It displays a grid of various images, including people, animals, and objects.

Further down, there are several text-based results:

- "We Can All Identify With This Woman's Raunchy Letter To ..." from [dply.com/love-eat/article/raunchy-letter-to-adele](http://dply.com/love-eat/article/raunchy-letter-to-adele). Snippet: "Everyone knows what it feels like to be in the middle of a breakup where all you can do is blast your favorite song and belt it at the top of your lungs. I once broke ...".
- "9 Cat Personalities We All Identify with ... -> Lifestyle" from [lifestyle.allwomenstalk.com/cat-personalities-we-all-identify-with/](http://lifestyle.allwomenstalk.com/cat-personalities-we-all-identify-with/). Snippet: "They say that dog is man's best friend, but the wide spectrum of cat personalities is something we can all relate to. Dogs tend to be very similar when it comes to ...".
- "All Identify Trivia Quizzes and Games - Sporcle" from [www.sporcle.com/games/tags/identify](http://www.sporcle.com/games/tags/identify). Snippet: "Free online identify trivia quizzes. Learn and test your identify knowledge."
- "Do y'all identify with Bayonetta? - GameFAQs" from [www.gamefaqs.com/boards/683293-bayonetta-2/70549096](http://www.gamefaqs.com/boards/683293-bayonetta-2/70549096). Snippet: "Ya know, that stuff. I want to do a social experiment as well. To see the extent Bayonetta really is objectified by the players. If players identify with whom they are ...".
- "We can all identify with these 13 pictures of babies eating cake" from [www.thesun.co.uk/.../We-can-all-identify-with-these-13-pictures-of-babies-...](http://www.thesun.co.uk/.../We-can-all-identify-with-these-13-pictures-of-babies-...). Snippet: "EVERYONE loves a cake, no matter how old you are, we all enjoy a spongy slice of deliciousness. But sadly, over the years, the more cakes you see the less ...".
- "Got a new shirt, can you all identify some of the equations ..." from [https://www.reddit.com/.../got\\_a\\_new\\_shirt\\_can\\_you\\_all\\_identify\\_some...](https://www.reddit.com/.../got_a_new_shirt_can_you_all_identify_some...). Snippet: "Dec 28, 2015 - Image PostGot a new shirt, can you all identify some of the equations for me? Thanks 10/6 (i.imgur.com). submitted 1 day ago by ...".
- "all identify eng sub - YouTube" from <https://www.youtube.com/playlist?list...>. Snippet: "all identify eng sub. by MarPle\_Y; 96 videos; No views; Last updated on Nov 12, 2015. Play all. Share. Loading... Save ...".

At the bottom, there is a "Searches related to 'all identify'" section with links for "identify photos of friends (hourly limit exceeded)" and "identify mac".

Figure 55 Plural Query 7: "all identify"

The screenshot shows a Google search results page for the query "each identify". The search bar at the top contains the text "each identify" and the name "Cristina" is visible on the right. Below the search bar are navigation tabs for "All", "Images", "Videos", "News", "Maps", and "More". The search results are listed below, with the first result being "javascript - jQuery .each() - Identify last item - Stack Overflow". Other results include "Age Discrimination Litigation - Page 4-47 - Google Books Result", "Identify Audit Services", "Physician groups each identify five of their own ... - BMJ", "Textbook of Basic Nursing - Page 922 - Google Books Result", "Problem: 1. (4 Points Each) Identify FIVE Different ... | Chegg ...", "IDENTIFY statement - IBM", "1. (5 marks - 1 mark each) Identify each variable as ...", "Key Multiple Choice (5 pts each) Identify the choice that b...", and "Physician groups each identify five of their own ...". At the bottom of the search results, there is a pagination bar with numbers 1 through 10 and a "Next" button.

Figure 56 Plural Query 8: "each identifies"

GOOGLE "all approve" Cristina

All Images Videos News Maps More Search tools

About 96,600 results (0.41 seconds)

Did you mean: "all approved"

Vladimir Putin on Twitter: "Either you all approve of me or 49 ...  
<https://twitter.com/darthputinkgb/status/694163151353413632>  
 Feb 1, 2016 - Either you **all approve** of me or 49% of you wish an all expenses paid trip to Siberia. pic.twitter.com/Yl9fIbe7Hd. Embedded image permalink.

Hardware Canucks on Twitter: "We all approve of this ...  
<https://twitter.com/hardwarecanucks/status/696457992229752836>  
 Feb 7, 2016 - Hardware Canucks Retweeted Jonathan Morrison. We **all approve** of this message! <https://twitter.com/1tdtoday/status/696416338621804544> ...

Courtesy lights came in, hope you all approve : pokemon  
[https://www.reddit.com/.../courtesy\\_lights\\_came\\_in\\_hope\\_you\\_all\\_appr...](https://www.reddit.com/.../courtesy_lights_came_in_hope_you_all_appr...)  
 Dec 19, 2015 - 2842. 2843. Courtesy lights came in, hope you **all approve** (i.imgur.com). submitted 1 month ago by nomadd917 · 93 comments; share. loading.

All Approve Trivia Quizzes and Games - Sporcle  
[www.sporcle.com/games/tags/approve](http://www.sporcle.com/games/tags/approve)  
 Free online Approve trivia quizzes. Learn and test your Approve knowledge.

We all approve it - 9GAG  
[9gag.com/gag/3524061/we-all-approve-it](http://9gag.com/gag/3524061/we-all-approve-it)  
 We **all approve** it - 9GAG has the best funny pics, GIFs, videos, memes, cute, wtf, geeky, cosplay photos on the web. We are your best source of happiness and ...

All approve - English - Italian Translation and Examples  
[mymemory.translated.net/en/English/Italian/all-approve](http://mymemory.translated.net/en/English/Italian/all-approve)  
**All approve**, Approvazione unanime, English, Italian, Translation, human translation, automatic translation.

Why we should all approve of assisted suicide ...  
[knuckledraggin.com/.../why-we-should-all-approve-of-assisted-suicide/](http://knuckledraggin.com/.../why-we-should-all-approve-of-assisted-suicide/)  
 Why we should **all approve** of assisted suicide. Posted on 02/08/2016 by Wirecutter. 84913331. Steal this: Share · Pinterest · Facebook · Google · Tumblr · Reddit ...

Nic Cassel - Did y'all approve of all that cop block crap?  
<https://www.facebook.com/WrightStateUniversity/.../101533229648827...>  
 Did y'all **approve** of all that cop block crap? ... October 21, 2015 · Fairborn, OH · Did y'all **approve** of all that cop block crap? 1 Comment · LikeCommentShare ...

Works: Collated with all the former editions, and ...  
<https://books.google.ca/books?id=hZDuAAAAMAAJ>  
 Ben Jonson - 1756  
 Yes, gentle /Eglamour, we **all approve**. And come to gratulate your just revenge : Which, since it is so perfect, we now hope You'll leave all care thereof, and mix ...

Aerie: Book Four of the Dragon Jousters - Google Books Result  
<https://books.google.ca/books?isbn=1101118156>  
 Mercedes Lackey - 2007 - Fiction  
 Letis did not at **all approve** of looking above one's self for a mate; she did not at **all approve** of what she called the "presumption" of the "jumped up." She had ...

Searches related to "all approve"  
 approve in sentence approval letter  
 approve deutsch approve antonym

Figure 57 Plural Query 9: "all approve"

GOOGLE "each approves" Cristina

All Images News Videos Maps More Search tools

About 1,350 results (0.43 seconds)

**Social Action: A Teleological Account - Page 137 - Google Bo...**  
<https://books.google.ca/books?isbn=0521788862>  
 Seumas Miller - 2001 - Philosophy  
 In this revised scenario **each approves** of his own conformity to the norm. However, no one else is aware of this. So the attitude of each to his own conformity is ...

**The Eudemian Ethics on the Voluntary, Friendship, and ...**  
<https://books.google.ca/books?isbn=9004225366>  
 Fiona Leigh - 2012 - Philosophy  
 And so too in the interpersonal case, at least where the friends are good: **each approves** of the other's attitudes and actions, and so is pleased by the other's ...

**Ethics of the Future - Page 211 - Google Books Result**  
<https://books.google.ca/books?id=sTEXAAAAAYAAJ>  
 William Henry Whinfield - 1876 - Ethics  
 And observe particularly, — it is the very gist of the business, — he will point out how **each approves**, or disapproves itself to the instinctive sense ; how each is ...

**The Life and Poetical Works of the Rev. George Crabbe**  
<https://books.google.ca/books?id=ChwtAAAAAYAAJ>  
 George Crabbe - 1847  
 Hear frequent sermons on fraternal love ; Nay, **each approves**, and answers — " Very true ! " Brother would heed it, were he not a Jew." II. P. — Read I aught ...

**[PDF] Satisfaction Approval Voting**  
[www2.eco.uva.es/presad/SSEAC/.../Tilburg09-Brams-Kilgour.pdf](http://www2.eco.uva.es/presad/SSEAC/.../Tilburg09-Brams-Kilgour.pdf)  
 by SJ Brams - Cited by 16 - Related articles  
 By contrast (a, e) gives some representation to all 12 voters—**each approves** at least one of its candidates— though it does not maximize total voter satisfaction.

**Agreement between subject and verb - English-test.net**  
[www.english-test.net/forum/ftopic24220.html](http://www.english-test.net/forum/ftopic24220.html)  
 Apr 22, 2008 - 15 posts - 6 authors  
 (**each APPROVES**) Every day there (be) more than a dozen traffic accidents in the city. (are ACCIDENTS) The imagery, diction, and syntax of ...

**Harry Graham's Poem: The Gourmand - Read book online**  
[www.readbookonline.net](http://www.readbookonline.net) > ... > Browse all available works of Harry Graham  
 Yet **each approves** the things he loves, From caviar to pork, Some guzzle cheese or new-grown peas, Like a cormorant or stork; The poor man's wife employs a ...

**[PDF] Center for Game Theory at Stony Brook**  
[www.gtcenter.org/Archive/2010/Conf/Brams991.pdf](http://www.gtcenter.org/Archive/2010/Conf/Brams991.pdf)  
 by SJ Brams - Cited by 16 - Related articles  
 voters—**each approves** at least one of the winners—but it does not maximize total voter satisfaction. SAV usually represents at least as many, and often more ...

**GOV Exam 2 - Congress flashcards | Quizlet**  
<https://quizlet.com/15271660/gov-exam-2-congress-flash-cards/>  
 ... chamber for vote) • President o Approved - law o Veto • Goes back to each chamber • If **each approves** it by two-thirds, the veto is overridden • Becomes a law.

**Multiple Approvals Needed - PerfectForms**  
[www.perfectforms.com/forum/topic/multiple-approvals-needed/](http://www.perfectforms.com/forum/topic/multiple-approvals-needed/)  
 Apr 16, 2012 - After **each approves** it goes to the Director (four directors) stage. The question I have now relates to escalation. If one of the managers is out ...

Figure 58 Plural Query 10: "each approves"

## APPENDIX B

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# USAGE FREQUENCY STUDY II

A usage frequency study was conducted with various usage queries using the Brigham Young University Wikipedia Corpus. This corpus contains the full text of Wikipedia with more than 4.4 million articles totalling 1.9 billion words. This usage study uses the corpus to identify collocation usage frequencies.

A list of queries to assess different modifier placements was created by pairing the modifier only with each of the five most commonly used verb forms, which are listed below. The modifier only is the most frequently used modifier and the only modifier

to cause ambiguity in the three RSs. For this reason, only is the modifier chosen to conduct the usage frequency queries for modifiers.

A list of the five verbs that are the most commonly used with the modifier only in the RSs was created. These verbs were identified using word frequency counts, using the three RSs as input data. The five verbs identified are: be, add, change, send, and record.

A list of queries to assess different plural usages was created by pairing each of the quantifiers each and all with each of the five most commonly used verb forms, which are listed below. These quantifiers were chosen for the plural queries because they can demonstrate examples of the usage of plural quantifiers when the intended interpretation is distributive.

A list of the five verbs that are the most commonly used with the quantifiers all and each in the RSs is created in a similar manner, using word frequency counts, and the three RSs as input data. The five verbs identified are: identify, support, approve, impact, and request.

## B.1 Modifier Placement Usage Frequency Examples

Modifier placement is indicative of people's awareness of modifier ambiguity. The study reveals that overall, for each of the 5 verb forms studied, the modifier *only* is placed before the main verb 28,483 times and is placed after the main verb 3,671 times. Thus, *only* is placed before a verb 7.8 times more often than after a verb, supporting the assumption that before the main verb is the placement used frequently.

Table 12 shows the results of the queries with **only**. Query 1, *only be*, shows that the modifier *only* is placed before the main verb 27,008 times. Query 2, *be only*, shows that *only* is placed after the main verb only 3,058 times. Thus, *only be* occurs 8.8 times more frequently than *be only*.

Table 12. Usage Frequency of Modifier Queries

Query Number	Query	Usage Frequency
1	only be	27,008
2	be only	3,058
3	only send	140
4	send only	104
5	only add	294
6	add only	58
7	only change	618
8	change only	156
9	only record	423
10	record only	295



Query 3, *only send*, shows that the modifier *only* is placed before the main verb 140 times. Query 4, *send only*, shows that *only* is placed after the main verb only 104 times. Thus, *only send* occurs 1.3 times more frequently than *send only*.

Query 5, *only add*, shows that the modifier *only* is placed before the main verb 294 times. Query 6, *add only*, shows that *only* is placed after the main verb only 58 times. Thus, *only add* occurs 5.1 times more frequently than *add only*.

Query 7, *only change*, shows that the modifier *only* is placed before the main verb 618 times. Query 8, *change only*, shows that *only* is placed after the main verb only 156 times. Thus, *only change* occurs 4 times more frequently than *change only*.

Query 9, *only record*, shows that the modifier *only* is placed before the main verb 423 times. Query 10, *record only*, shows that *only* is placed after the main verb only 295 times. Thus, *only record* occurs 1.4 times more frequently than *record only*.

As noted at the end of Appendix A, the verb **be** is a highly irregular verb and it seems to have an idiomatic use with the modifier **only**. With **be** and **been** there is a preference for placement before the verb form 7.6 times more often than after the verb form. With the other six forms of **be** (**being, am, is, are, was, and were**) there is a preference for placement after the form 17.3 times more often than before the verb form. The difference could be because of **be**'s usage as an auxiliary verb more often

than is the case with other verbs. The queries include when each of the verb forms is either a main verb or an auxiliary verb. When the verb form **am, is, are, was,** or **were** is used as an auxiliary verb then the placement of the **only** is after this verb form, which means that the **only** is placed before the main verb because the main verb follows the auxiliary verb. Table 13 shows the results of the queries with the different forms of the verb **be**.

Table 13. Usage Frequency of Modifier Queries with the Verb **be**

Query	Usage Frequency
only be	27,008
be only	3,058
only been	6,174
been only	1,287
only being	2,051
being only	2,109
only am	55
am only	202
only is	1,923
is only	48,132
only are	897
are only	19,639
only was	2,315
was only	54,699
only were	901
were only	16,367

## B.2 Plural Usage Frequency Examples

The use of a singular subject is indicative of people’s awareness of plural ambiguity. The study reveals that overall, for each of the 5 verb forms studied, people write plural rather than singular, supporting the assumption that plural quantifiers are commonly used more frequently.

Table 14 shows the results of the queries with **all** and **each**. Query 1, all support, shows that the quantifier all is used with the plural verb support 324 times. Query 2, each supports, shows that the quantifier each is used with the singular verb supports only 11 times. Thus, all support occurs 29.5 times more frequently than each supports.

Table 14. Usage Frequency of Plural Queries

Query Number	Query	Usage Frequency
1	all support	324
2	each supports	11
3	all request	86
4	each requests	1
5	all impact	27
6	each impacts	0
7	all identify	32
8	each identifies	1
9	all approve	8
10	each approves	0

Query 3, all request, shows that the quantifier all is used with the plural verb request 86 times. Query 4, each requests, shows that the quantifier each is used with the singular verb requests only one time. Thus, all request occurs 86 times more frequently than each requests.

Query 5, all impact, shows that the quantifier all is used with the plural verb impact 27 times. Query 6, each impacts, shows that the quantifier each is used with the singular verb impacts zero times. Thus, all impact occurs 27 times and each impacts does not occur in the corpus.

Query 7, all identify, shows that the quantifier all is used with the plural verb identify 32 times. Query 8, each identifies, shows that the quantifier each is used with the singular verb identifies only one time. Thus, all identify occurs 32 times more frequently than each identifies.

Query 9, all approve, shows that the quantifier all is used with the plural verb approve eight times. Query 10, each approves, shows that the quantifier each is used with the singular verb approves zero times. Thus, all approve occurs eight times and each approves does not occur in the corpus.

## APPENDIX C

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# EXAMPLES OF EACH PERSISTENT AMBIGUITY TYPE THAT ARE REQUIREMENTS

**Modifier Ambiguity Requirement Example:**

**Will only bring into System A those items needed to do X, Y, and Z.**

**Interpretation A:**

**Will bring into only System A those items needed to do X, Y, and Z.** Not into System B, etc.

Interpretation B:

**Will bring into System A only those items needed to do X, Y, and Z.** Not other items into System A.

Referential Ambiguity Requirement Example Affecting the Data Structure Required:

**If there is a company & supplier relationship, need to store this to identify the payment recipient.**

Interpretation A: **The company.**

Interpretation B: **The supplier.**

Interpretation C: Some combination of A & B. Example: payment split 50:50.

Referential Ambiguity Requirement Example Affecting the Implementation of a Process:

**The encoding scheme will provide the ability to issue notifications of intrusions.**

**The simple digest security scheme may be used as a direct replacement for the HTTP/1.0 basic authentication scheme with minimal modifications of clients and servers.**

**This prevents security breaches & is a priority.**

Interpretation A: **The encoding scheme prevents security breaches & is a priority.**

Interpretation B: **The simple digest security scheme prevents security breaches & is a priority.**

Interpretation C: **The referent may not even be any particular word or phrase; it may be the idea embodied by whole or multiple sentences & is a priority.**

Elliptical Ambiguity Requirement Example:

**The database needs a data structure faster than System B.**

Interpretation A: **The database needs a data structure faster than System B is.**

Interpretation B: **The database needs a data structure faster than System B needs.**

Conditional Clause Ambiguity Requirement Example:

**When a user requests a book with an available status, assign book to user.**

**When a user requests a book with a checked-out status, place a hold on the book for the user.**

**If so, increase the book's number-of-user-requests counter.**

Interpretation A: **If a user requests a book with an available status, increase the book's number-of-user-requests counter.**

Interpretation B: **If a user requests a book with a checked-out status, increase the book's number-of-user-requests counter.**

Plural Ambiguity Requirement Example Affecting the Data Structure Size:  
**Maximum of 10 X's and Y's in module A.**

Interpretation A: **Maximum of 10 for each X's and Y's, totalling 20.**

Interpretation B: **Maximum of 10 total.**

Plural Ambiguity Requirement Example of a Plural Quantifier Affecting the Implementation of a Process:

**All overdue library books have their own fees of \$1.**

Interpretation A: **There is one \$1 fee for all overdue library books. Total fee is \$1 regardless of the number of overdue books.**



Interpretation B: **There is one \$1 fee for each overdue library book. Total fee is \$1\*number of overdue books.**

Plural Ambiguity Requirement Example Affecting the Implementation of a Process:

**Module A summarizes corporate, charity, non-profit, and personal tax laws.**

Interpretation A: **Module A summarizes corporate, charity, non-profit, and personal tax laws together into one summary.**

Interpretation B: **Module A summarizes corporate, charity, non-profit, and personal tax laws into separate summaries, one for each category.**