REFERENTIAL PROCESSES IN CHILDREN’S SENTENCE
COMPREHENSION: EVIDENCE FROM NUMERICALLY
QUANTIFIED EXPRESSIONS

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REFERENTIAL PROCESSES IN CHILDREN’S SENTENCE COMPREHENSION: EVIDENCE FROM NUMERICALLY QUANTIFIED EXPRESSIONS

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Abstract

The current thesis reports seven experiments investigating the interpretation that children and adults assign to numerically quantified expression ambiguities like the one shown in (1).

1. Three cats were on the wall. Two cats were playing with a mouse.

In this example, the quantified noun-phrase *two cats* is ambiguous, since it can be interpreted as referring to the set of three cats already established in discourse (i.e. subset reading) or as introducing new referents into discourse (i.e. new-set reading). Research with adults (Frazier *et al.*, 2005; Kaan, Dallas & Barkley, 2007; Paterson, Filik, Mousoulidou, Baliousis & Moxey, 2008b; Wijnen & Kaan, 2006) showed that adults have a preference for interpreting referential expressions with respect to the prior discourse context and thus prefer the subset reading of ambiguities like the one shown in (1). By employing a task involving pictures, the current research examined whether six to eight year old children have the same preference.

Each experiment used different techniques to examine children’s interpretative preferences when analysing numerically quantified expressions. In the initial experiment children were presented with sentence pairs accompanied with two pictures; one picture matched the subset reading of the ambiguity and the other matched the new set reading. The sentence pairs either included an ambiguous quantified expression, as in (1), or quantified expressions that were disambiguated in favour of a subset reading (e.g., "two of the cats...") or a new set reading (e.g., "two other cats..."). The results of seven experiments showed that children do not interpret numerically quantified expressions in the same manner to adults. Whereas adults preferred the subset reading of ambiguous quantified expressions and always assigned the appropriate reading to unambiguous ones, children showed a strong preference for the new-set reading of both ambiguous and unambiguous quantified expressions. The significance of this finding is considered in relation to studies showing that whereas adults readily establish coreferential links between sentences, children have more difficulty in doing so (e.g., Karmiloff-Smith, 1979; 1980).
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When you depart for Ithaca,
wish for the road to be long,
full of adventure, full of knowledge…

Keep Ithaka always in your mind.
Arriving there is what you're destined for.
But don't hurry the journey at all.
Better if it lasts for years,
so you're old by the time you reach the island,
wealthy with all you've gained on the way,
not expecting Ithaka to make you rich.

Ithaka gave you the marvellous journey.
Without her you wouldn't have set out.
She has nothing left to give you now.
And if you find her poor, Ithaka won't have fooled you.
Wise as you will have become, so full of experience,
you'll have understood by then what these Ithakas mean.”

Ithaka, Konstantinos P. Kavafis, 1911.
Dedicated to my grandfather Thomas

who I lost on my way to Ithaka....
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Chapter 1:
Introduction

In the field of cognitive psychology and psycholinguistics, discourse comprehension has been a central issue, with researchers attempting to identify and explain how readers are able to connect sentences together in order to make sense of what they are reading. Many important processes need to be accomplished for readers to be able to successfully comprehend a text; one of the most important processes is to integrate the meaning of what they are currently processing with information from prior discourse context. This helps readers to keep track of the ongoing information and thus, successfully comprehend a text.

There are many properties within a text that enable the reader to form links between sentences; nevertheless, two of the most agreed properties of the text that influence integration are coherence and cohesion. A text is cohesive if it involves repeated references, such as anaphors, that are essential tools for connecting information found in one part of the text with information found in another part of a text. Coherence refers to the way a sentence can be connected to another and can take place even in the absence of any cohesion, such as when the relationship of two sentences can only be inferred.

Research with adults has been successful in establishing the processes by which adults are able to use anaphoric devices as a means of connecting together different parts of a text. It is clear that discourse integration is something that happens naturally and automatically when adults comprehend a text. Importantly however, the research that examined children’s language comprehension suggests that children are less successful in employing anaphoric devices as a means of forming links between
sentences in a text. It has been consistently shown that children have a general difficulty with integration, as forming links between sentences is not a natural process in children’s language comprehension.

The process by which children are able to successfully comprehend a text has been traditionally examined by investigations of children’s interpretation of discourses that contain pronouns (e.g., he, she, it), the definite article (i.e. the), as well as children’s inference generation. This research has clearly shown that children interpret sentences that contain anaphoric devices in a different manner to adults. It is well documented that unlike adults, children, have a difficulty in connecting an anaphor with its referent found in the prior discourse context, which results in children being less able in forming links between sentences. This finding contributed immeasurably to our understanding of children’s language processing strategies. Nevertheless, in order to gain a broader understanding of children’s discourse comprehension it is also vital to examine children’s processing of other types of anaphors. This is the main reason the current research has been conducted.

The present research is concerned with one type of anaphor that has only recently received attention by researchers; that is quantified noun-phrases (e.g., two cats) and bare cardinals (e.g., two). Numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) when contained in a text usually refer to elements, or part of elements, already established in prior discourse context; thus, similar to other types of anaphors, numerically quantified expressions are a very important tool for successfully connecting the information contained in a text.

Interestingly, these anaphors have also another important characteristic; when contained in a text they are often ambiguous between interpretations, in which they can either be interpreted as referring to an already established discourse referent, or
interpreted as introducing new referents into the discourse. Thus, unlike other types of anaphors (e.g., pronouns and the definite reference) which explicitly denote a relationship between two parts of a text, these types of anaphors are more “flexible” by also allowing a non-anaphoric interpretation of the discourse. Importantly therefore, examination of numerically quantified expressions also allows for the study of reader’s interpretative preferences when comprehending a text. Consider for example the ambiguity shown in (1).

1. Three cats were on a wall. Two cats caught a mouse.

The quantified noun-phrase *two cats* in the second sentence of the discourse shown in (1) is ambiguous between two readings. In one reading, *two cats* is interpreted as referring to the set of *three cats* already established in the discourse context (i.e. first sentence). Throughout this thesis, this anaphoric interpretation will be referred to as a *subset reading*, since *two cats* is interpreted as referring to a subset of the set of cats that has been already established in discourse. In the other reading, the quantified noun-phrase *two cats* is interpreted as referring to a new set of cats, different than the set already established in the discourse context. For this reason, in the current thesis this non-anaphoric interpretation will be referred to as *new-set reading*. A similar ambiguity arises if the numerically quantified expression is replaced with a bare cardinal where the noun is omitted (e.g., *two*…).

Thus, it is clear that successful comprehension of ambiguous discourses like the one shown in (1) largely depends on the reading that readers assign to the ambiguity. If as it has been consistently shown, adults naturally and automatically form links between sentences, then this suggests that adults would have a preference for the subset reading.
of ambiguities like the one shown in (1). This is because the subset reading is the interpretation that connects together the information contained in the first sentence, with the information contained in the second sentence. Also significantly, if children have a general difficulty in integrating information contained in different sentences, as previous research examining other types of anaphors has clearly shown, then it appears possible that children might follow different strategies than adults when interpreting ambiguities such as the one shown in (1).

The present study is primarily aimed at obtaining an answer to these considerations. The current research examines and compares the interpretative preferences of adults and children when analysing discourses that contain numerically quantified expressions. Understanding the differences between how children and adults interpret such types of anaphors will be a valuable step towards a more detailed picture of children’s sentence processing strategies when they comprehend a text.

1.1. Overview of this Thesis

Chapter 2 is concerned with adult’s language comprehension. In this chapter different approaches that have been developed to explain the process by which adults form links between sentences will be discussed. The main theme that arises from this chapter is that connecting sentences in the discourse happens naturally and automatically while adults are reading a text. This chapter also reviews relevant research which examined whether children use the same strategies as adults when comprehending a text. As it will be discussed children appear to follow different strategies to adults when comprehending a text.
In Chapter 3 attention will be turned to children’s language comprehension. In this chapter, a number of studies will be described which suggest that children have several difficulties when comprehending a text. The discussion of this chapter will centre on four areas that have showed difficulties for children. This will include a review of a general difficulty for children in establishing the relationships between a class and its subclass, as well as difficulties for children in using both explicit (e.g., pronouns and definite reference) and implicit anaphors (e.g., inference generation) as a means of connecting different parts of a text.

Chapter 4 is divided into two parts. The first part is concerned with research that has been conducted investigating children’s and adults processing of sentences that contain quantifiers. This will involve a general discussion of a number of difficulties that children face when a quantifier is used in a sentence. The second part is specifically concerned with the interests of the current research; that is, how children and adults process discourses that contain numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals). In this section two accounts that provide explanations of how readers should interpret discourses that contain numerically quantified expressions will be described. Then relevant research which examined how adults and children interpret these expressions will be presented.

Chapter 5 introduces the current research. This chapter introduces the general methodology that was employed in the current experiments, as well as a pilot study that was conducted prior to running the main body of experiments.

In Chapter 6 the first two experiments that have been conducted in the current research will be described. As it will be shown these experiments provided an important background on what should be further examined in the following experiments.
In Chapter 7, Experiments 3 – 7 will be described. Each of these experiments tested a different possible reason behind children’s interpretative preferences when analysing numerically quantified expressions. The results from these experiments provided some valuable insights for the possible reasons that can account for the effects observed in the current research.

Chapter 8 discusses the main theme that emerged from the findings of the current research. This chapter presents two alternative explanations that can account for the significant effects observed in the current research. The chapter concludes with a discussion of considerations that should be tackled in future research, as well as a general conclusion for the significance of the present findings.
Chapter 2:
Approaches to Adult Language Comprehension

The discussion of this section concentrates on the importance of forming links between sentences when readers comprehend a text. The first part, discusses two accounts that provide explanations on how adult readers or listeners form links between sentences. Importantly, both of these accounts suggest that adults naturally and automatically form links between sentences when they comprehend a text. In the second part the attention is turned to a particular influence that has been suggested to have an effect on successful integration of information contained in different parts of a text; that is, the referential continuity within a text. The last part of this chapter discusses a theory that places importance on the contextual influence when readers are processing ambiguities. All the accounts discussed in this section are very important for the current research purposes, since successful comprehension of the discourses that children and adults will be presented with largely depends on successfully forming links between information contained in the two sentences of the discourse.

2.1. Models of Discourse: Connecting Information in Discourse

A general approach that has been taken in studies investigating how people comprehend a text has assumed that as readers or listeners comprehend a text, they build a mental representation of the information conveyed in the text (e.g., Avrutin 1999; Avrutin & Coopmans, 2000; Garrod & Sanford, 1994; Heim, 1982; Haviland & Clark, 1974; Johnson-Laird, 1983; Sanford & Garrod, 1981; Kintsch and van Dijk,
This discourse or mental model contains explicit information such as causal relations among people, objects and events specified in the text, as well as implicit information that can only be inferred or specified by discourse context. What is important about this discourse model is that it enables readers to keep track of information contained in one part of a text, which they can later use to add new ideas found in another part of the text. Thus, by building a mental representation, readers are able to successfully link succeeding sentences in a text.

Two of the theories that provide explanation of how readers or listeners integrate information found in different sentences are the Given-New Theory (i.e. Clark & Haviland, 1977; Haviland & Clark 1974) and the File-Card Theory (i.e. Avrutin 1994; 1999). These theories are important for the current purposes since both of them propose that forming links between sentences happens naturally and automatically as readers comprehend a text. In the following section these two theories will be reviewed in more detail.

2.1.1. The Given-New Theory

Perhaps one of the most influential accounts that explains how readers or listeners integrate information found in different sentences comes from the studies of Haviland and Clark (1974; see also Clark & Haviland, 1977). What is important about this work is that it has provided clear strong evidence that not only do adult readers attempt to form links between sentences when comprehending a text, but importantly that these links are formed automatically as the text is being processed. Clearly this has major importance for the current research purposes, since the current research is concerned with how children and adults link sentences in discourse.
In their research Haviland and Clark (1974; Clark & Haviland, 1977) focused on bridging inferences, which are the inferences that are needed in order to link (i.e. form a “bridge” between them) sentences together in a text. Haviland and Clark proposed that one important process of successful integration of different parts of the text depends on readers’ or listeners’ ability to form links between given information and new information contained in a text. Given information refers to information mentioned previously in the text and is therefore already established in the readers’ discourse model, whereas new information refers to information that is newly introduced in the text.

The core of Haviland and Clark’s (1974; Clark & Haviland, 1977) theory is the view that the speaker and the listener make an agreement or “contract”, that while communicating with each other, they will share a “mental world” where they will both know what is the given information and what is the new. Building on previous suggestions that speakers and listeners share a common ground or mutual knowledge (e.g., Grice, 1975; Branigan, McLean, & Reeve, 2003; Clark & Wilkes-Gibbs, 1986), the given-new theory suggests that in a conversation, speakers use information that they think their listeners already know and information they believe their listeners do not yet know. Readers on their part, agree to interpret this information expecting that the speaker will use this information based on the reader’s knowledge of what is new and what is given.

Having this contract in mind, listeners use a general strategy that helps them understand each sentence’s relation to the ongoing discourse. This strategy involves three steps. In the first step, the listener has to identify and distinguish the new information from the given information. Since the listener is expected to know the given information, the second step is to search back in memory to find the referent of that
given information. The third step is to revise memory structure by integrating the new information with the established referent that already forms part of the current discourse model. Having done that, the listener will have a revised discourse model containing this new information. Thus, this strategy provides a general explanation of how readers and listeners automatically integrate information contained in two different sentences. In its simplest case, this strategy explains how readers are able to connect information found in succeeding sentences when the referent is explicitly stated in a discourse, like it is in the example shown in (2).

2. We got some beer out of the trunk. The beer was warm.

Following the first step of the strategy, when listeners or readers encounter a discourse like the one shown in (2) they will first have to identify the given and the new information. The definite expression *the beer* in the second sentence of (2) indicates to listeners that this is the given information, since definite expressions (e.g., the beer) are usually used when a referent is already established in the discourse. Therefore on encountering this expression, listeners then should search in their memory of the previous discourse context for a suitable referent. In this case the referent for *the beer* is given from the phrase *some beer* in the first of the two sentences of (2). Therefore, listeners will integrate the meaning of the two sentences by reaching an understanding in which the discourse is interpreted as some of the beer that was taken out of the trunk was warm.

There are many cases however, where an anaphor, such as *the beer*, cannot be directly related to a referent from prior discourse context, often because it has not been explicitly mentioned. Haviland and Clark (1974; Clark & Haviland, 1977) proposed that
in such cases a bridging inference is essential in order for listeners to establish the appropriate linkages between the new and the given information. Importantly, they proposed that these bridging inferences are made automatically while the text is being processed. Consider for example the discourse shown in (3).

3. We checked the picnic supplies. The beer was warm.

Following the same strategy as before, the reader will identify the beer as the new information and will start a search procedure in previous discourse context for its antecedent. In the discourse context of (3) however, there is no direct mention of beer to serve as a referent for this expression. Having the “contract” of communication in mind, readers will assume that speakers deliberately used implicit information to make them draw specific inferences. This will lead the reader to attempt to construct an antecedent from the information they already have. Since the context sentence (i.e. first sentence) of the discourse shown in (3) mentions picnic supplies, and beer can be an example of picnic supplies, the reader will build a “bridge” to connect the two, by inferring that the beer is part of the picnic supplies. After the construction of this bridging inference, the reader will not have a difficulty in integrating the information of the two sentences and successfully interpret that the beer that was contained in the picnic supplies was warm.

Although Haviland and Clark (1974; Clark & Haviland, 1977) argue that such inferences are drawn automatically, nevertheless the comprehension process is more complex when a bridging inference has to be drawn for successful comprehension. Therefore, readers spend longer integrating the meaning of such sentences. Haviland and Clark empirically tested this prediction by measuring the reading times of adult
readers while they processed discourses such as those shown in (2) and (3). The results were in line with this prediction; participants’ reading times for the entire discourse were longer by 181 milliseconds when they had to interpret discourses like those shown in (3). Thus, forming links between sentences when a bridging inference is necessary was more cognitively demanding for adult readers, than forming links between sentences when the referent was established in discourse.

Thus, Haviland and Clark’s (1974; Clark & Haviland, 1977) given-new account provides some important insights into how adults successfully comprehend a text. Importantly, this theory does not only explain how readers successfully connect two sentences together when an explicit anaphor is used, but also explains how readers successfully connect sentences in a text when their relation can only be inferred. Although Haviland and Clark’s research has shown that the speed of comprehension is reduced when a bridging inference has to be made, significantly however, according to this theory the process of integration is a natural part of adult’s comprehension which happens automatically while each sentence is processed.

Another theory that is closely related with the account of Haviland and Clark (1974; Clark & Haviland, 1977) is Avrutin’s (1994; 1999) theory. Avrutin suggested a different way that readers or listeners are able to keep track of the ongoing information for successful integration of the information contained in successive sentences; nevertheless, similarly with what has been proposed by Haviland and Clark, Avrutin suggested that readers and listeners naturally form links between successive sentences, even when the relationship between information contained in a text can only be inferred. It is valuable to review this theory.
2.1.2. File-Card Theory

Avrutin’s (1994; 1999) theory has been developed from earlier theoretical accounts which propose that listeners or readers keep track of information contained in a text by creating what was by analogy called file cards (see Heim, 1982). These mental file cards are created when new information is introduced in a text and are continually updated to include information that refers to elements already established in the listener’s or readers’ discourse model. According to this theory, a set of rules govern the creation of file cards and these rules explain how readers interpret definite and indefinite articles, as well as information that can only be inferred.

According to one of the rules of this theory, an indefinite expression (e.g., a car) is used to introduce a new referent in discourse and thus a new file card should be created to include this information. Therefore, in discourses like the one shown in (4), where both the first and the second sentence include the indefinite expression a car, two different file cards must be created; one file card to account for the information contained in the first sentence (i.e. that a car was passing by) and one to account for the information contained in the second sentence (i.e. that a car was green). In other words, following this theory the discourse shown in (4) should be interpreted as referring to two different cars, one that was passing by, and another car that was green.

4. A car is passing by. A car is green.

A second rule of Avrutin’s (1994; 1999) account is relevant to the interpretation of definite expressions (e.g., the car), and suggests that definite expressions denote the existence of an already established file card (it can be assumed that a similar process is
also applied to other explicit anaphors like pronouns). Therefore, according to this account when a definite expression (or pronoun) is used, readers should search their discourse model to find the file card that includes the referent of this information. When this file card is found, readers will update their discourse model to include the integrative version of this information. For example, consider the discourse shown in (5).

5. A car was passing by. The car was green.

Following the two rules of this theory, when readers encounter the indefinite expression *a car* in the first sentence of the discourse shown in (5) they will apply the first rule to create a new file card to include this information. Since the second sentence of the discourse shown in (5) contains the definite expression *the car*, this will lead the readers to apply the second rule to the interpretation of this phrase. Therefore, readers will understand that a file card already exists that contains the referent of *the car*. As a result, readers will search back in memory to find the already established file card and update it to include this new information. This will enable them to have a file card that contains the integrated version of the information contained in the two sentences. More precisely that the car that was passing by was green.

Furthermore, Avrutin’s (1994; 1999) theory also explains how readers are able to form links between sentences when the information contained in the text can only be inferred. For instance, in the example shown in (6) a definite expression is used without an existing file to attach the new information. According to this account, for successful interpretation of such discourses readers apply another rule; that of “bridging”. According to this rule, readers are allowed to create a new file card for a definite
expression, only if this file card can be bridged to an already established file card. For explanation of how this rule works, consider the discourse shown in (6).

6. A car is passing by. The door is green.

The use of the indefinite expression a car in the first sentence of (5) leads readers to create a new file card. In the second sentence, the use of the definite expression the door denotes that a file card that contains the referent of this information is already established in the readers discourse model. However, when readers search in memory for a referent for the door, they will realise that there is not any established file card that refers to this information. Importantly however, following the rule of "bridging", the door can be linked to the information contained in the previous sentence by inferring that the door is part of the car that was mentioned previously. Therefore, following the third rule of this account, readers will create a new file card for the door that will be “bridged” with the established car card. Thus, the discourse will be interpreted as meaning that a car with a green door was passing by.

Clearly therefore, Avrutin (1994; 1999) provides a different account that explains how adult readers or listeners are naturally forming links between sentences for successful comprehension of a text. Also importantly, Avrutin and his colleagues (i.e. Avrutin & Coopmans, 2000) suggested that readers automatically form links between information contained in one sentence and information mentioned in an earlier part of the text. Thus, according to Avrutin and Coopmans, if adults are presented with a picture that illustrates a car with a red door, and a house with a green door, and asked to judge whether this picture corresponds to the correct meaning of (6), they will be expected to judge this picture as wrong. This is because although the picture illustrates a
green door (i.e. the door of the house), this door does not correspond to the door mentioned in the first sentence (i.e. the door of the car); therefore, “bridging” the door with the information contained in the first sentence (i.e. the car) cannot be achieved. Importantly however, “bridging” can take place if the same picture is presented together with the discourse shown in (7). In this case the door mentioned in the second sentence of (7) can be successfully “bridged” to the car mentioned in the first sentence; thus, adults are expected to judge such picture as correct.

7. A car is passing by. The door is red.

Thus, similarly with the suggestions of Haviland and Clark (1974; Clark and Haviland, 1977), Avrutin and Coopmans (2000) have suggested that integration of information contained in different sentences, even when a bridging inference has to be drawn, is a natural process that happens automatically as adults are processing a text. Importantly, as will be discussed in Chapter 3 in more detail (which deals with children’s language comprehension) Avrutin and Coopmans tested whether children, similarly to adults, also naturally form links between sentences when they interpret a text. Significantly, their findings suggest that children do not follow the same rules as adults when they comprehend a text. It appears that for children forming links between sentences is not a process that happens automatically when they are processing a text (see Chapter 3 for details of Avrutin and Coopmans’s 2000, study).
2.1.3. Section Summary

In summary, this section described two theories that provide explanations on how readers or listeners are able to connect explicit and implicit information contained in a text. Each theory suggests different ways of how readers are able to keep track of the ongoing information when they are processing a text. The given-new theory (i.e. Clark & Haviland, 1977; Haviland & Clark, 1974) makes a general suggestion of how readers form links between sentences, while Avrutin’s (1994; 1999) file-card theory suggests a mechanism of how these links can be made. Importantly however, both theories suggest that forming links between sentences is a natural part of what happens automatically when readers comprehend a text. This is of considerable importance for the purposes of the current research where children and adults will be presented with discourses that contain numerically quantified expressions (i.e. quantified noun-phrase or bare cardinal) and of which successful comprehension largely depends on forming links between information contained in one sentence and information contained in the prior discourse context.

2.2. Influence of Referential Continuity

From the discussion of the previous section it has become clear that forming links between sentences is an important process that occurs naturally and automatically when adults comprehend a text. Having established the importance of discourse integration in successfully comprehending a text, this section discusses one approach that suggests that an important factor which influences integration of different parts of a text is the context distance between an anaphor with its referent. This approach is called
referential continuity (e.g., Ehrlich & Johnson-Laird, 1982; Garnham, Oakhill & Johnson-Laird, 1982) and suggests that readers and listeners are unable to construct an integrated representation of a text, unless two parts of the text have a set of referents in common. In particular, according to this approach it is easier for readers to integrate information in two sentences when an entity introduced in one sentence refers to an entity that was introduced in the immediately previous sentence.

This approach is important for the current purposes. In the current experiments six to eight year old children and adults will be presented with discourses containing numerically quantified expressions such as “three cats were on a wall. Two cats caught a mouse.” which are often ambiguous between two readings. In one reading the quantified noun-phrase two cats is interpreted as a subset of the already established set of cats (i.e. two of the three cats), whereas following the other reading two cats is interpreted as introducing new referents into discourse (i.e. two new cats, different than those on the wall). The referential continuity account appears to suggest that readers would have a preference for the subset reading when asked to interpret such ambiguities. This is because the subset reading is the one that connects information from one part of a text with information from the immediately previous sentence. Thus it is clear that the referential continuity approach is vital for the current purposes. One valuable study that provided support for the referential continuity account comes from Ehrlich and Johnson-Laird (1982).

In one of Ehrlich and Johnson-Laird’s (1982) experiments adult participants were presented with three sentence long problems that described the special layout of a set of four small objects. Participants’ task was to draw a diagram that corresponded to the description of the scene. The descriptions of the sentences were of two types; they were either referentially continuous, or referentially discontinuous. However, the
correct diagram that participants had to draw was identical for both of these types of
descriptions. In the referentially continuous version after the first sentence, every other
sentence referred back to an item mentioned in the preceding sentence. An example of a
referentially continuous text is shown in (8).

8. The knife is in front of the pot. The pot is on the left of the glass. The glass
is behind the dish.

As it is clear from the example shown in (8) the special relation between the
three objects can be clearly understood, since each object can find its referent in the
previous sentence. In the referentially discontinuous version however, the first and the
second sentence did not have a referent in common, rather the relationship between the
two sentences could only be established in the third sentence. An example of the
referentially discontinuous version is presented in (9).

9. The knife is in front of the pot. The glass is behind the dish. The pot is on
the left of the glass.

The results of Ehrlich and Johnson-Laird (1982) experiment showed that
participants drew more incorrect diagrams in the referentially discontinuous version of
the descriptions, than in the continuous ones. Ehrlich and Johnson-Laird took this
finding as supportive evidence that adults are highly influenced by the referential
continuity within a text when they are interpreting a text. To further support this view,
in another experiment Ehrlich and Johnson-Laird measured the time that it took adults
to draw the diagram with the purpose to examine whether adults spend longer time to
understand a text that does not contain referential continuity. Indeed the results of this experiment supported Ehrlich and Johnson-Laird suggestions that adults take longer to draw a diagram for discontinuous descriptions than continuous ones. Ehrlich and Johnson-Laird interpreted this finding as providing clear evidence that readers or listeners are better able to construct an integrated description of the text when there is referential continuity within the text.

The finding that more processing time is needed to understand a text not containing referential continuity is very important, since it can be related to the way adults comprehend a text. Specifically, it is suggestive that adults will be quicker in forming links between sentences when the information contained in a text contains referential continuity, than when it does not. Indeed this suggestion has been investigated by Garnham et al. (1982) who compared the impact of referential continuity in children’s and adult’s comprehension of texts.

In particular, Garnham et al. (1982) examined whether children and adults are influenced by referential continuity when they have to remember and recall information from a story. In their first experiment, participants were adults who heard six stories with the task of rating on a scale of 1-10 how comprehensible the story was. After rating the stories, adults then had to write down all of the information they remembered from the stories. Adult participants were auditorily presented with three versions of stories; “normal stories”, “random stories” and “revised random stories”. The “normal stories” contained sentences that were connected together through reference. The “random stories” contained the same sentences as the “normal stories”, but the order in which they appeared was randomised; therefore, in this version the referents of the anaphoric expressions that the story contained could not be easily identified. The last version of stories, “revised random stories”, contained the same random order of sentences as in
the previous version; however, the referential continuity was re-established by replacing pronouns and other anaphoric expressions with more appropriate noun phrases.

The results showed that adults rated the “normal stories” as more comprehensible than “revised random stories”. Nevertheless, both the “normal stories” and the “revised random stories” were rated as more comprehensible than “random stories”. The same effects were found in adults’ recall of the stories. Adults recalled more information of “normal stories” than “revised random stories” and “random stories”. Also, adults remembered less information of “random stories” than “normal stories” and “revised random stories”. According to Garnham et al. (1982) these effects showed that adults remembered and understood a story better when the story contained referential continuity. Additionally, Garnham and colleagues proposed that the finding that adults remembered more ideas from stories when the referential continuity was restored (i.e. “revised random stories”) supported the view that adults’ successful comprehension of a text is largely influenced by referential continuity.

In a second experiment, Garnham et al. (1982) tested whether, similarly to adults, seven- to eight-year-olds’ recall of stories is influenced by referential continuity. In this experiment children were presented with short stories which they had to read and try to remember; their task was to recall as much as they could from the story. As with their previous experiment with adults, Garnham et al. presented children with three versions of the stories: “normal stories”, “revised random stories” and “random stories”. Additionally, children that participated in this experiment formed two groups based on two tests examining their comprehension levels (see Garnham et al. 1982, and Cain & Oakhill, 1999, for further details on these tests). One group of children was considered to be skilled-readers, since their comprehension level was above their chronological
age, whereas the other group of children was considered to be less-skilled readers, since their comprehension level was below that of their chronological age.

The results of Garnham et al.’s (1982) study showed that children who were skilled-readers recalled more ideas from the three story conditions (i.e. “normal stories”, “revised random stories” and “random stories”) than their less-skilled peers. Additionally, skilled and less-skilled children recalled more “normal stories” than the “revised random stories”. Nevertheless, whereas for the less-skilled readers the “revised random stories” and “random stories” had the same effect, being able to recall only a few ideas out of both of these stories, skilled-readers recalled significantly more ideas from “revised random stories” than from “random stories”.

Overall, there was some indication in Garnham et al.’s (1982) results that children who are performing better than expected for their age (i.e. skilled-readers) perform fairly similarly to adults when they need to recall information from texts that contain referential continuity. The other children however, had clear difficulty in taking advantage of referential continuity when recalling information from a story. It appears that children have difficulty in establishing the referent of an anaphor even when its referent can be found in the immediately preceding sentence.

This is a valuable finding for the purposes of the current research. Although children in the current experiments will not be asked to recall information and rather will be asked to match a discourse to pictures, nevertheless, the finding that seven- to eight-year-olds have difficulty in taking advantage of referential continuity is of particular importance. This is because in the current experiments by employing the same range of ages it will be investigated whether six- to eight-year-olds’ successful interpretation of two-sentence discourses that contain numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) is influenced by
connecting information found in one sentence with information found in the immediately previous sentence. Thus, the findings from Garnham *et al.*’s (1982) research appear to suggest that six- to eight-year-olds in the current experiments might find it difficult to connect numerically quantified expressions with their referent found in the immediately previous sentence.

In summary, this section has described the account of referential continuity which suggests that an important influence which leads to successful comprehension is for incoming information to make reference to information mentioned in the immediately previous part of the text. The research which investigated the influence of referential continuity clearly showed that for adults referential continuity plays an important role in successfully linking two sentences together. Importantly however, research with children showed that referential continuity within a text is of much less importance for children. Seven- to eight-year-olds appear to have a particular difficulty in taking advantage of referring expressions when they comprehend a text. In relation to the specific case of referential processing that the current research is concerned with, this finding appears to make some specific suggestions of how six- to eight-year-olds and adults will interpret numerically quantified expressions. Specifically, successful interpretation of numerically quantified expressions is largely determined by connecting information contained in succeeding sentences. Thus, the finding that unlike adults, children, do not easily establish the referent of an anaphor appear to suggest that children in the current experiments might find it difficult to follow the reading which connects information from one part of a text with information from the immediately previous sentence. To be precise, children might find it difficult to follow the subset reading of numerically quantified expressions and instead have a preference for the new-set reading which introduces new referents into discourse.
2.3. Influence of Prior Discourse Context: The Referential Theory of Sentence Processing

The previous sections have discussed accounts which suggest that connecting sentences in a discourse is a natural process that happens automatically when adults are processing a text. It was also shown that adult readers are more successful in comprehending a text when incoming information makes reference to information mentioned in the immediate discourse context. Thus, it must be clear by now that prior discourse context plays a crucial role for successful comprehension of a text. The current section is concerned with a highly influential approach that has been developed to account for the contextual influence when adult readers are processing an ambiguous sentence; that is, the referential theory of sentence processing (e.g., Altmann & Steedman, 1988; Crain & Steedman, 1985). Although this theory has been primarily developed to account for different aspects of language comprehension than the ones of interest in the current research, nevertheless like the previous work that has been described, this account is important since it shows that adult readers automatically form links between what they are currently processing and the prior discourse context.

The referential theory of sentence processing (e.g., Altmann & Steedman, 1988; Crain & Steedman, 1985) is concerned with how readers resolve syntactic ambiguities that arise when a sentence is temporarily structurally ambiguous and can be interpreted by assigning two or more different syntactic analyses of a phrase. According to this theory, the nature of the reference in the prior discourse context affects the reader’s decision about which of the different possible analyses should be assigned to an ambiguity. Core to the referential theory are two principles that readers are thought to employ when resolving syntactic ambiguities, the Principle of Referential Success and
the *Principle of Parsimony*. These two principles work together to enable the reader to choose the reading that best fits the current discourse representation; that is the analysis that requires the fewest additions or revision to the current discourse model. To illustrate how these principles enable readers to resolve syntactically ambiguous sentences, consider the examples shown in (10).

10. a) The fireman told the woman *that he had risked his life for* many people in similar fires.

   b) The fireman told the woman *that he had risked his life for* to install a smoke detector.

When the sentences shown in (10) are encountered out of context, they are ambiguous since the phrase *that he had risked his life for* can either be analysed as a sentential complement of the verb *told* as in (10a), or as a relative clause modifying the definite expression *the woman*, as in (10b). Readers face a processing difficulty when they have to interpret sentences like those shown in (10), and research (e.g., Altmann & Steedman, 1988; Altmann, Garnham & Dennis, 1992) that has measured the time taken to read this ambiguous phrase (i.e. that he had risked his life for) has shown that adults spend longer reading these phrases in sentences like the one shown in (10b) than sentences like the one shown in (10a). This suggests that upon reading the phrase *that he had risked his life for*, adults are expecting continuations that involve a complement syntactic analysis.

The Principle of Parsimony (e.g., Altmann & Steedman, 1988; Crain & Steedman, 1985) explains why readers have a preference for the complement analysis of ambiguous sentences like those in (10). According to this principle readers and listeners
are able to resolve syntactic ambiguities by adopting the syntactic analysis that requires the fewest unsupported presuppositions. Therefore, readers or listeners should avoid inferring the existence of new or additional entities as much as possible. Unlike the sentence shown in (10a), the sentence shown in (10b) can only be disambiguated by inferring the existence of more than one woman; thus following the Principle of Parsimony adults will find sentences such as the one shown in (10b) more difficult to interpret. However, in situations in which the sentences are in referentially supported contexts, such as in (11) the difficulty in interpreting ambiguous sentences like (10b) is minimised. This is because in (11) the discourse context introduces two women and one woman can be identified using the relative clause analysis. That is, the reader has already been told that the fireman has risked his life for one of the two women. Consider the example shown in (11), in which the sentence in (10b) is introduced after the discourse context has been clearly established.

11. An off-duty fireman was talking to two women. He was telling them how serious the situation had been when their house had caught fire. The fireman had risked his life to rescue one of the women while the other had waited outside.

He told the woman *that he had risked his life for* to install a smoke detector.

The first thing that readers need to establish when presented with a discourse like the one shown in (11) is to whom *the woman* refers to. Readers are able to do this by finding a referent in prior discourse context. However, in this particular example the prior discourse context includes two possible references (i.e. two women) for the expression. Therefore, the reader needs further information in order to work out which
of the two women this phrase refers to. According to the Principle of Referential Success (e.g., Altmann & Steedman, 1988; Crain & Steedman, 1985), a noun phrase analysis which is referentially supported will be favoured over one that is not. That is, if the prior referential context contains a phrase that can be related to the phrase that is currently been processed, then readers should adopt the analysis that links these phrases together. Following this principle one possible source of information to whom the woman is referring to, is provided by the phrase that he had risked his life for. Thus, the reader will follow this principle and interpret the phrase as meaning that the fireman was talking to the woman that he had risked his life to rescue.

Many studies that have directly investigated this theory’s predictions have provided evidence that adult readers and listeners make rapid use of contextual information to reach the intended interpretation (e.g., Altmann et al. 1992; Altmann, Garnham & Henstra 1994; Ni, Crain, & Shankweiler, 1996; Trueswell, Tanenhaus & Kello, 1993). For example, Altmann et al. (1992) in a series of eye-movement experiments, measured and compared the reading times of participants when reading ambiguous sentences like those in (10b) in isolation (i.e. out of context) versus sentences like (11) which are in referentially supported contexts. Consistent with the predictions of the referential theory, these researchers found that adult readers spent longer reading ambiguous sentences that are not supported by context, similarly to the ones shown in (10b), than sentences that are contextually supported, like those shown in (11).

Subsequent studies, such as the one conducted by Tanenhaus, Spivey-Knowlton, Eberhard and Sedivy (1995) provided supportive evidence for adults’ rapid use of context when disambiguating a syntactic ambiguity. These researchers studied adults’ processing of syntactically ambiguous sentences using a different paradigm than the one
employed by previous researchers; in particular, Tanenhaus et al. (1995) employed the visual world paradigm. Note here that there are various versions of the visual world paradigm, but in general in such paradigms participants’ eye-movements are measured while participants are asked to look at a visual display depicting pictures of objects or real objects while hearing a sentence or a story. The visual world paradigm that Tanenhaus and colleagues employed involved giving adult participants spoken instructions to manipulate a set of real objects in a workspace while their eye-movements were measured throughout the instruction. An example of an instruction given to participants in Tanenhaus’ study is shown in (12).

12. Put the apple on the towel in the box.

The sentence in (12) is ambiguous at the prepositional phase on the towel which can be either interpreted as specifying the location of the object to be picked up (i.e. the apple on the towel should be placed in the box), or else the destination that the apple is to be put (i.e. the apple should be placed on the towel in the box). Tanenhaus et al. (1995) tested whether adult listeners are affected by the visual context when processing an instruction like (12). Adult participants in this study were presented with two different visual contexts: a one-referent context or a two-referent context. In the one-referent context participants were presented with a visual context that contained a towel with an apple on it, another towel without an apple, a box, and a pencil. Therefore, the one-referent visual context supported the destination interpretation. In the two-referent visual context the pencil was replaced by a second apple that was on a napkin. Thus, this visual context supported the modification interpretation; that is the interpretation in
which on the towel provides modifying information that specifies which of the two apples is the correct referent.

The findings from Tanenhaus et al.’s (1995) research appear to suggest that the visual context is very important in resolving ambiguities like (12). Their results showed that adults processed instructions like (12) incrementally, making eye movements to objects immediately after the relevant instruction. In particular, Tanenhaus and colleagues found that in the one-referent visual context, adults made eye movements from the apple to the second towel on hearing the word towel indicating that their initial interpretation was to interpret on the towel as the destination of the apple. In two-referent visual contexts however, adults looked at both apples immediately as they heard the word apple, indicating that they tried to establish the referent of the apple immediately.

Thus, importantly, the findings of Tanenhaus et al.’s (1995) study suggest that adults attempt to establish the referent of an expression as soon as they process a sentence and that the interpretation of a sentence is strongly influenced by the information provided in the visual context. This is an important observation since it shows that adults automatically interpret a sentence with respect to information in the visual context. Nevertheless, much of the research that has examined the influence of context on the processing of syntactic ambiguities has been concerned with adult language comprehension. For the current research aims however, how children perform on these tasks is very important, since it will provide a useful insight into how children resolve syntactic and referential ambiguities. One influential study that investigated if children are sensitive to context when processing syntactic ambiguities comes from Trueswell, Sekerina, Hill and Logrip (1999). This work is important since it suggests
that unlike adults, children are less able to interpret a sentence with respect to the prior context. It is important to review this study in more detail.

Trueswell et al. (1999) used similar methods as Tanenhaus et al. (1995) to study how children and adults resolve syntactically ambiguous sentences. In particular, Trueswell and colleagues monitored the eyes of four- to five-year-olds and adults while performing spoken instructions of manipulating actual objects. For instance, in one trial participants were presented with the following objects: one toy frog sitting on the table, one toy frog sitting on a napkin on the table, an empty napkin and an empty box, and asked to perform the instruction shown in (13).

13. Put the frog on the napkin in the box

As it has been described earlier, the sentence in (13) is ambiguous at the prepositional phrase on the napkin, which can either be interpreted as indicating the destination of the frog or else where the frog is to be found. Importantly the results of Trueswell et al. (1999) clearly showed that children processed ambiguous sentences like (13) in a different manner to adults. Specifically, children did not use the visual context to disambiguate the meaning of the sentence and had a great difficulty in choosing between the two frogs; with the frog sitting on the table receiving the most selections. Additionally, Trueswell and colleagues noticed that children ignored referential information and frequently looked at the incorrect destination of where the frog should be put (i.e. on the empty napkin or in the box). Adults on the other hand, used the referential context to guide their decisions and reached the intended interpretation of the ambiguity shown in (13).
Trueswell et al. (1999) interpreted their findings as showing that children are less able than adults to exploit the referential context to guide their parsing decisions. They suggested that whereas adults interpret an ambiguous sentence following the Principle of Referential Success, which suggest that an interpretation which is referentially supported should be preferred over one that it is not, children are less able to do so. According to Trueswell and colleagues, children often decided which object to move at a very early stage of processing and were then unable to revise their initial syntactic commitments, even though the referential context did not support this interpretation. That is, unlike adults who are highly influenced by context and can switch between both interpretations of an ambiguity, children are less able to depart from the interpretation they already assigned to an ambiguity. Although, there are studies that showed that modifications of the task, as well as the way the instruction is presented, can improve children’s performance (e.g., Meroni & Crain, 2003), the difficulty for children in using the contextual information when interpreting ambiguities is well documented in literature (e.g., Hurewitz, Brown-Schmidt, Thorpe, Gleitman, & Trueswell, 2000; Snedeker & Trueswell, 2004; Weighall, 2008).

The findings from Trueswell et al. (1999) generalise to the issues the current thesis is concerned with. The current research examines six- to eight-year-olds and adult’s interpretations of quantified expressions (i.e. quantified noun-phrases and bare cardinals), which when contained in a discourse are often ambiguous between a contextually supported interpretation, and an interpretation that introduces new referents into the discourse. Thus, the finding that children are less influenced by context when interpreting ambiguities provides valuable information of how children might interpret the discourses that the current research examines. Perhaps six- to eight-year-olds will not be able to exploit the discourse context and follow the interpretation that is
referentially supported in the current experiments. Additionally, the observation that children and adults differ in the way they interpret ambiguities is in itself important, since it is suggestive that there are differences in children’s and adults’ sentence processing strategies.

In summary, this section described the referential theory of sentence processing, which places importance on the influence of referential context when readers are interpreting syntactically ambiguous sentences. Existing research that investigated the predictions of this theory showed that adults automatically interpret ambiguous sentences in favour of the analysis that is referentially supported. Significantly, however, research with children suggests that children employ different strategies than adults when interpreting ambiguous sentences. It has been shown that children are less able in exploiting the referential context to guide their syntactic commitments. This finding is important for the current research aims which examined children’s and adults’ interpretations of numerically quantified expression ambiguities, of which their successful interpretation is influenced by information contained in the prior discourse context.

2.4. Chapter Summary

In summary, this chapter discussed several accounts that suggest that adults automatically form links between succeeding sentences when they comprehend a text. It has been shown from this review that adults are largely influenced by prior context as well as reference when they process sentences in a text. Importantly however, the studies that have investigated children’s language comprehension suggest that children do not automatically form links between sentences. Apparently unlike adults, children,
have an overall difficulty in exploiting reference as well as context to form links between sentences. In the context of the present research, differences in the way children and adults comprehend language is of significant importance, therefore children’s language processing strategies when comprehending a text will be further explored in the next chapter.
The previous chapter discussed several accounts that have been developed to explain how adults successfully comprehend a text. It was clearly shown that forming links between sentences is something that happens naturally and automatically as adults are processing sentences in a text. Importantly however, a series of experiments with children have been also reviewed, which appear to suggest that children use quite different sentence processing strategies than adults when comprehending text. This chapter builds on these findings and discusses several studies that have been conducted in examining children’s language comprehension.

The first part of this chapter reviews Piaget’s (1952; Inhelder & Piaget, 1964) theory which is valuable for the current purposes, since it provides evidence that children have many difficulties until they are able to reason similarly to adults. The other three parts of this chapter are concerned with existing research that examined children’s processing of discourses that contain anaphors (e.g., pronouns, the definite reference and inference generation), which showed convincingly that children find it difficult to use anaphors as a means of connecting information contained in succeeding sentences. The current research is concerned with how children (and adults) analyse discourses that contain numerically quantified expressions, which can be interpreted as anaphoric to an established referent, therefore the finding that children have difficulty with anaphors is essential for the aims of the current research.
3.1. Piaget’s Cognitive Development Theory

The first account that appears to be important to the questions that are tackled in the current thesis is Piaget’s (1952; Inhelder & Piaget, 1964) cognitive development theory. This theory is important mainly for three reasons. First, Piaget’s account was one of the first attempts in explaining how children think, reason and solve problems. Therefore, it provides a detailed framework on children’s difficulties and competencies until their cognition fully develops. Second, this theory is also important because of Piaget’s observations that children younger than eight have difficulty in performing the class inclusion task; a task in which children have to resolve the relationships between a class and its subclass. This is something definitely important for the current purposes since children in the current research will be presented with discourses for which successful comprehension largely depends on resolving class-subclass relationships. Lastly, Piaget’s observation on children’s use of language is also something very important for the current research which concentrates in children’s language comprehension.

3.1.1. Piaget’s Stages of Cognitive Development

Piaget (1952; Inhelder & Piaget, 1964) mainly used naturalistic observations with his own children, and proposed that children go through four stages of cognitive development before they achieve cognitive growth; these stages are: sensorimotor stage, the preoperational stage, the concrete operations stage and the formal operations stage. All children were thought to progress through these four stages in the same sequence, although one child could take longer to pass through a given stage than another.
The first stage, the sensorimotor stage was thought to include newborn children until the age of about two years old. As the name of the stage implies, sensorimotor children are strongly influenced by their sensations and actions, and therefore, only rarely able to reason beyond what they are sensing and doing. Piaget (1952; Inhelder & Piaget, 1964) argued that children at this stage are completely egocentric; that is they do not recognise that a perspective other than their own might exist. Nevertheless, children at this stage begin to develop object permanence; that is the ability to recognise that objects exist in the world even when one cannot hear, feel or see them.

For the current purposes, the most important stage of Piaget’s theory is the second stage. This is because this stage includes the ages that the current research is concerned with. According to Piaget (1952; Inhelder & Piaget, 1964) after the age of two until about seven or eight, children advance to the second stage, the preoperational stage. Piaget considered that this stage was a preparation for the next stage and thus focused in what children in this stage could not do, rather than what they were capable of doing. Children at this stage were considered to rely on their senses and imaginations. Although they begin to use language and imagery, they still lack operational thought and thus fail to accomplish tasks that involve classifications and relations of quantity and space. Moreover, as in the previous stage, children’s reasoning in the preoperational stage was also considered primarily egocentric.

Children around the age of eight to eleven are capable of performing the actions that they failed in the preoperational stage, and thus advance to the concrete operations stage. Children at this stage are now able to reason with respect to the physical properties of objects. For instance, they understand that the physical properties of objects do not change (when nothing is added or taken away) even though the objects’ appearance might change. Children are not as egocentric as in the previous two stages
and they begin to reason not only based on what they think, but also based on what other participants in a conversation might think. Moreover, children at this stage are capable of mental operations; that is actions performed in the mind that give rise to logical thinking.

Children of around eleven to fifteen years of age advance to the final stage, the formal operations stage. According to Piaget (1952; Inhelder & Piaget, 1964), at this stage children develop the capacity for abstract reasoning and hypothetical thinking. They begin to use deductive reasoning (if A, then B…) to reach logical conclusions and they can solve complicated problems by systematically testing hypothetical solutions. Egocentrism continues to decline and now children can reflect on their own thinking and that of others. Piaget assumed that by achieving formal operations, children completed their cognitive structures.

Thus, Piaget’s (1952; Inhelder & Piaget, 1964) theory describes how children progress from one stage to another until they fully develop their cognitive thinking. Although this theory has been criticised in many levels, such as its view that children go through four stages in a fixed order (see Sutherland, 1992 for a review of Piaget’s criticisms), this theory contributed immeasurably to focus the attention to the importance of studying children’s cognitive development. Additionally, this theory had a wide influence in the area of psychology, which still holds to date.

Having established a general idea of the stages of Piaget’s (1952; Inhelder & Piaget, 1964) theory, the attention is now turned to a cognitive task that Piaget noticed that children younger than eight have difficulty in performing; that is, the class inclusion task. As it was previously mentioned this task is important for the current purposes, since being able to resolve the relationships between a class and its subclass
appears to be something that children in the current experiments also need to be able to perform.

3.1.2. *The Class Inclusion Task*

According to Piaget (1952; Inhelder & Piaget, 1964) class inclusion is one out of many logical operations (e.g., conservation, reversibility, knowledge of time and space, among many) that children have to learn in order to achieve cognitive development. In Piagetian’s terms, logical operations described the essence of thought; therefore, Piaget considered that children could only be able to achieve full cognitive development if they knew how to perform these logical operations.

Piaget (1952; Inhelder & Piaget, 1964) tested children’s knowledge of class inclusion relationships by using the class inclusion task; a task that involved understanding that things may belong simultaneously to two categories or classes, one of wider generality and the other of narrower. For instance, a “cat” is both a cat and an animal. In the traditional class inclusion task children were presented with two subclasses of objects that belonged to the same category, for example ten toy cats and five toy dogs that belonged to the general class of animals. Children’s task was to act-out the requests of the experimenter. For example children were asked to divide the animals based on their differences (e.g., “can you make separate piles with the animals which are like each other?”), or combine them based on their similarities (e.g., “can someone put cat and dogs together?”).

Piaget (1952; Inhelder & Piaget, 1964) noticed that children who were younger than eight, and thus still in the preoperational level, were able to divide the animals into two classes, one class of “dogs” and one class of “cats”, and could also combine the two
subclasses to form the bigger class of “animals”. Moreover, children younger than eight
did not have a difficulty in correctly replying to questions that involved comparisons of
the two subclasses, such as “if we divide the animals into cats and dogs which set will
be bigger?”. Importantly however, the same children often failed in correctly replying to
the class inclusion question “are there more cats or more animals”; a question which
involved a comparison of the subclass with the general class. In several experiments
Piaget noticed that children younger than eight often replied to this question by saying
the subclass of objects that contained the most members; for the current example “cats”.
This shows that children rather than comparing the subclass “cats” with the larger class
“animals” (i.e. cats and dogs), they mistakenly understood the question as meaning to
compare one subclass (cats) with another subclass (dogs).

According to Piaget (1952; Inhelder & Piaget, 1964), children younger than
eight fail on this task because they are unable to grasp and keep constantly in mind the
inclusion relation between a class and its subclasses; that is to recognise that a subclass
of objects is included in a more general class of objects, but does not exhaust it. Piaget
proposed that children will achieve the inclusion relation of classes after they advance
to the operational stage (after the age of eight) in which they will be able to understand
that objects can simultaneously be part of a subclass and a more general bigger class.

The difficulty that children experience with the class inclusion task, has received
a lot of attention by researchers since the 1970s, with a lot of different studies being
developed to further explore this difficulty by children. Most of these studies confirmed
the initial observations by Piaget (1952; Inhelder & Piaget, 1964), children younger
than eight appear to have a difficulty with the class inclusion task (e.g., Carpendale,
McBride & Chapman, 1996; Shipley, 1979; Steinberg & Anderson, 1975; Winer, 1974).
Other research however, has shown that different manipulations of the task can improve
children’s performance (e.g., Markman 1973; Sheppard, 1973; Wohlwill, 1968), and the ages that children are able to perform this task are not as strictly defined as Piaget original proposed (e.g., Judd & Mervis, 1979).

For the current research aims, the finding that young children have difficulty with class-subclass relations is of particular importance. Successful comprehension of the discourses that children will be presented with in the current experiments largely depends on resolving the relationships between a class and its subclass. Thus, the findings from the class inclusion research provide a valuable insight of what might be a possible outcome of the current experiments. Specifically, it is possible that children’s difficulty with classifications would be also present when children analyse the discourses that they will be presented with in the current research.

3.1.3. Children as Egocentric Communicators

Another important suggestion put forward by Piaget (1952; Inhelder & Piaget, 1964; Piaget & Inhelder, 1969) was concerned with how children use language when communicating. Perhaps one of the most widely discussed and investigated concept of Piaget’s theory is the view that children younger than eight are incapable of taking into account the needs of their listener when they communicate. This egocentricity view has been proposed by Piaget after observing that children younger than eight failed many times on tasks that involved taking into account perspectives other than their own. For example, Piaget and Inhelder (1969) noticed that children in the preoperational stage (approximately two- to eight-year-olds) failed to correctly respond to the three-mountain-task.
In this task children sat in front of a table and viewed a three-dimensional display of three mountains. Each of these mountains had a different object on top (e.g., a house) and each differed in shape and colour. Children were then presented with pictures that displayed the mountains from different perspectives and had to choose the picture that corresponded to the viewpoint of a doll that was moved around the table by the experimenter. For example, in one trial the child was sitting in one end of the table, while the doll at the other end. The child could see a mountain that had a house on top, which was only visible from the child’s side (i.e. the doll could not see the house). The child’s task was to choose the picture that corresponded to the viewpoint of the doll.

Piaget and Inhelder (1969) found that children in the preoperational stage in their answers most of the times failed to take into account the dolls’ perspective. Specifically, rather than selecting the picture that illustrated the viewpoint of the doll, children younger than eight mostly selected the picture that reflected what could be seen from their own viewpoint. According to Piaget and Inhelder the main reason that children were failing in performing this task was because children at the preoperational stage are predominantly egocentric. Significantly, this egocentricity was also noticed in children’s use of language.

In his early work, Piaget (1926:2001) being interested in the development of the child’s logical thinking he studied the way children use language when communicating. Specifically, Piaget recorded the conversations of two six-year-olds for one month and studied the way they used language. The data Piaget obtained suggested that children’s utterances could be divided into two major classes; egocentric speech and socialised speech. Egocentric speech reflected children’s inability to share the perspective of another individual. That is, children did not use language as a means of explaining to their hearer what they meant, but rather their talk was self-centred. On the contrary,
when children used socialised speech, they directed their speech to their listeners, as well as exchanging thoughts with their listeners. Interestingly, Piaget had found that nearly half of the conversations of the two six-year-olds he studied were egocentric rather than socialised.

In the light of these findings, Piaget (1926:2001) in a second study further examined whether children understand each other when communicating. Specifically, Piaget asked six- to eight-year-olds to repeat fairy tales and myths to a second child of the same age that did not know the story. Piaget found that children failed to adapt to the role of the listener and used mainly egocentric speech. For example, consider the following story that children were asked to repeat to another child.

“Once upon a time, there was a lady who was called Niobe, and who had 12 sons and 12 daughters. She met a fairy who had only one son and no daughter. Then the lady laughed at the fairy because the fairy only had one boy. Then the fairy was very angry and fastened the lady to a rock. The lady cried for ten years. In the end she turned into a rock, and her tears made a stream which runs to-day” (Piaget, 1926:2001, p. 83).

Importantly, Piaget (1926:2001) noticed that children lacked precision when they narrated this story to another child. Specifically, Piaget found that children’s use of pronouns (e.g., *he*, *she*), indefinite and definite articles (i.e. *a* and *the*), and demonstrative adjectives (e.g., *that*) were not used unambiguously to indicate to whom they were referring; thus, making it impossible for the other child to understand the story. Consider for example a child’s’ repetition of the story, with the square brackets representing Piaget’s comments.
“Gio (8 years old) tells the story of Niobe in the role of explainer: “Once upon a time there was a lady who had twelve boys and twelve girls, and then a fairy a boy and a girl. And then Niobe wanted to have some more sons [than the fairy. Gio means by this than Niobe competed with the fairy, as was told in the text. But it will be seen elliptical in this way of expressing it]. Then she [who?] was angry. She [who?] fastened her [whom?] to a stone. He [who?] turned into a rock, and then his tears [whose?] made a stream which is still running today” (Piaget 1926:2001, p. 102-103).

According to Piaget (1926:2001), such descriptions of stories, indicated egocentricity and limited communication abilities by children. Interestingly, Piaget’s egocentric view has been also advocated by other researchers. For instance, Flavell et al. (1968) in a series of experiments examined children’s ability to communicate accurately with a listener. In one experiment, they asked eight-year-old and twelve-year-old children to explain the rules of a board game, to children who could see the game, as well as to children who were blindfolded. The results of Flavell and colleagues have showed that eight-year-olds (unlike twelve-year-olds) gave similar explanations to both a listener who could see the game and to the one who was blindfolded. That is, eight-year-olds failed to take into account the fact that some children were blindfolded and thus more precise descriptions should have been given. Similarly with Piaget, Flavell and colleagues considered that this finding showed that children younger than eight are egocentric.
3.1.4. Section Summary

In summary, the purpose of this section was to briefly review some important concepts of Piaget’s (1952; Inhelder & Piaget, 1964) theory. As it has been discussed, for the current purposes one of the most important concepts of Piaget’s theory is that children younger than eight have a difficulty in correctly performing to a task that involves the relationship between a class and its subclass. Additionally, Piaget’s “egocentricity” view is of equal importance since it shows that unlike adults who use language as a means of providing information to their listeners or readers, children often fail to take into account their listeners’ point of view. This is important since it shows that adults and children do not follow the same strategies when communicating.

3.2. Children’s Difficulty with Definite and Indefinite Reference

In this section attention is turned to a particularly important finding concerning children’s language comprehension. Specifically, this part reviews several studies that have shown that children do not use the definite and indefinite reference in the same manner to adults. This research is very important for the current purposes, since as it will be discussed children have a difficulty in using the definite article (i.e. the) as a means of connecting together different parts of a text. This finding is highly relevant to the issues that the current research investigates, firstly because forming links between sentences is essential for successful comprehension of the type of anaphors the current research is concerned with (i.e. numerically quantified expressions), and secondly because, as it will be reviewed, studies which examined definite and indefinite reference have shown that children younger than eight have a particular difficulty in using the
definite and indefinite reference similarly to adults. This finding is of particular importance considering that children who will participate in the current experiments will be younger than eight. Specifically, in the current experiments six- to eight-year-olds and adults’ preferences when interpreting numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) will be examined and compared.

In the English language the indefinite article *a* has two main functions; it is used to refer to one out of many identical objects or items in the discourse context, or to introduce a new referent into the discourse. The definite article *the* on the other hand is mainly used to refer to a referent that is already established in the prior discourse context, and thus functions as a tool for successfully integrating information contained in one part of a text, with information contained in a different part of a text. As discussed in Chapter 2 adults are largely influenced by these expressions; adults mostly use and interpret the definite article as referring to an already established referent in the prior discourse context. Thus, for adults the definite article is an essential tool in forming links between succeeding sentences. Importantly however, research (e.g., Kail & Hickmann, 1992; Karmiloff-Smith, 1979; Krämer, 2002; Maratsos, 1976; Warden 1976) which examined children’s production and interpretation of the definite article clearly showed that children have a difficulty with the definite reference. Children often incorrectly use the definite article to refer to one out of many identical objects or items, or use the definite article to refer to an object or item that has not yet been established in the context. Consider for instance the dialogue of a mother and a child shown below (adapted, from Maratsos, 1976).

“‘Draw something’, a child says to his mother.

‘All right, what do you want me to draw?’
‘Draw the horse’” (Maratsos, 1976, p. 1).

Here the use of the definite expression *the horse* by the child suggests that there is a specific horse that the child wants to be drawn by the mother. This in turn implies that the mother already knows which horse the child means. However, in a context for which there is no reference of a specific horse, the use of the indefinite expression (i.e. *a horse*) is more appropriate. This dialogue illustrates the difficulty that young children face when they have to choose between employing a definite or indefinite expression. It appears that children do not acknowledge that a definite expression is usually used only after a referent is specified in context.

This difficulty by the young child was noticed very early by researchers. For example, one of the most well documented instances of children’s difficulty with definite expressions comes from the naturalistic data that Piaget (1951:2002) collected from his daughter Jacqueline. Consider the dialogue below that Piaget had with his daughter when she was two and a half years old:

“J. at 2,6: ‘that’s not a bee, it’s a bumble bee. Is it an animal?’ But also at about 2,6 she used the term ‘the slug’ for the slugs we went to see every morning along a certain road. At 2,7 she cried: ‘there it is!’ on seeing one, and when we saw another ten yards further on she cried: ‘there’s the slug again’; I answered: ‘But isn’t it another?’ J. went back to see the first one. ‘Is it the same?’ ‘Yes’. ‘Another slug?’ ‘Yes’. ‘Another slug or the same?’… The question obviously had no meaning for J” (Piaget, 1951:2002, p. 225)
As it can be seen from the above dialogue, rather than using the indefinite expression *a slug* to refer to a non-specific slug, Jacqueline used the definite expression *the slug*, which implies that the slug that she saw ten yards further was the same slug that she saw earlier. Piaget’s (1951:2002) explanation of young children’s difficulty with the definite reference goes back to the discussion in the previous section and children’s difficulty with resolving class subclass memberships; that is a difficulty by a young child to differentiate individual members of a class from the general class in which they belonged.

Nevertheless, other researchers like Warden (1976) suggested a different explanation for children’s difficulty with the definite and indefinite reference. Warden conducted a series of experiments and investigated adults and children’s knowledge of the definite and indefinite reference. The results he obtained led him to suggest that children’s difficulty with the definite reference stems from a difficulty to take into account their audience’s point of view. It is interesting to briefly review Warden’s research.

In Warden’s (1976) study, adults’ and three-, five-, seven- and nine-year-olds responses were compared, using description tasks, naming tasks and storytelling. For example, in a storytelling condition children were presented with three pictures depicting a three sentence story in cartoon form. Each participant had to repeat the story to another participant who could not see the pictures. For instance the pictures for one story were the following:

*Picture 1:* A dog is chasing a hen

*Picture 2:* A cow stops the dog, and the hen is hiding behind the cow

*Picture 3:* The hen has laid an egg.
Warden (1976) did not find any differences when children of all age groups (i.e. three-, five-, seven-, and nine-year-olds) and adults mentioned a referent for a second time; both children and adults correctly used a definite expression, such as *the dog*. However, there were significant age group differences when a referent had to be introduced for the first time. Whereas adults and nine-year-olds used an indefinite expression appropriately, specifically to introduce a new referent (e.g., *a dog is chasing a hen*), children younger than nine incorrectly used the definite expression (e.g., *the dog is chasing the hen*). More precisely, 100% of the time adults and 82% of the time nine-year-olds used the indefinite to introduce a new referent; the percentages of correct responses dropped for young children, with seven-year-old using the indefinite expression appropriately in a frequency of 61%, five-year-olds in a frequency of 62% and three-year-olds in a frequency of 46% of the time.

Warden (1976) suggested that children younger than nine have a tendency to use a definite reference to introduce a new referent, because they have difficulty in taking into account a point of view different than their one. Specifically, Warden proposed that when children describe a story, they do not recognise that their choice between a definite or indefinite reference does not only depend on their knowledge of the context, but also on the knowledge of their listeners. As a result, children often use a definite article in cases where only they know to whom it refers. According to Warden, children are able to differentiate where it is appropriate to use the definite and indefinite article after they become aware of their audience’s point of view; something which children appear only to be able to do after the age of about nine.

Having established children’s mistakes with some basic functions of the determiners, attention is now drawn to investigations concerning some more complex functions of the determiners which have also shown to be difficult for children. The
accounts of Maratsos (1976), Karmiloff-Smith (1979), Kail and Hickmann (1992; see also Hickmann, Kail & Roland, 1999), as well as Krämer (2002) are very important in this area. It is valuable to briefly review each of these suggestions.

3.2.1. Frequent use of the Definite Article

Maratsos (1976) suggested that there are two essential aspects of the indefinite and the definite articles that enable speakers to use them appropriately. The first aspect is that the definite article signals a *specific reference*; that is a reference to a particular member of the class. Therefore, the definite article must be used by speakers after the referent is uniquely identified in context. The indefinite article on the other hand, signals a *non-specific reference*, since it refers to no specific member of the class. Therefore, the indefinite must be used in cases where no specific referent is uniquely identified in context, such as when introducing a new referent. The other important aspect according to Maratsos is the shared knowledge of speakers and listeners. That is, speakers must ensure that when they use a definite article it is not only a specific reference for them, but that it is also specific to their listeners.

In a series of experiments (e.g., stories, games and sentence repetition tasks) with forty children aged three and four years old, Maratsos (1976) investigated if children know these two aspects of the articles and thus could differentiate when it is appropriate to use each one of them. For example, consider one of the game tasks that Maratsos tested whether children were influenced by shared knowledge when using the specific (i.e. definite) and non-specific (i.e. indefinite) reference. In this task children had to produce definite and indefinite expressions in order to request a toy from the experimenter. One of the games called “Down the Hill” is described below:
“Down the Hill was played with a wooden hill, a car, and Fisher-Price toy boys and girls which fit conveniently into the cars. The child sat across from the experimenter at a round table. The hill, the car on top of the hill, and the toys were placed on the experimenter’s side of the table out of child’s reach. The child was told that the experimenter would send the car down with a toy child in the car, and the child was to select a toy, one at a time, to be placed in the car. After the child had selected a toy doll for the car, it was rolled down the hill, which slanted towards the child” (Maratsos, 1976, p. 80-81).

This task had four conditions. In the first condition, the visible condition, the child was visually presented with the toys. In the second condition, the invisible condition, the toys were hidden. Moreover, in half of the visible and half of the invisible conditions children were presented with only one toy of each type, such as a boy and a girl (singular condition), whereas in the other half, children were presented with more than one toy, like three boys and three girls (plural condition). In the plural condition each one of the toys had distinctive characteristics (e.g., different hair colour) in order for children to be able to distinguish between them. The toys were presented to children with the experimenter naming them, such as ‘here are a boy and a girl we can use’, and then the experimenter asked ‘who shall we give a ride to now?’

For the singular condition (i.e. the condition in which only one toy of each type was used) the correct response should be with a definite expression (e.g., the boy or the girl), whereas for the plural condition (i.e. the condition that more than one toys of each type were used) the correct answer should be with an indefinite expression (e.g., a boy or a girl), or with a more complex definite expression that described the exact toy they
wanted (e.g., the boy with the blue hat). Note, that these are the expected responses regardless of whether the toys were visible or not.

The results have showed that the visibility of the toys did not affect children’s responses in the singular condition. In this condition children mostly used a definite expression (e.g., the boy) to ask for a toy, regardless of whether the toys were visible or not. Importantly however, very interesting results were obtained in the plural condition in which Maratsos (1976) noticed that both three- and four-year-olds many times used the definite reference even in cases where they were asking for one toy out of many identical ones. Maratsos interpreted this finding as showing that although young children have some basic knowledge of the distinction between the specific (i.e. definite) and non-specific (i.e. indefinite) reference, nevertheless, the aspect of shared knowledge develops at an older age.

For the current purposes, the finding that young children, unlike adults, do not use the definite article to refer to a specific referent from prior discourse context is very important. It shows that children do not use the definite and indefinite reference in a similar way to adults when communicating. Whereas adults use a definite article to refer to a specific object or item from the prior discourse context, children use the definite article regardless of whether one or more referents exists in the discourse context. This illustrates a general difficulty by children in their understanding of the rules that govern the definite and indefinite reference.

Importantly a similar difficulty by children in using the definite and indefinite reference has been also observed by Karmiloff-Smith (1979) who found that children rather than using the definite article as a means of connecting two sentences together, children use the definite article to introduce a new referent into discourse. According to Karmiloff-Smith however, this “inappropriate” use of the article is because young
children, unlike adults, often allow the *deictic reference* to take place even in situations when they are introducing a new referent into discourse and thus the indefinite reference is more appropriate. *Deixis* refers to different gestures, such as head movements, finger pointing and eye gaze, that is used to disambiguate to whom an anaphor, in this case the definite article, is referring to. It is very useful to review Karmiloff-Smith’s study.

### 3.2.2. Deictic use of the Definite Article

Karmiloff-Smith (1979) conducted a large developmental study with one thousand French speaking children. The children were between the ages of three to eleven and were presented with a series of production and comprehension experiments. For instance, in one experiment sixty-eight children were verbally presented with stories with the task to answer a “who” question. The stories were presented in two different situations. In one situation the story was about one entity of the same category (14a), whereas in the other situation the story was about several entities of the same category (14b). The difference between the two situations is that in the case of (14a) children should use the definite expression (e.g., *the boy*) to refer to a specific entity; in the case of (14b) however, the entity should be referred to using an indefinite expression (e.g., *a boy*). Consider the stories that are shown in (14a) and (14b).

14. a) In the playground there was a little boy and a little girl. Just one boy and one girl. They were having fun running about together very fast. Then one of the children fell down and started to cry. Guess who it was.
b) In the playground there were many many boys and many many girls, all playing together. They were running all over the place. Then one of the children fell down and started to cry. Guess who it was.

Importantly, similarly to what Maratsos (1976) observed, the results of Karmiloff-Smith’s (1979) verbal experiment showed that children younger than nine when answering the “who” question for stories like the one shown in (14b), often incorrectly used a definite expression (e.g., the boy) to refer to one out of many possible referents that were available in the context. Interestingly, however in addition to this finding, Karmiloff-Smith’s other experiments showed that young children often used deixis to disambiguate to whom the definite article referred to (e.g., by pointing at the picture or toy figure of the specific boy they meant). One of those experiments is what was called the “what did I do” experiment.

In this experiment children were presented with a bag full of toys. The experimenter performed a number of actions using the toys and children’s task was to say the action the experimenter performed by answering a “what did I do” question. For instance, in one case the experimenter took out of the bag a toy horse and performed the action of placing the toy horse in a box. Importantly, there were two versions of this experiment. In one version children could see the toys that the bag contained, whereas in the other version children could not see the toys in the bag. In the “visibility” case, if the bag contained only one toy horse then the children were expected to use the definite expression the toy horse to answer the question. This is because the toy horse is the only referent available in context. If the bag contained two or more horses however, then the children were expected to use the indefinite reference a toy horse to refer to the one the experimenter used, since the indefinite reference is used when more than one object of
the same category exist in context. Importantly, in the “invisible” version of this experiment children could only use the indefinite reference to refer to the toy the experimenter used (e.g., you put *a toy horse* in the box). This is because the indefinite reference is more appropriate in cases were there is no knowledge of whether the object is the only available referent in context or not.

The results of this experiment showed that children younger than eight often incorrectly used the definite reference to refer to the object the experimenter used regardless of whether there were more than one toy horses available in context or whether children could see the toys the bag contained or not. Thus, similarly with the results of Karmiloff-Smith’s (1979) previous experiment, children were found to use the definite reference in cases where more than one available referent might exist in context. Importantly however, Karmiloff-Smith noticed that most of the times children disambiguated to whom the definite reference referred to by pointing at the specific toy they meant (e.g., you put *the horse* in the box, pointing at the specific horse they meant). Based on the findings of this research, Karmiloff-Smith proposed that children go through three developmental phases before they learn the full function of definite and indefinite articles, and thus ultimately become able to use them in the same manner to adults.

According to Karmiloff-Smith’s (1979) suggestion, the first phase comprises of children around the ages of three and four. This phase is mainly characterised by using the definite article deictically to draw the attention to the referent they have under attention. Thus, in this phase three and four-year-olds rather than using the indefinite article to refer to one object out of many, children use the definite article and use deixis to disambiguate to whom it refers. Then at approximately six, children move to the next phase in which they do not only use the definite article deictically, but also in its
The *exophoric* function. That is, they begin to take into account the relation between objects in the extra-linguistic (outside of the text) context. Children are able to distinguish that a definite article should be used when only one object of the same category exists in context, whereas the indefinite article is more appropriate when several identical objects exist in context. Nevertheless, exophoric reference can also be deictic, since words like *that, this,* and *there* can be used to refer to an object (e.g., the boy over there).

According to Karmiloff-Smith, it is not until the final phase of development that children are able to use the anaphoric function of the definite article appropriately, and this is not until approximately eight. At this age children become aware that the indefinite article is mainly used for referring to a non-specific referent, while the definite article is mainly used for specific, anaphoric reference.

Thus, according to Karmiloff-Smith’s (1979) account, it is not until the last phase of development children are able to use the definite article in the same manner to adults; that is, without the need of using deixis to refer to one object out of many identical objects. Thus, importantly, Karmiloff-Smith research supports the view that children do not use the definite reference as a means of connecting together two different parts of a text. Note here, that as it will become clear in the next section of this chapter, in another study Karmiloff-Smith (1980) found that children also make frequent use of the deictic reference when they are trying to disambiguate the referent of a pronoun. This shows that children have an overall difficulty in using anaphors as a means of forming links between sentences.

Furthermore, other researchers have suggested different explanations of children’s difficulty with the definite and indefinite reference. One interesting account comes from Kail and Hickmann (1992; see also Hickmann *et al.* 1999) who have suggested that young children’s difficulties are because it is not until the age of eleven
that children learn the adult way of introducing referents; that is, always with the indefinite article. Specifically, Kail and Hickmann proposed that whereas young children’s use of the indefinite reference largely depends on the knowledge they share with their listener, older children, similarly with adults, are largely influenced by the rules of language when using the indefinite reference. It is useful to briefly review one study by Kail and Hickmann in this area.

3.2.3. *Impact of Mutual Knowledge in Reference Introductions*

In a series of experiments, Kail and Hickmann (1992) studied the impact of mutual knowledge on children’s introduction of referents. Kail and Hickmann compared referent introductions produced by sixty French speaking six-, nine- and eleven-year-olds. Their main investigation concerned whether children’s use of the definite or indefinite article when introducing a referent depended on whether they and their listeners share the same knowledge or not.

In Kail and Hickmann’s (1992) study, children were given a picture book that described three main characters; a boy, his dog, and his frog, and a number of secondary characters (e.g., bees, a mole, a reindeer an owl). Children’s task was to produce and narrate a story to an adult, based on these pictures. Children were placed in one of two different conditions; in the first condition both the child and the adult were looking at the picture book together, in the second condition only the child was presented with the picture book. Thus, whereas in the first condition children shared knowledge with the adult, in the case of the second condition no mutual knowledge existed between the adult and the child.
Interestingly, Kail and Hickmann (1992) found that mutual knowledge affected children’s responses. Their results had showed that children of all ages (i.e. six-, nine- and eleven-year-olds) used less frequently the indefinite article (e.g., *a dog*) when they shared mutual knowledge with their listener, than when they did not. Importantly, however, there were age differences in the way children used the indefinite reference in the condition that they did not share the same knowledge with their listener. Specifically, six-year-olds used both definite and indefinite articles very frequently regardless of whether they shared mutual knowledge with their listener. For nine-year-olds mutual knowledge was very important, and these children used the indefinite article more times in situations when no mutual knowledge was shared between them and their listener. Lastly, eleven-year-olds used the indefinite article when necessary, regardless of whether they shared mutual knowledge with their listener or not.

In light of these findings, Kail and Hickmann (1992) proposed that children’s adult-like competence with the indefinite reference develops into three stages. At first, children of approximately six years old do not use the indefinite reference in a systematic manner; these children, in the absence of mutual knowledge may use either a definite or an indefinite article to introduce a new referent into discourse. Also, even in cases in which six-year-olds do use the indefinite article, this reference is usually used as a deictic reference. At the next stage, children at around nine years of age no longer use deixis as a means of disambiguation to whom the indefinite reference is referring to. Nevertheless, nine-year-olds still have difficulty with reference introductions, since they use the indefinite reference strictly when the participant in the conversation does not share the same knowledge with them. Therefore, in the absence of mutual knowledge between them and their listener, the same children may also inappropriately use the definite reference to introduce a new referent to discourse. At the final stage, children at
eleven years of age learn the full functions of articles, and thus use an indefinite reference to introduce a new referent regardless of whether they share the same knowledge with their listener or not.

The suggestions of Kail and Hickmann (1992) are important for the current purposes, since they propose that it is not until eleven that children use the definite and indefinite reference in the same manner as adults. This shows that unlike adults, young children, do not use anaphoric devices strictly to form links between sentences. Perhaps this difficulty that young children experience when interpreting definite and indefinite reference will also be present in the current experiments when six- to eight-year-olds will have to interpret the type of anaphors (e.g., quantified noun-phrases and bare cardinals) that the current research examines.

Another important observation in children’s difficulties with the definite and indefinite reference comes from the study conducted by Krämer (2002). Krämer’s findings are very important for the current purposes, since her research clearly showed that unlike adults, children, have difficulty in considering prior discourse context when comprehending stories that contained the indefinite reference. In the current research, successful comprehension of the discourses that children and adults will be presented with largely depends on integrating the information found in one sentence with information from prior discourse context. It is therefore essential to review Kramer’s study that showed a difficulty by children in exploiting the prior discourse context.

3.2.4. **Non-Contextual Influence in the Interpretation of the Indefinite Reference**

Krämer (2002) examined whether four- and five-years-olds are influenced by prior discourse context when they comprehend stories that contain an indefinite article. In
particular, in one of her experiments Krämer presented children and adults with a series of pictures that described a story. The story that the pictures formed was narrated by an experimenter while participants were presented with one picture at a time. The picture that described the critical test sentence, that always contained an indefinite expression, was incomplete; participants’ task was to complete the picture from a set of cut-out figures they had in front of them. For instance, in the example story presented below, the third picture illustrated only the hand of the person that was feeding the elephant. Participants’ task was to select and stick on the picture, the figure they thought completed the picture.

*Picture 1:* Look this story is about these children. One day, they went to the zoo. The story is about all the things that happened, and things they saw.

*Picture 2:* First, they went to see the elephant.

*Picture 3:* A boy fed the elephant. “But look, there’s only an arm! Can you finish the picture for me?”

There were a number of cut-out figures that participants could select and stick, to complete the picture above. Some of them were identical to the protagonists of the story, whereas some others were figures of persons that were not involved in the story. Clearly, for adults prior discourse context plays a crucial role when comprehending a story, for this reason Krämer (2002) expected that adults would use one cut-out figure that was illustrating one of the protagonists of the story. This is because in the story context presented above the indefinite expression *a boy* should be interpreted as referring to one out of many identical referents (i.e. one out of many boys). Indeed the
results of Krämer showed that adults almost always (99% of the time) selected a cut-out figure of a boy that was already present in the story. Importantly however, four- to five-year-olds responded in a non-adult way. Specifically, four-year-olds 57.3% of the time and five-year-olds 58% of the time, rather than selecting a cut-out figure from the set of protagonists, they selected a figure that was not part of the story. Krämer suggested that this finding was an indication that young children are not influenced by discourse context when comprehending stories that contain the indefinite article.

Thus importantly, children’s difficulty with the definite and indefinite reference has been clearly shown in yet another study. Also importantly, as it will be reviewed in the next section of this chapter, Krämer (2002) conducted a similar experiment investigating if children are contextually influenced when comprehending pronouns, and significantly the results of this experiment showed that children have similar difficulties in interpreting a pronoun as anaphoric to an entity already established in the prior discourse context.

The observation that young children, unlike adults, are not largely influenced by discourse context when comprehending a story is very important for the current purposes. It suggests that young children do not naturally form links between sentences when comprehending a story. This is highly related to the issues of interest for the current research which examines whether children form links between sentences when interpreting discourses that contain numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals).
3.2.5. Section Summary

In summary this section reviewed a number of studies that have clearly showed that children have a difficulty with the definite and indefinite reference. The finding that it is not until a relatively old age that children begin to use articles in the same manner to adults, is of significant importance for the purposes of the current research. The research that has been reviewed in this section showed consistently that whereas adults mostly use the definite article as a means of referring to a specific referent from prior discourse context, young children often use the definite reference to introduce new referents into discourse. Additionally, it has been also shown that whereas adults mostly use an indefinite article to refer to one out of many identical objects that exist in the discourse context, children often use the definite article. The difficulty that children younger than eight have in using the definite and indefinite reference as a means of connecting together different parts of the text, is crucial for the current purposes. Perhaps this difficulty would be also present when six- to eight-year-olds will analyse the anaphors that the current research is concerned with; specifically, it is possible that children will have a general difficulty in using the numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) to form links between the two sentences that they will be presented with in the current experiments.

3.3 Children’s Difficulty with Pronouns

This chapter until now has been concerned with two main difficulties by children. The first section discussed Piaget’s (1952; Inhelder & Piaget, 1964; Piaget & Inhelder, 1969) suggestions of children’s difficulty in taking into account a perspective
other than their own, as well as children’s difficulties with resolving the relationships between a subclass and its class. In the second section several studies have been reviewed that clearly showed that children have a difficulty in using the definite and indefinite reference as a means of connecting together different parts of the text. The focus of this section is on yet another difficulty by children; that is, similarly with what has been observed from research which examined children’s use of the definite and indefinite reference, research has also showed that children have a difficulty in using pronouns (e.g., he, she, it) for connecting together different parts of a text. This difficulty is very relevant to the aims of the current research, since once again it shows that children’s use of anaphoric devices is quite different than those of adults. Consider for example the discourse shown in (15).

15. Tom went to the zoo. He saw many animals.

An adult reader is not expected to have a difficulty in comprehending a discourse like the one shown in (15). Similarly with the definite article, pronouns are usually used to refer to an already established referent in the prior discourse context. Therefore, an adult reader will interpret the pronoun he of the discourse shown in (15) as referring to Tom. Interestingly, research that examined how children use pronouns when narrating a story has highlighted considerable differences in the way children are using pronouns. This research clearly showed that children often use pronouns without first establishing to whom the pronoun is referring to. Pronouns have clearly an important role in communication therefore, it is clearly very important to review some of the research that has been conducted in this area. One valuable study that clearly shows children’s difficulty with pronouns was conducted by Karmiloff-Smith (1980);
this study showed that children often produce pronouns without ensuring that a referent of the pronoun exists in the prior discourse context. It is essential to review this study.

3.3.1. *Children's Non-Anaphoric use of Pronouns*

Karmiloff-Smith (1980) examined the production of pronouns in children’s story telling. The participants of this study were three hundred and fifty English and French speaking children, between the ages of four to nine. In one experiment, children were given a bound book with six pictures, with the task to say to the experimenter what was happening in the story. For instance, in one book the pictures formed the following story:

*Picture 1:* a little boy is walking along the road

*Picture 2:* the boy sees a balloon-man

*Picture 3:* the balloon-man gives the boy a green balloon (or the boy takes a green balloon from the balloon-man)

*Picture 4:* the boy walks off with the balloon

*Picture 5:* The balloon flies off into the sky (or the boy lets go of the balloon)

*Picture 6:* the boy starts to cry (Karmiloff-Smith 1980, p. 239).

Importantly, Karmiloff-Smith (1980) noticed that children younger than six did not describe the pictures anaphorically; specifically she noticed that children rather than using pronouns to connect the six pictures together, they used pronouns irrespective of the previous picture. For example, (16) illustrates a typical description from children.
Note, that here (B) stands for boy, (M) for the balloon-man, and (GB) for the green balloon.

16. He’s (B) walking along…and he (B) sees a balloon-man… and he (M) gives him a green one… and he (B) walks off home… and it (GB) flies away into the sky. So he (B) cries (Karmiloff-Smith 1980, p. 241).

Although the narration of the story in (16) appears to be ambiguous, Karmiloff-Smith (1980) noticed that children younger than six often disambiguated to whom each pronoun was referring to, by the use of deixis (i.e. different gestures such as pointing, eye gaze and head movements). Nevertheless, in cases in which listeners do not share the same visual context with the speaker, the deictic use of pronouns would not disambiguate the discourse. This is the main reason adults mostly use pronouns to refer back to elements established in the previous discourse context.

Karmiloff-Smith (1980) developed a theory based on the findings of this study. She suggested that children go through three stages of development in their use of pronouns. In the first level children approximately three to five use pronouns mainly to refer to objects in the immediate visual environment. In the second level, at around the age of five to eight, children begin to use pronouns to link sentences together; nevertheless they mainly use pronouns to refer to the protagonist of the story; something which has been described by Karmiloff-Smith as a thematic subject strategy. In the final level children roughly at eight to twelve used full anaphoric strategy in which they start to use pronouns similarly as adults do. Specifically, in this level children use pronouns to refer to entities mentioned previously in the discourse and to form links between different characters in a story.
Thus, importantly the research of Karmiloff-Smith (1980) clearly shows that children have a difficulty in using pronouns as a means of connecting together different parts of a text. This difficulty by children has been observed by many researchers (e.g., Bamberg, 1986; Bavin & Shopen, 1985; Shapiro & Hudson, 1991) and although it has been shown that manipulations of the task, such as showing the set of pictures before the task, appears to improve children’s use of pronouns as a means of referring to a previous established referent (e.g., Bamberg, 1986), nevertheless, even under these situations it is generally agreed that young children do not predominantly use pronouns to integrate together different parts of a text.

The difficulty by children in using pronouns as a means of establishing relationships between two sentences is highly relevant for the current research. Importantly it shows that children when narrating a story do not use pronouns in a similar manner to adults. While adults predominantly use pronouns as a means of connecting together different parts of a text, children often use pronouns without first establishing a referent in the prior discourse context. Clearly such difficulty has very important consequences on how children interpret discourse and thus definitely is very important for the purposes of the current research.

Importantly, the difficulty children face in using pronouns as a means of forming links between sentences has not been restricted to observations on how children narrate a story. Other research has shown that the same difficulty exists when children are comprehending stories. The experiment conducted by Krämer (2002) is very important in this area, since it has shown that young children, unlike adults, do not use pronouns as a means of connecting one part of the story with information already established in the prior discourse context. It is important to review this experiment since knowing
children’s difficulties when comprehending a text that contains anaphors is something which is highly related to the main issues of the current research.

3.3.2. Non-Contextual Influence in the Interpretation of Pronouns

Recall that in the previous section an experiment conducted by Krämer (2002) was reviewed which examined whether four- and five-year-old children are influenced by context when comprehending a story that contained an indefinite article. Recall that the results of that experiment showed that children, unlike adults, often had a difficulty in interpreting the indefinite article as referring to one out of the protagonists established in the story’s context; rather children often interpreted the indefinite article as referring to general entities not necessarily established in the story’s context. What is of particular importance is that Krämer obtained similar results when the same technique was used in another experiment which examined children’s interpretations of pronouns.

In particular in Krämer’s (2002) pronoun experiment, children and adults were again presented with pictures that formed a story that was narrated by an experimenter. Using the same task as in the indefinite experiment, in the pronoun experiment participants had to stick a cut-out figure to complete a picture that was described by a pronoun. Participants had the choice of selecting from cut-out figures that either corresponded to one of the protagonists of the story or cut-out figures that corresponded to persons that were not involved in the story. An example of a picture story that was used in this experiment is described below.
**Picture 1:** Look this story is about these children. One day, they went to the zoo. The story is about all the things that happened, and things they saw. First they had to have tickets to get into the zoo. This (point) boy bought some tickets.

**Picture 2:** First, they went to see the elephant.

**Picture 3:** He fed the elephant. “But look, there’s only an arm! Can you finish the picture for me?”

Crucially, if children are influenced by prior discourse context when interpreting a pronoun, then they are expected to select a cut-out figure corresponding to one of the protagonists of the story to complete the pictures illustrated above. This is because this will show that children interpreted the pronoun as referring to elements already established in the prior discourse context. The results of Krämer’s (2002) research have shown that adults always selected a cut-out figure corresponding to a boy protagonist of the story. This clearly shows that adults mainly interpret pronouns with respect to the referents introduced in the prior discourse context. Importantly however, this was not the case with four- and five-year-olds who were often found to select a non-protagonist figure to complete the story. In particular 48.4% of the time the four-year-olds, and 34.3% of the time the five-year-olds selected a non-protagonist figure to complete the picture.

This is a very important finding; it shows that children, unlike adults, also allow a non-anaphoric interpretation of pronouns. Specifically, whereas adults mainly use pronouns as a means of connecting together the information currently processing, with information from the prior discourse context, children often interpret pronouns irrespective of the discourse context. Thus, similarly with the findings of the research
that investigated children’s use of the definite reference, research with pronouns shows that children do not use anaphoric devices in a similar manner to adults. Whereas adults naturally use anaphors to form links between succeeding sentences, children have a difficulty in doing so.

Further support for the finding that children use pronouns in a non-adult way has been obtained from the research conducted by Tyler (1983; see also, Tyler, 1981). Significantly, Tyler’s study showed that whereas adults almost immediately spot a mispronounced word in a story that contains a pronoun, young children are less able in doing so. This is an important finding since it shows that adults automatically form links between sentences as soon as they hear a text, whereas children are less able in doing so. It is valuable to review this study in more detail.

3.3.3. Processing Demands Associated with Pronoun Assignment

In Tyler’s (1983) study, Dutch speaking adults and children of ages five, seven and ten, listened to short stories over the headphones with the task to press a button as soon as they heard a word that was mispronounced. The reaction time that was taken by participants to press the button from the time they heard the mispronounced word, was measured. For instance, in one of Tyler’s experiments participants heard stories containing discourses like the one shown in (17), with the word *ice, ijs* in Dutch, being mispronounced towards the end of the first syllable.

17. The skater in the orange suit was our nephew. He fell on the *ice* and broke his leg...
Spotting the mispronounced word *ice* for the discourse shown in (17) largely depends on hearers’ ability to interpret the pronoun *he* of the second sentence as referring to *the skater* that was mentioned previously in the context. This is because the word *ice* is predictable if the skater is the referent of the person who broke his leg. Tyler (1983) compared the reaction time of participants when presented with discourses like (17) with participants’ ability to spot the mispronounced word when in place of the pronoun was a repeated definite noun-phrase (e.g., the skater… the skater…) or a repeated property/name (e.g., the skater… our nephew…). The results showed that adults and older children were very fast in spotting a mispronounced word when the discourse contained a pronoun. This finding clearly showed that adults and older children automatically formed links between the pronoun and its referent from prior discourse context. Importantly however, unlike adults and older children, five-year-olds were often slower at finding the mispronounced word of a story that contained a pronoun. This shows that young children did not automatically connect the pronoun with its referent from prior discourse context.

Additionally, the results of Tyler (1983) showed that young children were also slower in spotting a mispronounced word in discourses where the referent of the pronoun was not clearly the main topic or theme of the discourse. Similarly to the suggestions of Karmiloff-Smith’s (1980) that young children use a thematic subject strategy (i.e. use of the pronoun mainly to refer to the protagonist of a story), Tyler suggested that five-year-olds are better in forming links between sentences when the referent is the thematic subject of the discourse than when it is not.

The results of Tyler (1983) are very important; they provide clear strong evidence that young children do not interpret pronouns in the same way as adults. Whereas for adults, a pronoun is a useful tool that enables them automatically to form
links between sentences, it appears that for young children forming links between sentences is not something that happens automatically when they are processing a text. This is a crucial finding regarding the aims of the current research. In the current experiments six- to eight-year-olds and adults will have to interpret discourses that contain numerically quantified expressions, for which many times their successful interpretation depends on the readers’ ability to form links between sentences. Significantly, Tyler’s findings appear to suggest that children might have a difficulty in forming the necessary links to successfully interpret discourses that contain numerically quantified expressions.

3.3.4. Section Summary

In summary, the purpose of this section was to review several studies that examined children’s processing of sentences that contain pronouns. The results from existing research that investigated children’s narration of stories clearly showed that children use pronouns differently than adults; whereas adults mainly use pronouns to refer to an already established discourse referent, children often employ a pronoun without first establishing its referent. Supporting evidence for this view comes from previous research which examined children’s interpretation of pronouns in written texts. Such research clearly showed that children, unlike adults, do not always use pronouns as a means of connecting together different information in a text. Whereas adults naturally and automatically use pronouns as a means of integrating different parts of a text, children are less able in doing so.

The findings from research that examined children’s use and interpretation of pronouns is very important for the aims of the current research, since they provide
strong evidence that children and adults employ different strategies when comprehending a text. This is a significant finding which appears to suggest that in the current experiments children and adults will interpret differently discourses that contain numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals). If children’s difficulty with anaphors is not restricted to their interpretation of pronouns and the definite expression, then it is possible that children in the current experiments will find it difficult to form links between anaphoric numerically quantified expressions and information from prior discourse context.

3.4 Children’s Difficulties with Inference Generation

The previous two sections have clearly showed that children have a difficulty in using explicit anaphoric devices (i.e. definite reference and pronouns) in order to connect together different parts of the text. This section discusses yet another difficulty experienced by children; a difficulty they have in connecting two sentences together when the information contained in a text can only be inferred. Inference making plays an essential role for successfully comprehending a text, since speakers or writers many times leave the links between ideas in a text implicit. In such cases readers or listeners will have to be able to infer the relationship between this information in order to successfully comprehend the text. For instance, consider the short story presented in (18), adapted from Charniak (1972).

18. Jane was invited to Jack’s birthday party. She wondered if he would like a kite. She went to her room and shook her piggy bank. It made no sound.
Although this is a relatively short story, nevertheless the reader has to draw a number of inferences to connect the information contained in the three sentences and thus be able to successfully comprehend this story. For instance, the reader has to infer that what Jane is intending to do is buy Jack a present. Generating this inference depends on the reader’s world knowledge of the act of giving presents at birthday parties. Moreover, it appears that Jane did not only wonder whether Jack would like a kite, but perhaps planned in buying him one, this is inferred by the fact that she searched in her piggy bank to see if she saved any money. Furthermore, the fact that the piggy bank did not make any sound suggests that she did not have any money, and therefore a further inference would be that she will not buy a present for Jack. This story, despite its simplicity, clearly shows how essential inferences are in successfully comprehending a text.

Research that investigated adult’s abilities to draw inferences for successful comprehension of a text, has clearly showed that adults do not have a difficulty in drawing inferences to connect information contained in different sentences. For instance, recall the research conducted by Clark and Haviland (1977) which has been described in Chapter 2, these researchers found that adults automatically draw an inference to form links between ideas found in different sentences. This shows that inference generation is a natural part of adults’ discourse comprehension. Importantly however, as it will be discussed in this section, children do not appear to be as successful as adults in drawing inferences for connecting sentences in a text. This finding is very important for the current research, since once again it suggests differences in the way adults and children comprehend a text.

In this section relevant research that examined children’s inference generation will be discussed which suggests that young children do not automatically draw
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inferences to connect together ideas contained in a text. This is a significant observation for the aims of the current work, since it clearly shows that children do not naturally form links between sentences when comprehending a text. Apparently, this finding suggests that children in the current experiments will have a difficulty in connecting numerically quantified expressions (i.e. quantified noun-phrase and bare cardinal) with information from prior discourse context.

One important study that showed differences between children’s and adults inference making comes from Avrutin and Coopmans (2000). These researchers found that although children were often able to draw inferences from a text, nevertheless these inferences were often not supported by prior discourse context. This is an important observation since it suggests that children, unlike adults, are not contextually influenced when comprehending a text. This appears to suggest that children in the current research might find it difficult to use the contextual information to find the referent of the quantified noun-phrase or bare cardinal in order to connect the information contained in the two sentences. It is important to review Avrutin and Coopmans study in more detail.

3.4.1. Non-contextual Influence in Inference Making

In their study, Avrutin and Coopmans (2000) examined whether three- to six-year-olds similarly with adults naturally draw inferences when comprehending a discourse. Avrutin and Coopmans presented Dutch, Russian, and English speaking children with one picture accompanied with a two-sentence discourse that was narrated by a hand puppet (controlled by an experimenter). After the presentation of the picture and discourse, the hand puppet made guesses concerning the events illustrated in the picture; children’s task was to evaluate if these guesses were in line with the events
depicted in the picture. For instance, in one trial the hand puppet presented children with one picture that illustrated a boy with red pants eating, and a girl with green pants playing, accompanied with two different discourses. In one condition the discourse that accompanied the picture was the one shown in (19a), whereas in the other condition the discourse was the one shown in (19b).

19.  
   a) A boy is eating. The pants are red.
   
   b) A boy is eating. The pants are green.

Following the general rules of English language, when a definite expression like the pants is used the reader has to search in the discourse context to find its referent. The discourse context for both (19a) and (19b) however, does not contain an explicit referent for the definite expression; therefore, in order for the reader to successfully comprehend the discourse it is necessary to rely on the contextual source and infer a referent for the pants. The prior discourse context describes a boy and since the boy is wearing red pants, the reader will infer that the boy is the referent of the pants. Following this rule the children in Avrutin and Coopmans’s (2000) experiment should evaluate as correct the picture illustrating a boy with red pants eating, and a girl with green pants playing, for the discourse shown in (19a), but crucially not for the discourse shown in (19b). This is because the discourse shown in (19b) can only be true if the picture illustrated a boy wearing green pants.

The results of Avrutin and Coopmans’s (2000) study have showed that whereas children of all age groups were able to draw the necessary inference and correctly accepted discourses like the one shown in (19a) as corresponding to the picture, the same children many times made many mistakes with discourses like those shown in
(19b). That is, children of all ages, and especially younger ones, interpreted discourses like that shown in (19b) as correctly reflecting the picture, even though the discourse was not supported by prior discourse context.

This is an important finding. It suggests that children do not have a difficulty in drawing an inference, instead what appears to be difficult for children is drawing the inference that is contextually supported. Avrutin and Coopmans (2000) suggested that this difficulty by children is because more processing resources are needed by children to follow solely the contextual influence. Specifically, Avrutin and Coopmans suggested that children also use non-linguistic reference such as deixis (e.g., pointing to the girl that was wearing the green pants) when interpreting discourses like (19b), mainly because finding when the contextual influence is more appropriate requires additional processing resources from children.

Recall that in Chapter 2 Avrutin’s (1994; 1999) file-card theory has been described which suggests how readers are able to keep track of the information contained in a text. Recall that according to this theory adults automatically form mental file-cards that enable them to connect together information contained in different sentences. The findings from Avrutin and Coopmans (2000) study appear to suggest that these file-cards are not constructed automatically when children comprehend a text. Thus importantly, this suggests that children and adults employ different strategies when comprehending a text; whereas adults automatically form links between sentences it appears that children are less able in doing so.

In terms of the current research this is a crucial finding. It suggests that children, unlike adults, are not strongly predisposed to follow the interpretation that is contextually supported when comprehending a text. This is definitely related to the phenomena that the current research investigates. In the current research six- to eight-
year-olds and adults will be presented with discourses that contain numerically quantified expressions for which successful interpretation largely depends on forming links between a sentence and its prior discourse context. Significantly therefore, the findings from Avrutin and Coopman’s (2000) research appear to suggest that children (unlike adults), in the current experiments, will find it difficult to form links between sentences to achieve the anaphoric interpretation of numerically quantified expression ambiguities.

Another interesting line of investigations that has provided some very useful information regarding children’s inference generation, comes from a considerable amount of studies that have been conducted by Cain, Oakhill, and their colleagues (e.g., Cain & Oakhill, 1999; Cain, Oakhill, Barnes & Bryant, 2001; Oakhill, 1982; 1984; among many). Most of their studies focused on examining the relation between children’s comprehension ability and inference generation; their findings suggest that there is a strong relationship between children’s ability to draw an inference and poor or good comprehension. Although the studies of these researchers provided some interesting findings on some general influences that are affecting good and poor comprehension, for the current purposes only one particular study will be discussed. This study is valuable for the current purposes, since it highlights that inferences are drawn automatically when readers comprehend a text.

3.4.2. Relation between Inference Generation and Comprehension Ability

In one of her earlier studies Oakhill (1982; see also Oakhill, 1983; 1984; Oakhill, Yuill & Parkin, 1986) investigated whether seven- to eight-year-olds could draw the necessary inferences in order to integrate information within a text. Oakhill
examined children that were divided into two groups based on a series of tests that tested their comprehension level (see Cain & Oakhill, 1999 for details on these tests); one group of children had comprehension levels that were advanced for their chronological age (skilled readers), whereas the other group of children had poor comprehension levels for their chronological age (less-skilled readers). In one experiment children listened to eight short stories, like the one shown in (20), which they had to remember. After children listened to the stories children were then presented with four test sentences with the task to say whether these sentences appeared in the story or not.

20. The car crashed into the bus. The bus was near the crossroads. The car skidded on the ice.

There were three types of sentences that children were presented with when they heard the story shown in (20); two of them were identical to those used in the story (e.g., the bus was near the crossroads), the other one contained a valid inference that could be drawn if children integrated the information contained in the text (e.g., “the car was near the crossroads”), and the last one although it contained information about the story, it nevertheless contained an invalid inference that was not compatible with the overall meaning of the text (e.g., “the bus skidded on the ice”).

The results of Oakhill’s (1982) memory experiment showed that both skilled and less-skilled readers made similar errors when they were presented with sentences that were originally contained in the story. Additionally, both groups incorrectly accepted sentences that contained valid and invalid inferences, showing that while they were listening to the story both groups of children were trying to form links between
sentences. Importantly however, skilled readers incorrectly accepted more sentences that contained valid inferences than did their less-skilled peers; this shows that for skilled readers forming links between sentences for successfully comprehending a text happens more naturally compared to less-skilled readers.

Oakhill (1982) suggested that the differences between skilled and less-skilled readers, drawing of inferences were because these two groups used different strategies when trying to understand connected text. Specifically, Oakhill proposed that when skilled readers were first presented with the stories, rather than simply trying to remember the sentences, they automatically integrated the ideas in the text, whereas less-skilled readers did not engage to the same extent in such constructive processing.

This proposal by Oakhill (1982) is a very important. It suggests that one of the main differences between populations with different comprehension skills is their ability to integrate together different parts of the text. Specifically, children whose comprehension level is above their chronological age are performing similarly to adults, whereas the other children have a difficulty in drawing the necessary inferences to successfully comprehend a text. If one goes a step further and compares the differences between adults and children, their biggest difference also lies in their comprehension skills. Thus, the finding obtained by Oakhill may also apply to the differences between children and adults. Apparently, whereas for adults comprehension happens automatically when reading a text, this is not always the case with seven- to eight-year-olds who need more processing in order to achieve integration. This finding is crucial for the aims of the current research, since it appears to suggest that there would be differences in six- to eight-year-olds’ and adult’s comprehension of the discourses which the current research examines.
A last relevant study that will be reviewed in this section comes from Wykes (1981). This study is valuable since Wykes investigated the ability of children to form links between sentences that contained a pronoun when the referent of the pronoun could only be inferred. As it was clearly shown in an earlier section of this chapter, children have a difficulty in using pronouns as a means of connecting different parts of the text. Thus, it is definitely important to see children’s competencies when the relationship between the pronoun and its referent can only be inferred.

3.4.3. *Inference Generation and Comprehension of Pronouns*

In Wykes’s (1981) study, five-year-olds were presented with two-sentence discourses with the task to act-out the second sentence of the discourse using puppets. There were two versions of discourses that children were presented with; in one version, shown in (21a), the referent of the pronoun could be distinguished by gender, in the second version however, shown in (21b), the entities described in the discourse were of the same gender and therefore the pronoun referent could only be distinguished by drawing an inference. Consider the examples presented in (21a) and (21b).

21. a) Jane found John’s ball. She gave it to him.
   b) Jane needed Susan’s pencil. She gave it to her.

Because of gender cues, the pronoun *she* in the second sentence of the discourse shown in (21a) clearly refers to Jane, whereas the objective pronoun *him* refers to John. Therefore this discourse is interpreted as “Jane gave the ball to John”. However, this is not the case with the discourse shown in (21b), since the pronoun *she* could refer both to
Jane and Susan. Thus, successful comprehension of discourses like the one presented in (21b) largely depends on drawing an inference. The relevant inference that has to be drawn for the discourse shown in (21b) is that based on general world knowledge when someone needs something they usually do not have that thing in their possession. Following this inference, the pronoun \textit{she} in the second sentence of the discourse shown in (21b) refers to Susan who has the pencil, whereas the objective pronoun \textit{her} refers to Jane who needs the pencil; therefore the discourse should be interpreted as “Susan gave the pencil to Jane”.

The results of Wykes (1983) study showed that five-year-olds had difficulty in assigning reference to pronouns, both when the referent of the pronoun could only be distinguished by gender (21a) and when the pronoun referent could be distinguished by drawing an inference (21b). Therefore, as with the previous research described in an earlier section of this chapter (i.e. Karmiloff-Smith, 1980; Krämer, 2002; Tyler, 1983), this study clearly showed that children have a particular difficulty with pronoun assignment. Additionally, children’s performance was poorer in cases in which they had to draw an inference for successful assignment of the pronoun. According to Wykes (1981), children’s difficulties in interpreting the pronoun were not because they failed to generate the necessary inferences, but because the children had an overwhelmingly strong tendency to interpret the pronoun as referring to the first mentioned subject. According to this argument, children’s mistakes with discourses like those illustrated in (21b) are because they assigned \textit{she} as referring to the first mentioned subject, in this case to \textit{Jane}.

A similar proposal was made by Wykes (1983) based on the results he obtained in a sentence comprehension study. Wykes found that children were able to draw inferences, but their mistakes were because they used an \textit{order-of-mentioned strategy}. 
According to this view, five-year-olds assignment of reference largely depends on the first mentioned noun-phrase. For instance, when interpreting sentences such as “I put the pencil in my pocket and because it had a hole it fell out” young children interpret the first instance of the pronoun *it* as referring to the first mentioned definite expression *the pencil*; that is, interpreting the sentence as meaning that the pencil had a hole.

Thus, according to the suggestions of Wykes (1981; 1983) young children appear to use different strategies when they resolve the referent of pronouns. Whereas adults draw the necessary inferences for successful comprehension of a text, it appears that children often have difficulty in drawing the necessary inference for successful interpretation of the discourse. As with all the previous experiments that have been described in this section, this finding shows clearly that children, unlike adults, do not naturally draw inferences in order to form links between different sentences in a text.

3.4.4. *Section Summary*

In summary, this section has clearly shown that young children, unlike adults, have difficulty in drawing the necessary inferences for successful comprehension of a text. The research that has been described in this part has shown that whereas adults are largely influenced by context when generating an inference, children are less able in doing so. This many times results in children drawing an incorrect inference, which affects successful comprehension of the text they are currently processing. The findings from research that examined inference generation are useful for the purposes of the present study, since they clearly show that connecting sentences in a text by drawing an inference is not something that happens naturally when children comprehend a text. This appears to suggest that children’s difficulty in forming links between sentences
might also be present when children will need to analyse the discourses that they will be presented with in the current experiments.

3.5. Chapter Summary

The purpose of the current chapter was to draw the attention to several difficulties by children when comprehending language. In the first section it was clearly shown that children younger than eight have a general difficulty in comparing a class of objects with its subclass. This finding is essential for the issues the current research is concerned with, since successful comprehension of the discourses that the six- to eight-year-old children will be presented with in the current experiments, largely depends on resolving the relationships between sets and subsets.

The other three sections discussed children’s competencies when employing and interpreting explicit (e.g., pronouns and the definite reference) and implicit (e.g., through inference generation) anaphors. Importantly, this research showed consistently that children roughly before the age of eight have a particular difficulty with anaphors. It has been clearly showed that whereas adults naturally and automatically use anaphors as a means of connecting information contained in different parts of a text, children often have a difficulty in doing so. In particular, children do not naturally form links between sentences, rather connecting sentences in a text appears to incur a processing difficulty for children. This is a critical finding for the aims of the current research. In the current research six- to eight-year-olds will be presented with anaphoric numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) which their successful comprehension largely depends on forming links between sentences. The findings from the research that has been described in this section appear to suggest that
children might have difficulty in using numerically quantified expressions as a means of connecting information found in different sentences.
Chapter 4:
Quantifiers & Anaphoric Numerically Quantified Expressions

The earlier chapters were concerned with discussing general issues that are related to the phenomena that the current research is concerned with. Chapter 2 presented several accounts that provide some valuable information on the strategies that adults employ when comprehending a text. The most important themes that came out from this discussion was that when adults are processing sentences in a text they automatically form links between the information they are currently processing and information from prior discourse context. Importantly however, it was also shown that children do not employ the same strategies as adults when comprehending a text. A number of studies have been discussed that highlighted that children, unlike adults, have difficulty in forming referential links between sentences in order to successfully comprehend a text. This difficulty was further emphasised in Chapter 3 in which it has been clearly shown that children have difficulty in resolving the anaphoric relations of both explicit (e.g., pronouns and the definite reference) and implicit (e.g., inference generation) anaphors.

The present chapter concentrates on the topic of main interest of the current research; that is, children’s and adults’ interpretations of quantifiers, that when contained in a discourse can function as anaphors. Similarly with other types of anaphors, quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…) often take their meaning from an earlier part of the text; thus, successful interpretation of discourses that contain numerically quantified expressions largely depends on connecting the anaphor with its referent found in an earlier part of the text. Importantly however, numerically quantified expressions also allow a non-anaphoric reading; when
they are contained in a text they are often ambiguous between interpretations, in which they can either refer to a referent already established in the discourse, or as introducing new referents into the discourse. This ambiguity is presented in the short discourse shown in (22).

22. Three cats were on a wall. Two cats caught a mouse.

In this example, the quantified noun-phrase of the second sentence *two cats* is ambiguous between two interpretations. On one reading *two cats* can be interpreted as referring to a subset of the set of *three cats* that has been already established in the first sentence, and thus already established as a discourse referent. Following this reading the ambiguous discourse shown in (22) is interpreted as meaning that there was a set of three cats from which two of them caught a mouse. This interpretation would be referred to as a *subset reading* (Note that Diesing (1992) referred to this interpretation as *presuppositional interpretation*, since *two cats* is presupposed to exist in discourse). On the other hand, the quantified noun-phrase *two cats* can be interpreted as referring to a set of cats different to those established in the previous context sentence. Following this reading, the discourse is interpreted as meaning that there were three cats on the wall, and another two cats that caught a mouse. Since by following this interpretation *two cats* does not refer to an established referent, but rather introduces a new referent into discourse, this interpretation will be referred to as a *new-set reading* (or *existential interpretation*, Diesing, 1992).

Research into the interpretative preferences of readers and listeners when processing ambiguities like the one shown in (22) has only recently received attention by researchers (e.g., Frazier *et al.* 2005; Kaan, Dallas & Barkley, 2007; Paterson, Filik,
Mousoulidou, Baliousis & Moxey, 2008b; Wijnen & Kaan, 2006). The majority of these investigations were concerned with adults preferred interpretation, which was examined using a variety of methodologies, including judgment tasks, sentence completions, as well as eye-movement measures. Such research has clearly shown that adults have a strong preference for a subset reading of ambiguous numerically quantified expressions. For instance, in a series of experiments Frazier et al. (2005) showed that English speaking adults have a 65% preference in following the subset reading when analysing discourses that contain ambiguous quantified noun-phrases (e.g., three cats… two cats…), an effect that was also observed with Korean and German speaking adults. Other research conducted by Kaan and colleagues (i.e., Kaan et al. 2007; Wijnen & Kaan, 2006) has shown a similar preference by English and Dutch speakers when interpreting discourses that contained ambiguous bare cardinals (e.g., three cats… two…).

Importantly however, with the exception of one published study by Wijnen, Roeper and van der Meulen (2004), children’s interpretations of such ambiguities have not been thoroughly examined. Knowing how children interpret discourses like the one shown in (22) provides potentially important insights into the mechanisms underlying children’s sentence processing system. This is because similarly with other types of anaphors (e.g., pronouns, the definite reference and inference generation), numerically quantified expressions play an essential role in successfully connecting together information contained in different sentences. Thus, studying this type of anaphors is an important step towards better understanding of children’s discourse comprehension. This is the main reason that the current research was conducted.

Although the current research is concerned with quantifiers that serve like anaphors, the way quantifiers have been widely approached is in terms of their use to
define an amount or quantity of a referent in the discourse context. For instance, expressions like “some men”, “many men”, and “a few men” convey different information about an amount or quantity, and thus serve a different function in language. It is definitely useful to review quantifiers in the context of this research.

4.1. Adult’s and Children’s Processing of Quantifiers

4.1.1. Adults Processing of Quantifiers

Much of the psychological research that investigated adults’ comprehension of quantifiers has been primarily concerned with quantifiers used in syllogistic reasoning. Johnson-Laird and colleagues (e.g., Johnson-Laird, 1983; Johnson-Laird & Bara, 1984; Johnson-Laird & Byrne, 1991) have conducted many experiments investigating how adult readers and listeners reach to a valid conclusion when given two statements (or premises) that contain quantifiers. The results of this research propose that the quantifier that is used plays a very important role on how difficult or easy a syllogism can be. For instance, research (e.g., Johnson-Laird & Bara, 1984) has shown that adults do not have difficulty to reach the valid conclusion that “some of the artists are chemists” when given the syllogism “Some of the artists are beekeepers. All the beekeepers are chemists”. Nevertheless, other syllogisms are very hard to solve. For example, only few readers can reach the valid conclusion that “some of the clerks are not archers” when given the syllogism “None of the archers are boxers. All the boxers are clerks”.

Other psychological research has been concerned with the focusing effects of quantifier (e.g., Moxey & Sanford, 1987; Paterson, Sanford, Moxey & Dawydiak, 1998; Sanford, Moxey & Paterson, 1994; 1996; see also Geurts, 2003 for a theoretical account
based on formal semantics), as well as the processing of sentences that contain more than one quantifiers, and thus give rise to scope ambiguities (e.g., Anderson 2006; Filik, Paterson & Liversedge, 2004; Kurtzman & McDonald 1993).

The research that examined the focus patterns of quantifiers have shown that natural language quantifiers are interpreted differently by adults depending on whether the quantifier in question is a positive natural language quantifier (e.g., nearly all, many, some) or a negative natural language quantifier (e.g., not all, not many, few). For explanation purposes consider the sentences shown in (23).

23. Some/few of the fans went to the game. They…
   a) Watched it with enthusiasm.
   b) Watched it on television instead.

Sentences like the ones in (23) can be completed in two different ways. They can be completed with respect of the reference set already available in the discourse context (i.e. the set of fans that went to the game) like (23a), or they can be completed with respect of the complement set that is not directly mentioned in the previous discourse context (i.e. the set of fans that did not go to the game) like (23b). The research by Sanford, Moxey and colleagues (e.g., Moxey & Sanford, 1987; Paterson et al. 1998; Sanford et al. 1994; 1996) has clearly shown that when adults are asked to continue a sentence that contains a positive natural language quantifier like some, they have a strong preference for continuations like the one shown in (23a). This is not the case with sentences that contain a negative language quantifier like few, where adults strongly prefer continuations like the one shown in (23b).
Additionally, eye-tracking experiments (e.g., Sanford et al. 1996; Paterson, et al. 1998) have shown that this preference has an immediate effect on interpretation. For instance, Sanford et al. (1996) found that adults take longer to comprehend a negative quantifier like few when the sentence that followed referred to the set of fans that went to the game (i.e. reference set) than when it referred to the set of fans that did not go to the game (i.e. complement set). The opposite result was obtained when adults read sentences that contained positive quantifiers like some. That is, adults were faster when the positive natural language quantifier some referred to the reference set, than when it referred to the complement set.

Another line of research has examined adults’ processing of sentences that contain more than one quantifier and thus give rise to an ambiguity. The ambiguity arises as to which of the two quantifiers is the most dominant one and thus determines how the other is interpreted. In the literature this ambiguity has been referred to as scope ambiguity and is presented in the example shown in (24).

24. Kelly showed a photo to every critic.

The sentence shown in (24) is scopally ambiguous since the two quantifiers differ in terms of the relative scope they convey. On the one hand, the indefinite article a denotes that there is at least one photo, whereas the universal quantifier every denotes that there are multiple objects or entities. Therefore, the sentence shown in (24) can be interpreted in at least two different ways. It can be interpreted as meaning that the same photo was presented to different critics (i.e. surface-scope reading) or that different photos were presented to different critics (inverse-scope reading).
Several accounts have been developed to explain how readers process scope ambiguous sentences; it is generally assumed that adults have a preference for interpreting sentences like the one shown in (24) following the surface-scope reading (e.g., Anderson 2006; Fodor, 1982; Fodor & Sag, 1982; Ioup, 1975; Johnson-Laird, 1969; Kurtzman & McDonald 1993). For instance, the eye-movement experiments conducted by Paterson and colleagues (Paterson, Filik & Liversedge, 2008a; Filik et al. 2004) have shown that adult readers face a processing difficulty when the sentence in (24) has to be interpreted in the inverse-scope reading (i.e. different photos presented to different critics). This shows that adults' preferred interpretation is the one where the same photo was presented to different critics. (See Filik et al. 2004; Paterson et al. 2008a for further details on this research, as well as an account based on their findings).

Having established how adults interpret sentences that contain quantifiers, the attention is now turned to the research that examined children’s interpretations. Much of this work focused on investigations on children’s interpretations of quantifiers that are contained in individual isolated sentences. Nevertheless, this work is important for the current purposes, since it shows that children do not interpret sentences that contain quantifiers in the same manner to adults. This provides a framework of what might be expected to be found in the current experiments.

4.1.2. Children’s Processing of Quantifiers

Investigations of children’s interpretations of sentences that contain quantifiers date back to Piaget and his colleagues (Inhelder & Piaget, 1964) who have found a systematic non-adult performance by children. For instance, Inhelder & Piaget noticed that many children younger than eight, when presented with blue triangles and blue
circles and are asked the question shown in (25), “are all the circles blue?”, they incorrectly reply by saying “no”. Children often account for their choices by saying that there are blue triangles also.

25. Are all the circles blue?

Recall that in Chapter 3 in which Piaget’s theory (e.g., Piaget, 1952; Inhelder & Piaget, 1964) has been reviewed, it has been shown that among the many difficulties children younger than eight face, children also had a difficulty in correctly replying to the traditional class inclusion question “are there more cats or more animals”. Specifically, Piaget has found that children were unable to divide a group of objects into classes which share common features. Inhelder and Piaget (1964) attributed children’s errors to questions that contain quantifiers, like the one shown in (25), to this difficulty. That is, they proposed that children interpret the quantifier *all* as modifying both “blue” and “circles”; therefore children younger than eight misunderstand the question as asking “are all the circles blue and all the blue things circles”. This observation by Inhelder and Piaget has been called “quantifier spreading”, since the universal quantifier *all* has spread to other parts of the sentence. In the Piagetian framework, children’s difficulties with quantifiers decrease when children, after the age of eight, advance to the “concrete operations stage” (see Chapter 3 for more details on Piaget’s theory).

The research that was conducted after the initial findings of Inhelder and Piaget (1964) supported the view that children have difficulty with quantifiers. Much of this research focused on the universal quantifier *every*, mainly because of the finding that children often had a difficulty in correctly replying to questions or statements that
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contained the universal quantifier in the same way to adults. For instance consider the question shown in (26).

26. Is every boy riding an elephant?

Several studies have showed that when young children are asked to evaluate whether a picture that illustrates all of the boys riding an elephant, but in addition an extra elephant, corresponds to the correct answer of the question “is every boy riding an elephant” shown in (26), they often reply by saying “no” (e.g., Drozd, 2001; Drozd & van Loosbroek, 1998; Meroni, Gualmini & Crain, 2000; 2004; Philip, 1995). When children are asked to justify their responses, they often point to the elephant that is not ridden by any boy. It appears that the source of children’s non-adult response is that children interpret questions like the one shown (26) the same way as questions like the one shown in (27). That is, they interpret the question as asking about symmetry between boys and elephants. Thus, children consider such questions as correct only if every boy is riding an elephant and every elephant is being ridden by a boy. For this reason children’s negative response has been called “symmetrical response”.

27. Is every elephant being ridden by every boy?

A number of researchers advanced a linguistic perspective to explain children’s errors. For instance, Philip (1995) suggested that the differences between adults and children’s responses are because in children’s grammar the determiner every quantifies over the entire situation described in the sentence, whereas for adults every quantifies over the specific noun phrase described in the sentence. That is, for adults to accept as
correct a sentence like the one described in (27) is sufficient that the picture illustrates all of the boys riding an elephant, whereas for children all the events described in the sentence must be satisfied. In other words the picture must illustrate all of the boys riding an elephant and all the elephants being ridden by a boy.

Alternatively, Drozd and van Loosbroek (1998) suggested that children’s responses are motivated by the application of the universal quantifier *every* to the set of elephants; therefore, children accept a sentence like the one shown in (27) as true only if every elephant is being ridden by a boy. Adults on the other hand, interpret *every* to the set of boys; therefore, they accept a sentence as true if all the boys are riding one elephant. Although Philip’s (1995) account differs in detail from that proposed by Drozd and van Loosbroek (1998), both provided a grammatical explanation for children’s errors. This was questioned by Crain et al. (1996) who argued that children errors on sentences that involve the universal quantifier are a consequence of the methods used to test children’s comprehension.

Specifically, Crain et al. (1996) argued that without the appropriate contextual background yes/no questions are infelicitous, since they leave children to consider both the affirmative and the negative answer of the target sentence. Thus, according to Crain and colleagues the reason behind children errors is that children were not given any reason to think otherwise, such as that some boys might end up not riding an elephant. Crain and colleagues suggested that if the task makes available the possibility that some elephants might end up not being ridden by a boy, children responses will be improved.

Indeed, Crain et al. (1996) reports experiments that satisfied this condition and children performed about as well as adults. For instance, in one experiment children were told about a story of a mum and her two daughters who were skiing. The skiers were thirsty so they went to have a drink, but each one of them had a different drinking
preference. The girls wanted to drink soda, but their mum persuaded them to drink warm apple cider instead. Therefore, each of the three skiers ends up drinking a cup of warm cider. At the end of the story children are presented with five bottles of soda and five cups of apple cider and are asked whether the statement “every skier drank a cup of hot apple cider” is correct. Crain and colleagues noticed that under these conditions children responded incorrectly only 12% of the times.

Nevertheless, although interesting, Crain and colleagues’ (1996) results were not replicated by other researchers. For instance, Philip and Lynch (1999) obtained the standard pattern of results despite modifying the task to eliminate any response bias by children. Importantly, note here that this debate does not affect the experiments of the current work, since the discourses that children will be presented with in the current research, will always have a referent in the discourse context.

Thus, much of the research that has examined children’s comprehension of sentences that contain the universal quantifier suggests that children have difficulty in correctly replying to questions that contain *every*. This is an important finding since it shows that children’s non adult-like performance is not restricted to the resolution of anaphoric relations, but rather holds to a variety of linguistic phenomena, including quantifiers.

Further support for the view that children interpret quantifiers differently than adults comes from the research that has examined children’s comprehension of sentences that contained *every* and negation (e.g., Musolino, Crain & Thornton, 2000; see also Musolino, 1998), as well as numeric quantifiers and negation (e.g., Lidz & Musolino, 2002; Musolino & Lidz, 2003). The interaction between *every* and negation gives rise to scope ambiguities, it is therefore important to review how children deal with such ambiguities. Importantly, existing research suggests that while adult readers
can reach both interpretations when analysing ambiguous sentences, children often assign only one of the two. For instance consider the sentence shown in (28).

28. Every horse didn’t jump over the fence.

On one reading every is interpreted outside the scope of negation and therefore the sentence is interpreted as meaning that every horse is such that it did not jump over the fence. On the other reading every is interpreted within the scope of negation, and thus the sentence is interpreted as meaning that not every horse jumped over the fence. Musolino et al. (2000) found interpretative differences between children and adults when analysing sentences like the one shown in (28). Specifically, whereas adults could easily access both of these possible interpretations, young children could only assign the interpretation in which every was interpreted within the scope of negation. A similar finding was also obtained from research that examined children’s analysis of sentences that contained numeric quantifiers and negation. For instance Lidz and Musolino (2002; see also Musolino & Lidz, 2003; Musolino et al. 2000) examined young children’s interpretations of sentences like the one shown in (29).

29. The detective didn’t find two guys

The sentence shown in (29) is scopally ambiguous, since the quantified noun-phrase two guys can be interpreted both outside and within the scope of negation. If the quantified expression is interpreted within the scope of negation, the sentence will be analysed as meaning that the guys that the detective found did not number two (so perhaps the detective found only one guy or three guys). By contrast when the quantifier
expression *two guys* is interpreted outside the scope of negation the sentence is analysed as meaning that the detective did not find two specific guys that he was looking for (maybe the detective found two other guys).

The results of Lidz and Musolino’s (2002) research showed that adults did not have any difficulty in reaching either of the two possible interpretations. Children however, accepted sentences like the one shown in (29) only in contexts that favoured the analysis in which the quantified expression was interpreted within the scope of negation. Lidz and Musolino suggested that this finding might be an indication that young children do not yet have the linguistic knowledge of the unavailable scope analysis, or that processing limitations do not allow them to consider alternatives to their default scope analysis. (For further details on these suggestions see Lidz & Musolino, 2002; Musolino *et al.* 2000; Musolino & Gualmini, 2004; Musolino & Lidz, 2003).

Importantly, recall that children’s difficulty in reaching both possible interpretations has also been proposed by Trueswell *et al.* (1999) who studied children’s interpretations of syntactically ambiguous sentences. As discussed in Chapter 2, Trueswell and colleagues have found that children were unable to depart from their initial syntactic commitments when they were processing syntactically ambiguous sentences like “put the frog on the napkin in the box”. That is, children were unable to revise their initial interpretations, even though the discourse context suggested that this interpretation was incorrect. These are important findings in terms of the current research, since they appear to suggest that children will not be able to reach both interpretations when analysing the ambiguity the current research is concerned with. Importantly, similar difficulties have been also suggested by Paterson, Liversedge, Rowland and Filik (2003) who investigated the focus particle *only*.
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Achieving the correct interpretation of sentences that contain only depends largely on how readers mentally represent (in their discourse model) the information contained in the text. The discourse model that has to be constructed for sentences that contain only should include a focus set, which is the set of entities or objects that are explicitly described in the sentence and contrast this set with an alternative set, that contains the set of the entities or objects that are not described in the discourse. Importantly, the syntactic position of only often indicates what type of contrast set needs to be established. When only is in the pre-subject position (i.e. the psychological subject of the sentence), like in the sentence shown in (30), the contrast set should be between the characters described in the sentence. That is, the correct mental representation of the sentence shown in (30) should include the focus set of the fireman holding the hose and an alternative set of some other unspecified persons that are not holding a hose.

30. Only the fireman is holding a hose.

On the contrary if only is in the pre-verbal position (i.e. when it precedes the verb in the sentence), like in the sentence shown in (31) the contrast set should be between the events described in the discourse. That is, the correct mental representation of the sentence shown in (31) should include the focus set of the fireman holding the hose and an alternative set of some other unspecified objects that the fireman is not holding. Thus, correct interpretation of only largely depends on constructing a discourse model that contains the correct set of alternatives.

31. The fireman is only holding a hose.
In their study Paterson et al. (2003) examined children’s and adults interpretations of sentences like the ones presented in (30) and (31), against unambiguous counterparts that did not contain the focus particle, such as “the fireman is holding a hose”. The aim of their study was to examine whether children and adults differ in their interpretation of sentences that contain only. In particular, participants of Paterson and colleagues were given a forced-choice picture-selection task in which they were presented with three types of sentences accompanied with a number of pictures; participant’s task was to select the picture that they considered truly corresponded to the meaning of the sentence.

The results of the three experiments conducted by Paterson et al. (2003) have showed that while both children and adults produced a high frequency of correct responses for sentences without only, children, unlike adults, made a large number of errors with sentences that contained only and especially with those for which only was in the pre-verbal position, like the sentence shown in (31). Paterson et al. proposed that children’s mistakes with sentences that contain only are most likely because children do not always include sets of alternatives in their discourse model. According to this account, while adults always construct both a focus set and a set of alternatives in their discourse model, children often mentally represent only the information given in the sentence, without contrasting this information with a set of alternatives. This gives rise to the mistakes Paterson and colleagues observed in their research.

The finding that children analyse ambiguous sentences by following only one interpretation (i.e. Lidz & Musolino, 2002; Trueswell et al., 1999), as well as the suggestion that children do not mentally represent the same information as adults (i.e. Paterson et al., 2003) is very important for the current research aims. Perhaps something similar might happen when children analyse the type of ambiguities that the
current research investigates. That is, it is possible that children will have difficulty in analysing ambiguous discourses that contain numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) following both possible readings.

4.1.3. **Section Summary**

In summary, this section reviewed some of the research that investigated children’s and adults interpretations of quantifiers. Although, in this research quantifiers have been approached from a different perspective than the one of interest for the current research, nevertheless the existing research provides important information on children’s and adults processing of quantifiers. Importantly, as it was described in this section, the research that investigated children’s interpretation of the universal quantifier, as well as research with scopally ambiguous sentences, has showed that children often fail in reaching to the adult-like interpretation. Children, unlike adults often have difficulty in correctly replying to questions that contain *every* and find it difficult to reach both interpretations of scopally ambiguous sentences. The research that has been reviewed in this section suggests a general difficulty in analysing sentences that contain quantifiers. This is an important finding for the current research which examines children’s interpretations of quantified noun-phrases (e.g., *two cats*) and bare cardinals (e.g., *two*).
4.2. Adults’ and Children’s Interpretations of Numerically Quantified Expressions: Quantified Noun-Phrases and Bare Cardinals

Having established how quantifiers have been approached by researchers, the attention is now turned to the topic of main interest for the current research. That is, adults and children’s interpretation of numerically quantified expressions that when contained in a text function as anaphors. For instance, the ambiguous discourse shown in (32) can be analysed following both a new-set and subset reading. Following the subset reading, the quantified noun-phrase two cats is analysed as being part of the set of three cats mentioned in the first sentence, whereas following the new-set reading, two cats is analysed as referring to a new-set of cats, different than those mentioned in the first sentence.

32. Three cats were on a wall. Two cats caught a mouse.

This section discusses the theories and existing research that has examined children’s and adult’s processing of ambiguities like the one shown in (32). The first part of this section discusses several theories that provide useful information on how readers should interpret discourses that contain numerically quantified expressions. This will involve a reconsideration of the general theories that were presented in Chapter 2, as well as two theories that make explicit suggestions concerning ambiguities like the one shown in (32). The next part of this section reviews the studies that were conducted to explore adults’ preferences when interpreting numerically quantified expressions, and in the last part one study that investigated children’s interpretative preferences when analysing numerically quantified expressions will be also presented.
4.2.1. Adults’ Interpretative Preferences of Numerically Quantified Expressions: A Subset Reading

In Chapter 2 several accounts have been discussed that offer explanations on the strategies that adult’s employ when comprehending a text. Recall that the key theme of Chapter 2 was that adults form links naturally to connect different ideas in a text. Indeed, discourse integration is so important in adult’s comprehension that it has been shown to occur automatically as soon as adults read or hear a text (e.g., Avrutin & Coopmans, 2000; Clark & Haviland, 1977; Crain & Steedman, 1985; Haviland & Clark, 1974; Johnson-Laird, 1983). For instance, recall the work of Haviland and Clark (1974; Clark & Haviland, 1977), they found that readers do not only automatically form links between sentences that contain explicit information, but also importantly even when information can only be inferred.

Following the suggestions of these researchers (e.g., Avrutin & Coopmans, 2000; Clark & Haviland, 1977; Crain & Steedman, 1985; Haviland & Clark, 1974; Johnson-Laird, 1983) one could imagine that adults would have a preference for forming links between the two sentences when they have to analyse ambiguous discourses like the one shown in (33). If this perception is correct, then readers are expected to analyse the quantified noun-phrase *two cats* as anaphoric to the three cats mentioned in the first sentence; thus, readers should have a strong preference for the subset reading of the ambiguity. Nevertheless, these accounts have been developed looking at other phenomena rather than the ones of interest for the current research, therefore it is not clear whether these accounts also apply to the processing of numerically quantified expression ambiguities.
33. Three cats were on a wall. Two cats caught a mouse.

Furthermore, one could imagine that ambiguities such as the one shown in (33) should be interpreted following a subset reading, because readers are highly influenced by context when comprehending a text. Recall the Principle of Referential Success that is core to the referential theory of sentence processing (e.g., Crain & Steedman, 1985; Altmann & Steedman, 1988). According to this principle, readers should favour analyses of a noun phrase that refers to entities already established in the discourse context. In the present case, this can be read as suggesting that there should be a preference to interpret the quantified noun-phrase two cats in (33), as being part of the set of cats that are already established in discourse context (i.e. three cats). However, as also noted by other researchers (Frazier et al. 2005) for this principle to apply to numerically quantified expressions, largely depends on the way the principle is perceived. Specifically, it is unclear whether subsets of an established set are available as referents themselves, or if they have to be instantiated as part of the discourse model to accommodate a subset reading. Therefore, it appears that this principle does not apply unambiguously to the interpretation of numerically quantified expressions.

Note here that clearly the other principle of the referential theory of sentence processing, the Principle of Parsimony, does not apply to numerically quantified expression ambiguities. Recall that this principle suggests that readers resolve ambiguities by adopting the syntactic analysis that requires the fewest unsupported presuppositions. However, as it has been also noted by Frazier et al. (2005), discourses like (33) do not have unsatisfied presuppositions. This is because, on the one hand the presuppositions of the subset reading are satisfied, and on the other hand there are no presuppositions to be satisfied when following the new-set reading.
One principle that appears to unambiguously suggest a preference for a subset reading is the principle of referential continuity (e.g., Ehrlich & Johnson-Laird, 1982; Garnham et al. 1982). Recall, that a number of studies have clearly showed that adults find it easier to comprehend a text when the entity introduced in one sentence finds its referent in the immediately previous sentence (e.g., Ehrlich & Johnson-Laird, 1982; Garnham et al. 1982). Following this principle, it appears that readers will be more successful in comprehending the ambiguity shown in (33) if the quantified noun-phrase two cats is interpreted as anaphoric to the previous quantified noun-phrase three cats, than interpreting two cats following the non-anaphoric new-set reading. Although this principle makes some very interesting suggestions, nevertheless it has not been tested with discourses that contain numerically quantified expressions, therefore it is not clear whether it applies to this type of anaphors or not.

Thus, the general theories that examined readers’ text and sentence comprehension appear to suggest that adults should have a preference for the subset reading when interpreting numerically quantified expression ambiguities. Nevertheless, as it was also noted, these theories were developed to account for phenomena other than the ones of interest in the present study; therefore, do not apply unambiguously to the processing of numerically quantified expressions.

Importantly, there are two alternative accounts that explicitly suggest a preference for a subset reading when readers analyse ambiguous discourses that contain quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…). The first one comes from Hendriks and de Hoop (2001) who suggested that readers or listeners have a general preference to interpret noun-phrases as referring to the current discourse context. The second suggestion was developed by Frazier (1999; 2000; Frazier et al. 2005) who proposed that the syntactic processing principle of Minimal Lowering
governs readers when interpreting ambiguities that contain numerically quantified expressions. It is significant to review these accounts in detail.

4.2.1.1. *Optimality Theoretic Account* (Hendriks & de Hoop, 2001)

Hendriks and de Hoop (2001) considered that context plays an important role when readers are interpreting sentences. Influenced by the connectionist approach of *Optimality Theory* (Prince & Smolensky, 1997), Hendriks and de Hoop suggested that the interpretation given to an anaphor largely depends on the optimal satisfaction of multiple “soft” constraints. These constraints are shared by all languages and form part of the Universal Grammar. Since these constraints express general statements with respect to language, more than one constraint can apply in a specific situation, and thus constraints will be in conflict. The conflict can be resolved by ranking (or prioritising) constraints according to their strength. Therefore a constraint can be violated if there is a stronger constraint in the ranking hierarchy. The constraint that will be chosen to follow will be the most optimal (or harmonic) out of this ranking (Prince and Smolensky, 1997).

Optimality Theory has been applied to a broad range of problems of both syntax and semantics. The approach taken for syntactic processing, takes the perspective of speakers or writers, who choose a specific syntactic structure (out of infinite number of syntactic structures) in order to express the message they want. The approach taken for semantic interpretation takes the perspective of listeners or readers, who want to achieve the intended meaning of the speaker or writer, by selecting the optimal interpretation out of an infinite number of interpretations.
In the optimality theoretical approach that Hendriks and de Hoop (2001) advocate there are many linguistic constraints that can contribute to govern the interpretation of an ambiguity. One particular important constraint that plays a fundamental part in interpretation is DOAP, which is an acronym for “Don’t Overlook Anaphoric Possibilities” (see also Williams, 1997). This constraint specifies that a reader should seize each and every opportunity to interpret an expression as an anaphor.

**DOAP**: Don’t Overlook Anaphoric Possibilities. Opportunities to anaphorise text must be seized (Hendriks & de Hoop, 2001; p.15).

According to this constraint, when readers or listeners are able to find an antecedent of an anaphor in the previous discourse context, they should seize that opportunity and interpret the text anaphorically. Therefore, this constraint accounts for the preference of readers and listeners to relate anaphors to the previous discourse context. Another important constraint that according to Hendriks and de Hoop’s (2001) leads to successful interpretation of anaphors is the constraint of *Topicality*, which imposes a preference to interpret anaphors as referring to the current discourse topic.

Significantly, in Hendriks and de Hoop (2001) approach there is also a constraint that explicitly accounts for the interpretation of *ellipsis*, which arises when there is an omission of a phrase in the discourse. This constraint is called *Forward Directionality* (see also Van Kuppevelt, 1996) and is very important for the aims of the current research, since it applies to interpretations of discourses that contain a bare cardinal (e.g., *two…*) which will be also explored in the current experiments. The constraint of forward directionality is defined as follows:
Forward Directionality: The topic range induced by the domain of quantification of a determiner (set A) is reduced to the topic range induced by the intersection of the two argument sets of the determiner (A ∩ B) (Hendriks & de Hoop, 2001; p.19).

For explanation of this constraint consider the discourse shown in (34). Following the forward directionality constraint, the first argument of the quantifier in the discourse shown in (34) is the set of students, whereas the second argument is the set of students who attended the meeting. Thus, the intersection of the two argument sets corresponds to the set of ten students who attended the meeting. In other words, according to this constraint, the bare cardinal three in the discourse shown in (34) is interpreted as being part of the ten students who attended the meeting. Thus crucially, this constraint suggests a subset reading of ambiguous bare cardinals.

34. Ten students attended the meeting. Three spoke

Also importantly, Hendriks and de Hoop (2001) suggest another constraint that can account for ellipsis; this constraint is called parallelism. According to this constraint, the antecedent of an anaphoric expression should be chosen from a parallel syntactic position in the preceding phrase. Thus, this constraint specifies that a new-set reading should be followed when readers are interpreting discourses like the one shown in (35). That is, the bare cardinal three such as in the example shown in (35) should be analysed as referring to three students that did not attend the meeting.

35. Ten students attended the meeting. Three didn’t.
Importantly however, in constraint satisfaction terms (i.e. choose the most optimal interpretation) the constraint of parallelism is ranked lower in hierarchy than the constraint of forward directionality; therefore, parallelism only comes into play when the forward directionality cannot apply, such as in cases like (35).

Thus, the optimality theoretic account that has been advocated by Hendriks and de Hoop (2001) makes some very important suggestions of which interpretation readers should favour when interpreting numerically quantified expression ambiguities. If this account is correct, then readers are expected to have a strong preference for the subset reading when analysing ambiguous bare cardinals (e.g., *two*...). Importantly, a preference for the subset reading of ambiguous numerically quantified expressions has been also suggested by Frazier (1999; 2000; Frazier *et al.* 2005) who proposed a syntactic processing principle known as *Minimal Lowering* to account for quantified noun-phrase ambiguities (e.g., *three cats*... *two cats*...). It is important review this principle.

4.2.1.2. *Minimal Lowering Account* (Frazier, 1999; 2000)

The *Minimal Lowering* account that has been advocated by Frazier (1999; 2000; Frazier *et al.* 2005) provides an alternative explanation of the interpretation of the ambiguity shown in (36). Frazier’s suggestions were highly influenced by Diesing’s (1992) *Mapping Hypothesis*, who proposed that a phrase will receive a presuppositional (i.e. subset) or an existential (i.e. new-set) reading depending on the phrase’s position at the *Logical Form*. Logical Form (henceforth, LF) is a formal representation of a
sentence logical structure, which is relevant to specifying its logical role and properties (see May, 1985 for a discussion of Logical Form).

36. Three cats were on a wall. Two cats caught a mouse.

According to Frazier (1999; 2000; Frazier et al. 2005), when readers are interpreting ambiguities like the one shown in (36) they are governed by the principle of Minimal Lowering, which suggests that the syntactic position of the quantifier in the discourse shown in (36) strongly predisposes the discourse towards a subset reading. The Minimal Lowering principle is defined as follows:

*Minimal Lowering*: “Lower only when necessary (e.g., interpret a DP [Determiner Phrase] in its surface position if possible)” (Frazier, 1999; p. 119).

Thus, according to this principle readers and listeners should avoid transformations that alter the syntactic structure of grammatical constituents at LF. That is, readers should keep the phrases as they appear in surface structure as much as possible, and lower the determiner phrase (e.g., *a, the, this, those* etc.) only in cases where there is evidence to lower it. This is because the “un-lowered” interpretation saves readers time and effort.

Following Diesing’s (1992) suggestions, Frazier (1999; 2000; Frazier et al. 2005) proposed that when in a phrase the quantifier is in the object position (or in the verb-phrase internal position), such as in the discourse shown in (37), the phrase is already lowered at LF, and thus readers should interpret the quantified noun-phrase
three ships as referring to a new set of ships, different than those described in the first sentence. That is, readers should follow the new-set reading when interpreting discourses like (37). Importantly however, when the quantifier is the grammatical subject of a phrase (or in the verb-phrase external position), like the one in (38), the discourse is ambiguous at LF. This gives the option to readers to follow either the subset or new-set reading of such ambiguities.

37. Five ships appeared on the horizon. Pirates sank three ships.

38. Five ships appeared on the horizon. Three ships were sunk by pirates.

Recall that according to the principle of Minimal Lowering, for reasons of processing economy the “un-lowered” or unchanged syntactic position of a quantifier should be preferred. Thus, according to this principle readers should interpret the quantified noun-phrase three ships in (38), as being part of the five ships already established in discourse context; that is interpret the discourse following a subset reading. This is because for discourses like the one shown in (38) to be interpreted in a new-set reading, it is necessary for the quantified noun-phrase three ships to be “lowered” into a new syntactic position. Thus, importantly the principle of Minimal Lowering clearly suggests a subset reading preference by readers when interpreting quantified noun-phrase ambiguities like the one in (38).

Relevant empirical evidence from adult readers provided support for the two alternative explanations (i.e. optimality theoretic account and Minimal Lowering) which suggest that adults would have a strong preference for analysing numerically quantified expression ambiguities in a subset reading. Specifically, the results of Frazier et al.’s (2005) research supported the suggestions of the principle of Minimal Lowering,
whereas Kaan and colleagues (Kaan et al. 2007; Wijnen & Kaan, 2006) research appears to provide support for the constraint of forward directionality, which has been proposed by the optimality theoretic account (Hendriks & de Hoop, 2001). The next section discusses this research in more detail.

4.2.1.3. Empirical Support for a Subset Reading in Adults Processing of Ambiguous Numerically Quantified Expressions

In a series of five experiments, Frazier et al. (2005) examined whether adult readers employ the Minimal Lowering principle when they analyse ambiguous discourses that contain quantified noun-phrases. In their first experiment Frazier and colleagues tested adults’ interpretative preferences using a questionnaire, in which adults were presented with discourses like the one in (39) with the task to reply to a yes or no question concerning the ambiguous quantified noun-phrase three ships.

   Were the three ships that sank among the five ships that appeared on the horizon?

Recall that as it was described in the previous section, the principle of Minimal Lowering suggests that the syntactic position of the quantified noun-phrase three ships reinforces the discourse towards a subset reading of the ambiguity, since there is a processing cost associated with “lowering” of phrases into LF in order to achieve the new-set reading. Indeed, the results of Frazier et al. (2005) experiment supported this
suggestion; adults 65% of the time interpreted three ships as referring to the set of five ships mentioned in the first sentence.

To further investigate whether adults employ the Minimal Lowering principle when interpreting quantified noun-phrase ambiguities, in a second experiment Frazier et al. (2005) examined adults’ preferences on-line using an eye-movement experiment. In this experiment the reading times of adult readers were recorded as they were processing the ambiguous quantified noun-phrase three ships. Importantly, in this experiment the discourses were disambiguated by adding a third sentence to examine adult’s preferences under normal reading conditions. Two of the discourses were disambiguated towards a subset reading (40a) and (40c), whereas the other two were disambiguated towards a new-set reading (40b) and (40d). Consider the examples shown in (40)

40. a) Five ships appeared on the horizon. Three ships sank. Two were bombarded by enemy fire.
   b) Five ships appeared on the horizon. Three ships sank. Six were bombarded by enemy fire.
   c) Five ships appeared on the horizon. Three of them sank. Two of them were bombarded by enemy fire.
   d) Five ships appeared on the horizon. Three others sank. Another six were bombarded by enemy fire.

According to Frazier et al. (2005) if readers initially assign a subset reading to ambiguous discourses that contain a quantified noun-phrase, as the principle of Minimal Lowering suggests, then they will not have a difficulty to interpret the discourse in (40a)
following this reading. Even with the inclusion of the third sentence the discourse in (40a) can still receive a subset interpretation (i.e. two of the three [or the five] ships). However, this is not the case with the discourse in (40b), which can be only interpreted following a new-set reading. This is because the cardinality of the bare cardinal of the third sentence *six* is larger than both the cardinality of the quantified noun-phrase of the second sentence, *three ships*, and the cardinality of the quantified noun-phrase of the first sentence, *five ships*.

The discourses shown in (40c) and (40d) are both unambiguous. In (40c) the partitive construction *of them* disambiguates the discourse towards a subset reading; thus, both the partitive construction *three of them* in the second sentence, and the partitive construction *two of them* in the third sentence, should be interpreted as referring to the set of five ships that are described in the first sentence. On the contrary the expression *other* in (40d) disambiguates the discourse towards a new-set reading. Thus, both the partitive construction *three others* in the second sentence, and the partitive construction *another six* in the third sentence, should be interpreted as referring to new set of ships different than those mentioned in the first sentence.

Frazier *et al.* (2005) proposed that if readers are strongly influenced by the Minimal Lowering principle when interpreting discourses that contain quantified noun-phrases, then they should not have difficulty in interpreting discourses like those presented in (40a) and (40d). This is because the syntactic position of the quantifier (if not lowered) in both (40a) and (40c) reinforces a subset reading of the discourse. Accordingly, longer reading times should be observed when adults analyse discourses like those shown in (40b) and (40d). This is because for achieving the intended new-set reading, adults should “lower” the syntactic position of the quantifier at LF. The results of Frazier’s and colleagues experiment supported the suggestions of Minimal Lowering
principle. Adult readers had longer reading times when they interpreted discourses that favoured the new-set reading. Importantly, this effect was present to both ambiguous and unambiguous discourses. This shows that adults initially assign a subset reading to discourses that contain numerically quantified expressions.

To directly test whether the Minimal Lowering principle is employed by readers, in a third experiment Frazier et al. (2005) modified their questionnaire experiment and tested if by presenting the quantified noun-phrase in the subject versus the object position would affect reader’s interpretations. Recall that according to the principle of Minimal Lowering, if the quantified noun-phrase is in the subject position, like the one shown in (41), readers have the option of following either the “un-lowered” subset reading, or to lower the phrase, and assign a new-set reading to the ambiguity. On the contrary when the quantified noun-phrase is in the object position, like the one in (42) the phrase is already lowered, and thus it should be interpreted in a new-set reading.

41. Five ships appeared on the horizon. Three ships were sunk by pirates.

42. Five ships appeared on the horizon. Pirates sank three ships.

The results obtained by Frazier et al. (2005) supported the suggestions of the principle of Minimal Lowering; more subset responses were obtained by adults when the quantified expression three ships was in the subject position, like in the discourse shown in (41), than when three ships was in the object position, like in the discourse shown in (42). By manipulating the surface position in another two experiments with Korean and German speakers, Frazier and colleagues have showed that the suggestions of the principle of Minimal Lowering also apply to speakers of these languages.
Thus, the study of Frazier et al. (2005) supports the suggestions of the principle of Minimal Lowering. Adult readers prefer the subset interpretation over the new-set interpretation when analysing ambiguous quantified noun-phrases. Frazier and colleagues’ research has clearly shown that there is a processing cost associated with the new-set reading, and importantly this cost is present even in cases where the discourse is disambiguated towards a new-set reading. Subsequent studies by Kaan and colleagues (Kaan et al. 2007, Wijnen and Kaan, 2006) supported the finding that adults have a strong preference for the subset reading when interpreting ambiguous numerically quantified expressions. Contrary to the suggestions of Minimal Lowering principle however, Kaan and colleagues attributed the preference for the subset reading to costs associated with the establishment of new discourse referents.

In particular Wijnen and Kaan (2006) investigated Dutch adults processing of ambiguous discourses that contained bare cardinals. Supporting the suggestions of the optimality theoretic account (Hendriks & de Hoop, 2001), Wijnen and Kaan expected that adults would have a strong preference in analysing ambiguous bare cardinals following a subset reading. Their first experiment concerned a sentence completion task, in which adults were presented with discourses like those shown in (43a) – (43c) which were cut off after the bare cardinal four; participants’ task was to complete the sentence in a meaningful way.

43. a) It turned out that five ships did not survive the hurricane. The coast guard reported this morning that four (had capsized during the night in the towering waves).
b) It turned out that *five ships survived* the hurricane. The coast guard reported this morning that *four* (had capsized during the night in the towering waves).

c) It turned out that *three ships survived* the hurricane. The coast guard reported this morning that *four* (had capsized during the night in the towering waves).

The second sentence of the discourse shown in (43a) is ambiguous between a new-set and subset reading, since the bare cardinal *four* can be analysed either as a referent of the five ships that did not survive the hurricane (i.e. subset reading), or as referring to four new ships, different than those that did not survive the hurricane (i.e. new-set reading). However, this is not the case with the discourse shown in (43b) where the use of the verb *survived* suggests that the bare cardinal *four* should be completed in a new-set reading. Similarly, in the discourse shown in (43c) the cardinality of the bare cardinal *four* in the second sentence is larger than the cardinality of the bare cardinal *three* of the first sentence, therefore this discourse can only be completed following a new-set reading.

The results of Wijnen and Kaan’s (2006) experiment showed that 51.7% of the time adults had a preference to complete discourses like those shown in (43a) in a subset reading. Additionally, as these researchers suggested, adults completed discourses like those presented in (43b) and (43c) in favour of a new-set reading. The preference for the subset reading was also observed in a second experiment in which participants had to rate from a scale of 1-5 the difficulty of discourses like the ones presented in (43a) – (43c). Note that in this experiment adults were presented with the completed version of the discourses; that is, with the version that is presented in the
brackets for the discourses shown in (43). The results from this experiment showed that discourses like the one presented in (43a) were rated as the easiest by adults. This finding supported the view that adults strongly prefer to analyse discourses containing bare cardinals in a subset reading.

In their last experiment, Wijnen and Kaan (2006) measured the reaction times of participants while reading discourses like those shown in (43a) – (43c). Specifically, in this experiment adults sat in front of a computer monitor and were initially presented with the first sentence of the discourse in full, and then upon pressing a button the second sentence of the discourse was presented in a phrase-by-phrase manner. Participant’s task was to press a button to judge whether the second sentence was a plausible continuation of the first sentence or not. The interval between the press of the button after the presentation of the second sentence and the press of the button for participants’ answer was measured.

The results showed that the readings times of participants when a discourse had to be interpreted in a new-set reading were significantly longer than those in which the subset reading was a possible reading. According to Wijnen and Kaan (2006) this finding provided strong evidence for a processing cost associated with the new-set reading. Following on from these findings, in another study Kaan et al. (2007) explored adults’ preference for the subset reading on-line. Specifically, Kaan and colleagues used ERP measures, and studied adults’ EEG activity over the scalp during the time taken to read sentence pairs like those shown in (44) and (45).

44. Twelve flowers were put in the vase. Six had a broken stem and had to be cut very short.

45. Four flowers were put in the vase. Six had a broken stem and were trashed.
The first sentence of each of the above examples establishes the discourse referent (i.e. *twelve flowers* or *four flowers*), while the second sentence begins with the bare cardinal *six*. In the discourse shown in (44) the bare cardinal *six* has lower cardinality than its referent *twelve flowers*, therefore the discourse can be interpreted following either a subset reading (six of the twelve flowers) or a new-set reading (six different flowers than those in the vase). In the discourse shown in (45) however, the bare cardinal *six*, has greater cardinality than its referent; therefore, this discourse can only be interpreted in a new-set reading (i.e. six flowers different than the four that were put in the vase). Also note here that the sentence pairs that Kaan et al.’s (2007) participants were presented with were the same at least up to the fourth word of the second sentence (i.e. “stem” for the above examples). This was done to ensure that the meaning of the discourse was compatible with the intended subset or new-set reading.

Kaan et al.’s (2007) results of the ERP study have showed a divergence in the ERP record, which was reflected by a positivity over posterior electrodes, approximately 900-1500 milliseconds following the presentation of the bare cardinal *six* for both the discourse shown in (44) and the discourse shown in (45). More importantly however greater positivity over posterior electrodes was observed when adults were interpreting discourses like the one presented in (45), in which the bare cardinal was incompatible with a subset reading. In the ERP waveform, this positivity occurred almost one second after the critical word was read. Kaan et al. suggested that this relatively late posterior activity effect is not a consequence of a preference for the subset reading, but rather reflects additional integration and storage costs that are associated with new referent introductions. A similar explanation was advocated by Burkhardt (2006) who observed greater positivity over posterior electrodes when adults interpreted
definite expressions (e.g., the student) that introduce new referents (see also the work conducted by Filik, Sanford, and Leuthold (2008), who observed greater positivity when a new referent had to be established for a pronoun).

Importantly, the research that has been conducted by Paterson et al. (2008b) which measured the eye-movements of adult readers when processing discourses that contained quantified noun-phrases supported the findings of Kaan et al. (2007). In the experiments reported by Paterson et al., adult participants were presented with both ambiguous and unambiguous discourses that contained quantified noun-phrases. Examples of the materials used in this study are shown in (46).

46. a) The fishermen saw six ships appear on the horizon. Apparently, three ships had been bombarded by enemy fire.

b) The fishermen saw two ships appear on the horizon. Apparently, three ships had been bombarded by enemy fire.

c) The fishermen saw six ships appear on the horizon. Of these, three ships had been bombarded by enemy fire.

d) The fishermen saw two ships appear on the horizon. Another three ships had been bombarded by enemy fire.

The quantified noun-phrase three ships in the second sentence of the discourse shown in (46a) is ambiguous between a new-set and subset interpretation. This is not the case with the discourse presented in (46b) however, in which although the quantified noun-phrase of the second sentence three ships is ambiguous, the discourse can be only interpreted following a new-set reading. This is because the quantified noun-phrase three ships has higher cardinality than its referent. The discourses shown in
(46c) and (46d) are both unambiguous. The partitive determiner construction of these in the second sentence of the discourse shown in (46c) explicitly denotes that the quantified noun-phrase three ships should be interpreted as being part of the six ships mentioned in the first sentence of the discourse; thus, the discourse shown in (46c) can only be interpreted following a subset reading. On the contrary, the determiner another in the second sentence of the discourse shown in (46d) explicitly denotes that the quantified noun-phrase three ships refers to a different set of ships than the set of two ships mentioned in the first sentence of (46d). The advantage of using unambiguous controls was that Paterson et al. (2008b) could also examine if the processing difficulty with new referent introductions is also present when readers comprehend discourses that the quantifier is unambiguous, like in the example shown in (46d).

In a pre-test of their materials, Paterson et al. (2008b) used a number judgment task in which adults had to say how many ships there were in total when interpreting ambiguous discourses like the one shown in (46a). The results clearly showed that adults had a 70% preference for interpreting the quantified noun-phrase three ships following a subset reading; that is, as referring to the set of ships mentioned in the context sentence (i.e. six ships). In the subsequent two experiments, Paterson and colleagues monitored and measured adults’ eye movements when reading discourses like those presented in (46).

Paterson et al.’s (2008b) eye-movement experiments produced two key findings. First it was shown that it did not take adults longer to re-read portions of text when the quantified noun-phrase could only be analysed in a new-set reading. Importantly however, this effect was not only observed when adults analysed ambiguous discourses like the one shown in (46b), but also when adults analysed discourses that were disambiguated towards a new-set reading, like the discourse in (46d). According to
Paterson et al., the finding that adults had difficulty processing both ambiguous and unambiguous quantified noun-phrases clearly shows that adults have an overall difficulty with introducing new referents into the discourse.

The second key finding from this study supported this suggestion and showed that adults did not produce longer reading times when they were initially processing a quantified noun-phrase that could only be interpreted following a new-set reading (as measured by first-pass and second-pass reading times), but rather longer reading times were only observed in the total reading time that it took adults to read the text, which shows that the processing difficulty emerges late in sentence processing. This finding suggests that adult’s difficulty in assigning a new-set reading to a quantified noun-phrase is not present as soon as adults read a discourse that should be analysed following the new-set reading, but rather is an effect that only occurs when adults process the discourse in full and acknowledge that a new referent has to be established in discourse.

According to Paterson et al. (2008b), taken together these two findings suggest that adults prefer to assign a subset reading to a quantified noun-phrase, not because of a preference for assigning a subset reading to an ambiguity, but rather because of costs associated with the establishment of a new referent in a readers’ mental representation of the discourse. Thus, in line with the suggestions put forward by Kaan et al. (2007), who suggested that there is a processing cost with new referent introductions, Paterson and colleagues suggest that there is not processing advantage in following a subset reading of ambiguous quantified noun-phrases, but rather a processing cost associated with the establishment of a new referent in a readers’ mental representation of the discourse.
Thus importantly, existing research that investigated adults processing of ambiguous discourses that contain quantified noun-phrases and bare cardinals, showed a clear strong preference by adults for the subset reading of the ambiguity. Whereas Frazier (1999; 2000; Frazier et al. 2005) proposed the linguistic constraint of Minimal Lowering which suggests that there are costs associated with the new-set reading, Kaan et al. (2007) and Paterson et al. (2008b) suggested that the costs are associated with introducing new referents within a reader’s discourse model. Kaan et al. and Paterson et al. suggestions are consistent with the optimality theoretic account of Hendriks and de Hoop (2001), providing that the forward directionality constraint is considered as a mechanism for avoiding costs associated with introducing new discourse referents.

4.2.2. Children’s Interpretative Preferences of Numerically Quantified Expressions: Subset or New-Set Reading?

Having established adults’ preference for a subset reading when analysing quantified noun-phrase (e.g., *two cats*) and bare cardinal (e.g., *two* ...) ambiguities the attention of this section is turned to how children analyse such ambiguities. Knowing how children analyse discourses that contain numerically quantified expressions is the main reason that the current research was undertaken. This is because children’s interpretations of such discourses will provide valuable information concerning children’s processing strategies when comprehending a text.

As it has been discussed in detail in Chapter 3, much of the existing research that examined children’s processing of anaphors has been concerned with investigations of children’s interpretations of explicit anaphors, like pronouns (e.g., *he, she*) and the definite reference (i.e. *the*), as well as implicit anaphors that can only be interpreted
through inference generation (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). Importantly, recall that this research has clearly shown that children do not interpret anaphors in a similar manner to adults. Whereas adults predominately use anaphors as a means of connecting different information within a text, children often have difficulty in doing so.

For instance, recall that research that has examined children’s use of the definite and indefinite reference when narrating a story has clearly shown that whereas adults use the indefinite article *a* to introduce a new referent into discourse, children often use the definite article (e.g., Kail & Hickmann, 1992; Karmiloff-Smith, 1979; Warden, 1976). Additionally existing research which examined children’s interpretations of stories that contain an indefinite article showed that children, unlike adults, are not contextually influenced in their interpretations. Children have a difficulty in interpreting the indefinite article as referring to one out of many identical objects that exist in the discourse context (e.g., Krämer, 2002).

Furthermore, recall that the research which examined children’s interpretations and use of pronouns when narrating stories clearly showed difficulty by children in referentially connecting a pronoun with information from the contextual discourse (e.g., Karmiloff-Smith, 1980; Krämer 2002; Tyler, 1983); a finding which was also observed in studies which investigated children’s inference generation (e.g., Avrutin & Coopmans, 2000).

Also importantly, recall the research that has been described in the beginning of this chapter which investigated children’s processing of quantifiers. This research has showed that there are differences in the way adults and children interpret quantifiers (e.g., Drozd & van Loosbroek, 1998; Lidz & Musolino, 2002; Meroni et al. 2000; 2004;
Musolino & Lidz, 2003; Musolino et al. 2000; Paterson et al. 2003; Philip, 1995). As it has been discussed, children have difficulties when they need to interpret sentences that contain the universal quantifier *every*, and are often unable in reaching both possible interpretations of scopally ambiguous sentences.

This research provides a useful background for forming predictions for the possible outcome of the current experiments which examine children’s processing of ambiguities like the one shown in (47). It appears that existing research suggests that children might find it difficult to form links between the numerically quantified expression and its referent found in the context sentence (i.e. first sentence). Recall that discourses like the one shown in (47) are ambiguous between two readings following the subset reading the quantified noun-phrase *two cats* is interpreted as anaphoric to the set of three cats that are on the wall, while following the new-set reading the quantified noun-phrase *two cats* is interpreted as referring to a new set of cats different than those on the wall.

47. Three cats were on a wall. Two cats caught a mouse.

Thus, if children’s difficulty with integration which has been observed by previous research that examined other types of anaphors (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976), is also present when children interpret anaphoric numerically quantified expressions, then children might have difficulty in reaching the subset reading. Recall that a prerequisite of the subset reading is to referentially link the quantified noun-phrase or bare cardinal with information from prior discourse context; thus, if children have difficulty in forming referential links between sentences, then
inevitably they will also have difficulty in reaching the subset reading of discourses like the one shown in (47). Similarly, if children have difficulty in reaching both interpretations of ambiguous sentences (e.g., Lidz & Musolino, 2002; Meroni et al. 2000; 2004; Musolino & Lidz, 2003; Musolino et al. 2000; Paterson et al. 2003), or difficulty to depart from their initial syntactic commitments (e.g., Trueswell et al. 1999), then children might have difficulty in reaching both the subset and the new-set reading of discourses like (47).

To date, only one published study by Wijnen et al. (2004) has been conducted that examined children’s processing of ambiguities that arise when the discourse contains a numerically quantified expression. Wijnen and colleagues’ study produced striking results; it suggested that unlike other types of anaphors (e.g., pronouns, the definite reference and inference generation) in which it has been consistently showed that children have difficulty with integration (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976), children analyse ambiguous bare cardinals following the subset reading (but see the unpublished studies of Obdeijn, 2005, and van Weelden, 2008, who did not replicate this finding). It is definitely important to review this study in more detail.

4.2.2.1. Children’s Interpretative Preferences of Ambiguous Bare Cardinals: A Subset Reading?

Wijnen et al. (2004) conducted two experiments to examine how English and Dutch speaking four-year-old children interpreted ambiguous discourses that contained a bare cardinal. In their study, Wijnen and colleagues employed a variation of the truth value judgment task (Crain & Thornton, 1998), in which children were verbally
presented with a story like the one shown in (48) together with one picture. The critical sentence which contained a bare cardinal was presented as a question and children had to evaluate by a “yes” or “no” answer whether the picture reflected the story.

48. Here’s a playground. It’s great to do all kinds of funny things when you’re out in the playground, like swinging, making a sand castle or climbing on the monkey bars.

There are some kids playing in the sandbox. Are two upside down?

In Wijnen et al. (2004) study each child was presented with fifteen ambiguous experimental stories, analogous to the one shown in (48), together with ten filler stories. The experimental stories were divided into three conditions, each one of them having a story that contained an ambiguous bare cardinal, but a different picture. For example, for the story shown in (48) the picture could be one that involved two children upside down inside the sandbox (picture in line with the subset reading), a picture that illustrated two children that were upside down outside the sandbox (picture in line with the new-set reading), or a picture where two adults were upside down outside the sandbox. According to Wijnen and colleagues the last picture is in line with a non-anaphoric reading of the bare cardinal, where two is interpreted as meaning “two anything”.

Wijnen et al. (2004) proposed that if children accepted the picture corresponding to the subset reading and rejected the other two (i.e. the pictures that illustrated a new-set or a non-anaphoric reading), it would be an indication that children are capable of discourse integration. According to Wijnen and collaborators, this is because an acceptance of the picture that illustrated two kids upside down inside the sandbox shows
that children analysed the bare cardinal *two* as anaphoric to the expression *some kids*; while a rejection of the other two pictures shows an acknowledgement by children that the bare cardinal signals an interpretation with respect of the prior discourse context.

The results from the first experiment of Wijnen *et al.* (2004) investigating English speaking children preferences indicated that 84% of the times children accepted the picture that was consistent with the subset reading of the ambiguous discourse (i.e. two children upside down inside the sandbox). This acceptance rate was significantly higher than children’s preference for the other two pictures. Specifically, children accepted the picture that illustrated a new-set reading (i.e. kids upside down outside the sandbox) 35.6% of the time, whereas the picture that illustrated a non-anaphoric reading (i.e. adults upside down outside the sandbox) 26.7% of the time. In a second experiment, children’s strong acceptance for the picture that depicted a subset reading when interpreting ambiguous bare cardinals was replicated with Dutch speaking children.

Thus, the study conducted by Wijnen *et al.* (2004) indicated that children had a strong preference for accepting the picture that was illustrating a subset reading of ambiguous stories that contained a bare cardinal, and were less likely to accept a picture that was in line with a new-set or non-anaphoric reading of the ambiguous bare cardinal. Wijnen and colleagues interpreted this finding as evidence, that contrary to previous suggestions, children do not have difficulty with discourse integration.

This is a striking result; recall that findings for other types of anaphors (e.g., pronouns, the definite reference, and inference generation) that have investigated children’s comprehension of discourses that contain these expressions, have consistently shown that young children have difficulty in reaching an interpretation in which these expressions refer to entities in the prior discourse context, and therefore...
that children have difficulty in integrating the sentences that contain these expressions with the discourse (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). By contrast with the findings for these other expressions, the data reported by Wijnen et al. (2004) appear to indicate that no such difficulty is present when children interpret discourses that contain anaphoric bare cardinals.

Importantly, the results by Wijnen et al. (2004) also appear to be at odds with the findings from research conducted by Frazier et al. (2005), as well as their own research with adults (Wijnen & Kaan, 2006). Recall that Wijnen et al. (2004) found that 84.4% of the time children accepted the picture depicting a subset reading of ambiguous stories containing bare cardinals; this percentage is substantially greater than what both Frazier et al. (2005) and Wijnen and his colleagues (Wijnen & Kaan, 2006) obtained investigating adults’ preferences. The results of the questionnaire study of Frazier et al. showed that adults had a preference for analysing an ambiguous quantified noun-phrase in favour of a subset reading 65% of the time, whereas Wijnen and Kaan’s sentence completion task showed a preference of 51.7% from adults to complete an ambiguous bare cardinal following a subset reading.

Thus, the children that participated in Wijnen et al. (2004) study seem to have shown a substantially larger preference for the subset reading of ambiguous bare cardinals than what the adults produce in previous studies by Wijnen and colleagues (Wijnen & Kaan, 2006) and previous studies of adults’ interpretation of quantifier noun-phrases conducted by other researchers, like Frazier et al. (2005). This is a matter of concern, since it was definitely not expected for children to have a stronger bias for the anaphoric reading than adults do. Thus, it is important to look at how this study was run in more detail, since it might be helpful in establishing why children produced a higher
preference for analysing ambiguous bare cardinals in a subset reading, than did adults. It may well be that the way this study was conducted influenced children in following a subset analysis of this particular ambiguity.

What is particularly striking about the materials Wijnen et al. (2004) used in their study is that children were always presented with stories containing an ambiguous bare cardinal. Specifically, although Wijnen and colleagues divided their pictures into three different conditions, the type of story that children were presented with remained ambiguous across all three conditions. A problem of using only ambiguous stories is that the results obtained cannot be compared to how children would have behaved under normal unambiguous control conditions. Recall that in Frazier et al.’s (2005) eye-movement experiment, adult readers were also presented with discourses that contained expressions which explicitly disambiguated the discourse towards a subset reading (i.e. when the discourse contained the partitive construction of them) or a new-set reading (i.e. when the discourse contained the expression other). Wijnen and colleagues did not use such control conditions, therefore the results do not show how children would have behaved under unambiguous normal reading conditions. It is possible that children would have judged the discourses differently if they were also presented with unambiguous stories; something which was not tested in Wijnen and colleagues’ experiments.

Furthermore, another disadvantage of lacking baseline conditions is that presumably children would be more likely to develop a task-specific strategy because of having only encountered ambiguous texts. Hearing only ambiguous stories may have highlighted the nature of the ambiguity and therefore encouraged the children to interpret them differently from normal comprehension. Therefore, it is possible that what Wijnen et al. (2004) observed, was not a preference from children to interpret
ambiguous stories that contain bare cardinals in a subset reading, but rather a choice for the picture depicting a subset reading, because children were only hearing stories that contained ambiguous bare cardinals.

Importantly, this explanation accounts for the discrepancies between children and adults responses. Although Wijnen et al. (2004) suggested that children have a preference for a subset reading when analysing ambiguous stories that contain bare cardinals, the questions raised in the above discussion suggest that this finding does not unequivocally show children’s preferred interpretation. In order to understand how children comprehend discourses that contain numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) children’s preferences must not be only tested using ambiguous materials, but also importantly with unambiguous counterparts. This is indeed how the materials of the current experiments will be designed.

4.2.3 Section Summary

In summary, this part reviewed two theories that provide some useful information on how readers should interpret anaphoric numerically quantified expressions. Both the optimality theoretic account advocated by Hendriks and de Hoop (2001), as well as the syntactic principle of Minimal Lowering (e.g., Frazier, 1999; 2000; Frazier et al. 2005) suggest that readers should have a preference for the subset reading when analysing numerically quantified expression ambiguities. These suggestions have been supported by research with adults, in which it was shown that adults have indeed a strong preference for the subset reading of the ambiguity (e.g., Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan, 2006). Strikingly, the preference for the subset reading of an ambiguity was also observed in
research with children (Wijnen et al. 2004). Importantly however, this study lacked an unambiguous control material which raises questions to whether this preference by children indeed exists. For this reason, the experiments that will be conducted in the current research will examine children’s interpretative preferences when analysing both ambiguous and unambiguous numerically quantified expressions.

4.3. Current Research Predictions

In the current research six- to eight-year-olds and adults will be presented with ambiguous and unambiguous numerically quantified expressions. The participants will be presented with pictures and their task will be to select the picture that corresponds to the meaning of the discourse. Children and adults will have a choice between a picture that corresponds to the new-set meaning of the discourse and a picture that corresponds to the subset meaning of the discourse (see Chapter 5 for more details on the discourses and pictures that will be used in the current research). A preference for the picture depicting a subset reading will be an indication that numerically quantified expressions are analysed anaphorically and thus similarly to other types of anaphors. A preference for the new-set reading however, will be an indication that these types of anaphors are processed differently by readers. The findings will provide an insight into children’s and adults’ interpretative preferences when analysing numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals).

Existing research which examined adult’s interpretative preferences has clearly shown that adults analyse quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…) following the subset reading (e.g., Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan 2006). That is, adults analyse numerically
quantified expressions as referring to information mentioned earlier in the text. It is expected that the same strong preference will also be found in the current research. Additionally, it is expected that adults will not have difficulty reaching the subset interpretation when analysing unambiguous numerically quantified expressions. This is supported by the findings of Frazier et al. (2005), who found that adults reached the subset reading when analysing unambiguous controls similar with the ones that will be used in the current research.

Importantly, existing research which examined children’s interpretative biases is not unambiguously informative of children’s interpretative biases when analysing numerically quantified expressions and more precisely ambiguous bare cardinals (i.e. Wijnen et al. 2004). It is therefore the task of the current research to examine whether children assign a new-set or subset reading when analysing both ambiguous and unambiguous numerically quantified expressions. The research which examined children’s interpretations of other types of anaphors (e.g., pronouns, the definite reference and inference generation) has clearly shown that children have difficulty with anaphors. For instance, it has been found that children younger than eight find it difficult to link an anaphor with information from prior discourse context (i.e. Karmiloff-Smith 1979; 1980). Perhaps a similar difficulty will be also present when children analyse discourses that contain numerically quantified expressions. A difficulty to link the quantified noun-phrase or bare cardinal with information from prior discourse context will inevitably lead to a difficulty in reaching the subset reading. This is because to reach the subset reading it is necessary to connect the definite noun-phrase or bare cardinal with information from the previous discourse context. Thus, if the difficulty by children observed with other types of anaphors is also present in this type
of anaphors, then it is expected that children will find it difficult to assign a subset reading of an ambiguity.

Importantly, supportive evidence for the above predictions might be suggestive that children and adults employ qualitatively different strategies when analysing text. This would be a tremendous finding, which would add significantly to the existing research concerned with children’s processing of anaphors. Additionally, finding differences in how adults and children interpret quantified noun-phrases and bare cardinals would also have implications for the two theories that were reviewed earlier in this chapter. Recall that both the optimality theoretic account (Hendriks & de Hoop, 2001) and the principle of Minimal Lowering (Frazier et al. 2005) suggest a preference for the subset interpretation when readers or listeners interpret numerically quantified expressions. Thus, if children respond differently than adults, this will provide evidence that both of these accounts do not apply to children’s processing of text.

4.4. Summary of Chapter 4

The discussion of this chapter was divided into two parts. In the first part some general functions of quantifiers in the discourse, as well as some factors governing their interpretation, had been described. Additionally some relevant research into children’s processing of sentences that contain quantifiers has been presented. It was clearly shown that existing research suggests that children, unlike adults, have difficulty in analysing sentences that contain quantifiers. The second part of this chapter concentrated on the topic of main interest for the current research; that is children’s and adults interpretations of numerically quantified expressions that when contained in a text function as anaphors. Two theories that make some explicit suggestions of how
readers should analyse these anaphors have been described. The relevant research that investigated adults’ interpretative preferences has clearly shown that adults respond in line with these suggestions. Importantly however, the research that investigated children’s interpretative preferences was not unambiguously informative on children’s processing of these anaphors. It is thus, the aim of the current research to provide an unambiguous account of children’s interpretative preferences when analysing ambiguous and unambiguous discourses that contain numerically quantified expressions. Specifically, the current research examines and compares the responses of six- to eight-year-old children and adults by presenting them with discourses that contain ambiguous and unambiguous quantified noun-phrases and bare cardinals.
Chapter 5:  
The Present Study

The purpose of this chapter is to introduce the present study. The discussion is divided into two parts. The first part of the discussion will concentrate on the general methodology that was used in the current research. This will involve some general explanations on how participants were selected, how the specific methodology was chosen, as well as a general description of the discourses and pictures that were used in the current research. In the second part of this chapter, a pilot study that was run prior to the experiments will be described. As it will be clearly shown, the pilot study was very useful in showing certain modifications that had to be completed before running the experiments.

5.1. General Methodological Design

The current research was conducted in Cyprus and all of the discourses were presented in participant’s native language, Greek. For explanation purposes, in this thesis the translated English version of these discourses will be presented. The original Greek version of the discourses, for each of the seven experiments, can be found in the Appendices.

5.1.1. Participants

The participants of the current research were native Greek speaking children and adults. Adults were postgraduate college students who volunteered to take part in the
current research, whereas children were first and second graders, between the ages of six to eight, who were recruited from four schools of Aradippou, a small town in the city of Larnaka. The main reason for having Greek and not English speaking participants was because Greek speakers were more accessible as participants. Importantly the way readers resolve reference is a universal phenomenon so the same pattern of performance is expected to be obtained if this research was undertaken with English speakers.

Importantly, this specific age group of children was selected because much of the existing research that examined children’s language comprehension has shown that some very interesting things are happening to children younger than eight. For instance, recall the research that was described in Chapter 3. Much of this research that examined children’s processing of other types of anaphors (e.g., pronouns, the definite article, and inference generation) has clearly shown a difficulty by this age group in forming the referential links between an anaphor and its prior discourse context (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). Similarly, research that examined children’s interpretations of quantifiers (e.g., Drozd, 2001; Drozd & Loosbroek, 1998; Meroni et al. 2000; 2004; Paterson et al. 2003; Philip, 1995), as well as children’s processing of scopally ambiguous sentences (e.g., Lidz & Musolino, 2002; Musolino & Lidz, 2003; Musolino et al. 2000) has shown that this age group analyses sentences in a non-adult like way. Thus, it was vital to examine whether any of these significant findings will be also found when children are processing ambiguous and unambiguous numerically quantified expressions.

Note that ages of children participants are presented throughout this thesis as: Year;Month for example a child aged seven years and five months is presented as 7;5.
5.1.2. **Materials and Design**

In the current research, different experimental techniques were employed in each of the seven experiments to test different possible reasons behind children’s preferences. Nevertheless, the general design that was employed remained stable throughout this research. Specifically, in all seven experiments children were verbally presented with two-sentence discourses together with a number of pictures with the task to select (or evaluate) the picture (or pictures) they considered as best corresponding to the meaning of the discourse. Note that in all experiments except for Experiment 1, six- to eight-year-olds were both verbally and visually presented with the written form of the two-sentence discourse.

Additionally, in all of the current experiments children’s interpretative preferences were examined using three types of experimental discourses. In one sentence type, the numerically quantified expression was ambiguous; that is, it was equally likely to be analysed following both a subset and new-set reading. Nevertheless, note that existing research with adults showed consistently a preference for the subset reading of ambiguous discourses; therefore, a preference for the subset reading under ambiguous sentence types could be more expected. Importantly, the other two sentence types that were used in the current research were unambiguous. One included the partitive construction of *the*, which disambiguated the numerically quantified expression in favour of a subset reading, and the second included the expression *other* which disambiguated the numerically quantified expression in favour of a new-set reading. Recall that as it was discussed in the previous chapter, unambiguous controls are crucial for understanding how children process numerically quantified expressions, since they
enable to examine children’s interpretations under normal reading conditions. An example of each of the three sentence types is presented in (49) - (51).

49. Three cats were on a wall. Two cats caught a mouse.

(Ambiguous Sentence Type)

50. Three cats were on a wall. Two of the cats caught a mouse.

(Unambiguously Subset Sentence type)

51. Three cats were on a wall. Two other cats caught a mouse.

(Unambiguously New-Set Sentence type)

The quantified noun-phrase two cats in (49) is ambiguous between a subset and a new-set reading. If the discourse is analysed in a subset reading, the quantified noun-phrase two cats is interpreted as referring to the set of three cats already established in the discourse context; thus, the discourse is interpreted as meaning that there were three cats on the wall, two of which caught a mouse. If the discourse is analysed in a new-set reading, the quantified noun-phrase two cats is interpreted as referring to a new set of cats different to the set of cats on the wall; thus the discourse is interpreted as meaning that there were three cats on the wall, and two different cats that caught a mouse.

The discourse in (50) contains the partitive construction of the, which explicitly denotes that the set of two cats that caught a mouse are part of the set of cats that were on the wall; therefore, the discourse shown in (50) can only be interpreted in favour of a subset reading. On the contrary, the discourse shown in (51) contains the expression other, which explicitly denotes that the set of cats mentioned in the second sentence is a different set of cats than those mentioned in the first sentence; thus, the only possible reading of (51) is the new-set reading.
To ensure that participants’ responses would reflect their preferences and not the specific discourse they were presented with, it was necessary for each experimental discourse to be presented in all three sentence types, to different participants. For this reason three files were created, with one version of each experimental discourse in each file. For instance, the cat example in the first file was presented as unambiguously new-set, in the second file as ambiguous, and in the third file as unambiguously new-set. Each participant was presented with only one of these files, thus ensuring that the participant viewed no more than one version of each experimental discourse. Each file consisted of the same number of discourses, with an equal number of unambiguously new-set, ambiguous, and unambiguously subset sentence types. Additionally, to control that the presentation order would not have cued participants towards a specific pattern of responses, half of the participants viewed each file in a fixed order, whereas this order was reversed for the other half of the participants.

The discourses that participants were presented with were always paired with pictures. These pictures were always black and white which were printed in a single sided A3 or A4 paper. The main reason for choosing pictures was because tasks that employ such techniques are well suited in assessing the interpretation that participants assign on an ambiguous fragment. Also importantly, existing research which looked at children’s preferences by using pictures has been shown to be successful in testing children’s interpretative preferences during comprehension (e.g., Paterson et al. 2003).

The number of pictures that were used varied across experiments; nevertheless, two critical pictures were included in all seven experiments. These pictures are illustrated in Figure 1. As it is demonstrated in the figure, picture (a) depicts a situation in which the two cats that caught a mouse are a subset of the ones on the wall. Therefore, picture (a) can only be selected if participants analyse the quantified noun-
phrase *two cats* in favour of a subset reading. On the contrary, picture (b) illustrates that the two cats that caught a mouse are a different set of cats than the ones on the wall. Consequently, this picture can only be selected if participants analyse the discourse in favour of a new-set reading.

Note that the label of the pictures (i.e. subset and new-set picture) was not presented to participants in the experiments; it is only used here for explanation purposes. Also note that the symbol “Ø” indicates an empty set, and it will be used throughout this thesis to refer to the ambiguous sentence type that did not involve any additional expression.

![Figure 1: Example of the two critical pictures that were used in the current experiments](image)

The experimental materials were mixed with a number of filler items. For these items the first and second sentence of the discourse referred to different sets of entities (e.g., *x* lions and *y* deer) and therefore these discourses could not be interpreted with either a subset or a new-reading. The filler items served as an indication that participants and especially children were paying attention to the task; therefore the
responses of participants who failed to correctly reply to any of these filler items were not included in the analysis of the results. An example of a filler item is illustrated in Figure 2.

**Figure 2:** Example of a filler item that was used in the current experiments

Moreover, since the quantified expression was always a numeral (e.g., *two cats*), it was important to ensure that the responses given by children were not due to deficiencies in their arithmetic skills. To control such possibility, seven simple arithmetic problems were created and presented to children prior to the comprehension experiment. One of the arithmetic problems was a counting task, in which children were presented with a single sided A4 paper that illustrated nine balls. The children’s task was to tell the experimenter the total number of balls. In the other six problems, which were printed on another single sided A4 paper, children had to add and subtract a similar range of numerals to those employed as quantifier terms in the experimental discourses (See Appendix 1 for the arithmetic problems). Failing any of the arithmetic problems was suggestive that children would have difficulty in performing the
comprehension experiment, thus the responses of children who incorrectly replied to these problems were not included in the analysis of results. Note here, that the arithmetic problems were only presented to children participants, adults that participated in the current research were not presented with these problems.

5.1.3. Procedure

For children to take part in this study, prior to each experiment approvals were obtained from the Ministry of Education in Cyprus, headmasters and teachers of the school, as well as the children’s parents. Additionally, before running each experiment, children were told that their participation was voluntary, and thus they would take part only if they wanted to. This was to ensure that children felt comfortable in taking part in the experiment. At the end of the session of each experiment, children were given a small gift, such as a pencil, as an appreciation for their participation.

In each of the experiments, each child was individually taken to a quiet room within the school premises, with the experimenter and was presented firstly with the arithmetic problems. After the completion of these problems, children were then given the comprehension experiment. It was stressed to children that they were not being tested, and so they were free to choose whichever picture they thought was the best, without the fear of being graded.

At the start of each trial, the experimenter read aloud the short discourse (without emphasizing any words) and then children were simultaneously presented with two or more pictures printed in a single sided A4 or A3 paper. The pictures were numbered so the experimenter could record the picture children selected. Also, each
picture was randomly placed in the paper, to ensure that children were not picking the first picture they saw. Each test session lasted approximately 20 minutes.

5.1.4. Analysis of the Results

Prior to analysing participants’ choices on the pictures, children’s performance on the arithmetic problems was examined. Recall that these problems were used to ensure that children’s choices were not reflecting difficulty in their ability to do arithmetic; thus, the responses of the children who failed to correctly reply to any of the seven arithmetic problems, were excluded from the analysis. Then children’s and adults responses to the filler items were examined. Recall that the fillers were included to ensure that participants were paying attention to the task; therefore, the responses of the participants who failed in correctly evaluating any of the fillers were also excluded from the analysis.

In the current experiments data was always analysed using two ANOVAs; one was treating the participants as a random variable ($F_1$), whereas the other was treating the discourses as a random variable ($F_2$). Effects were only considered to be significant when both the $F_1$ and $F_2$ analyses were significant at $p < 0.05$.

5.1.5. Section Summary

In summary, the purpose of this part was to make the reader familiar to the general methodology that was employed in this research. The general materials and design of this research were briefly discussed. More detailed descriptions of the
techniques employed in each of the experiments will be presented in the methodology section of each of the seven experiments.

5.2. Pilot Study

Prior to running the experiments, it was necessary to examine whether children were able to perform the experimental task. For this reason a pilot study was conducted which examined if the experimental sentences and pictures could be easily understood by the youngest age group of children.

5.2.1. Experimental Design

5.2.1.1. Participants

Five first graders with mean age seven years and two months took part in the pilot study. These children were recruited from “Alpha Primary School Aradippou”.

5.2.1.2. Materials and Design

The materials and design that were used in the pilot study were identical with the ones planned to be used in Experiment 1. Children were presented with a forced-choice picture-selection task in which they were presented with twenty two-sentence discourses, each with two pictures. Children’s task was to select the picture they thought best described the meaning of the discourse. The twenty discourses were made up of five filler items and fifteen experimental discourses. The fifteen experimental discourses
were divided into three sentence types; five were ambiguous (e.g., *eight horses… four horses*), another five unambiguously subset (e.g., *eight horses… four of them…*) and the remaining five unambiguously new-set (e.g., *eight horses… four other horses…*). Figure 3 illustrates an example of one experimental material that was used in the pilot study.

![Figure 3: Example of an experimental item used in the pilot study](image)

As it is shown in Figure 3, children were presented with two pictures. One picture depicted a subset reading of the discourse (a), since it illustrated a situation in which the four horses that were eating were part of the set of horses that were in the farm. The other picture illustrated a new-set reading of the discourse (b), since it illustrated that the four horses that were eating were a different set of horses than those specified in the first sentence (i.e. *eight horses*).

The design of the pilot study was within subjects and items. There was one independent variable, sentence type, and one dependent variable, the frequency of time
children selected the picture depicting a new-set reading in each of the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset).

5.2.1.3. Procedure

The procedure that was used in the pilot study was identical with the one that was going to be used in Experiment 1. Children were tested individually and the test session lasted approximately twenty minutes. Children were first presented with the five arithmetic problems that they had to complete. After the completion of these problems children were then presented with the comprehension experiment. At the beginning of each trial, the experimenter read aloud each discourse, without emphasising any words and children were simultaneously presented with the two pictures, printed in two A4 papers. The experimenter moved to the second discourse only after children indicated the picture they considered to be the best description of the discourse.

5.2.2. Results and Discussion

Prior to analysing children’s preferred pictures, children’s performance on the arithmetic problems and filler items were first examined. Recall that the responses of children who failed to correctly reply to any of the arithmetic problems, and/or filler items were not included in the analysis of the results.

The results of the pilot study have showed that three out of the five children failed to find the correct answer to the arithmetic problems. Moreover, the experimenter noticed that even the two children who did solve these problems correctly, had a great difficulty with the comprehension experiment, spending a long time to decide which of
the two pictures to select. Additionally, only one child responded correctly to all five filler items. Taken together this was an indication that children had a difficulty with the materials that were used in the pilot study. Thus, it was vital to re-examine the materials and find a way to revise them to be more easily understood by children.

A closer look at the discourses that were used in the pilot study provided one possible explanation of why children found the pilot study difficult to perform. It is possible that the numerals that were used to describe the entities in the discourses were quite large for first graders to understand. In particular the twenty discourses that children were presented with were of three combinations: eight x… four x…, six x… three x… and five x… three x… Perhaps a smaller range of numerals would have eliminated the difficulty that children faced. For instance, it is possible that children would have performed better if they were presented with combinations that the numeral did not exceed the number four (e.g., four horses… two horses…).

For this reason the discourses that were employed in the pilot study were revised. In the revised version, the numeral of the first and second sentence of each discourse was replaced with a smaller number, ensuring that the numerical expressions were not exceeding the number four. It was anticipated that this change would make the discourses easier for children.

Furthermore, the long time children spent in deciding which picture to choose, and their failure to correctly evaluate the fillers, also suggested a difficulty by children to understand the pictures. A possible drawback of the pictures that were created is that they illustrated objects that were not necessary for the successful comprehension of the discourse. The reason these objects were included in the picture was to make the picture more interesting for children; however unnecessary objects, such as a tractor, could have been distracting for children. Thus, it was also necessary to revise the pictures.
Figure 4 illustrates the revised version of the experimental discourse that was presented in Figure 3.

![Figure 4: Example of a revised experimental item](image)

As it is clearly illustrated in Figure 4, the revised version of the pictures does not illustrate a tractor or any other any unnecessary item that might have been confusing for children. Rather, the pictures illustrate only the entities (e.g., horses) and items (e.g., food) that are necessary for the short discourse to be true. Similar changes were done for all of the pictures that were used in the pilot study. The assumption is that these changes would make the task be better understood by children.

5.2.3. *Section Summary*

In summary, the pilot study was very helpful in showing modifications that had to be done before running the current experiments. In particular, the results suggested that the discourses and pictures had to be modified to be better understood by children.
For this reason, the materials that were employed in the pilot study were revised and this revised version was presented to the participants of the experiments that follow.

5.3. **Summary of Chapter 5**

The first part of this chapter introduced the general methodological design that will be employed in the current research. In particular, a general picture of the participants, materials and procedure that will be employed in the current research was presented. The second part of this chapter discussed a pilot study that was utilised to explore whether the materials could be easily understood by the younger group of children that will participate in the current research. The results of the pilot study suggested that the discourses and pictures had to be modified for the task to be better understood by children. Thus, the discourses and pictures were revised and participants of the seven experiments that follow were presented with the modified version of these materials.
Chapter 6:
Experiments 1 & 2: Children’s and Adult’s Interpretative Biases

This chapter reviews two experiments that were conducted as a preliminary exploration of children’s and adults’ interpretative preferences when analysing quantified noun-phrases (e.g., *two cats*) and bare cardinals (e.g., *two*). The goal of these experiments was to investigate whether children analyse ambiguous and unambiguous numerically quantified expressions in a similar manner to adults. Experiment 1 compared adults and children’s responses using a forced-choice picture-selection task in which participants were presented with two pictures with the task to select the picture that best described the discourse. Experiment 2 aimed at testing whether the effects obtained in the initial experiment could be replicated in a condition in which children had to select between four pictures.

6.1. Experiment 1. Subset or New-set Reading of Numerically Quantified Expressions?

Experiment 1 was the first attempt to explore children’s interpretative preferences when analysing ambiguous and unambiguous numerically quantified expressions. Of main importance was to examine whether children interpret numerically quantified expressions similarly with adults, thus both children’s and adults’ responses were tested. Participants’ interpretative preferences were examined using a forced-choice picture-selection task in which they were presented with ambiguous or unambiguous two-sentence discourses together with two pictures. One picture illustrated a subset interpretation of the discourse, whereas the other depicted a new-set
reading of the discourse. Children’s and adults’ task was to select the picture they thought best described the meaning of the discourse.

Existing research which examined adults’ interpretative preferences when analysing numerically quantified expressions, examined discourses that contained quantified noun-phrases (e.g., Frazier et al. 2005) or bare cardinals (e.g., Kaan et al. 2007; Wijnen & Kaan, 2006; Wijnen et al. 2004), nevertheless none of this research directly investigated whether these two types of numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) are interpreted similarly or not.

A comparison of these numerically quantified expressions is important, since finding differences between the two might be an indication that these expressions are analysed differently by readers. Such a finding would suggest that different examinations should be employed for better understanding of readers’ processing of ambiguous numerically quantified expressions. Similarly, differences on how quantified noun-phrases and bare cardinals are interpreted might be an indication that one type of numerically quantified expression tends to be more anaphoric than the other, which would also demand an explanation of why this is the case. For this reason it was considered important in Experiment 1 to directly compare children’s and adults’ preferences when interpreting quantified noun-phrases as opposed to bare cardinals. This was done by dividing the participants into two groups; one group was presented with discourses that contained quantified noun-phrases and the other with bare cardinals. Importantly, the responses of these two groups were then compared.
6.1.1. Predictions

Existing research which investigated adults’ interpretative biases when analysing ambiguous quantified noun-phrases and bare cardinals (e.g., Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan 2006) make some clear suggestions on how adults would respond in this experiment. The research conducted by Frazier et al. (2005) and Paterson et al. (2008b) with quantified noun-phrases, as well as Kaan and colleagues (Kaan et al. 2007; Wijnen & Kaan, 2006) research with bare cardinals, showed a strong preference by adults for the subset reading. It is expected that the same strong preference will be found in the current experiment.

Moreover, it is also expected that adults will not find it difficult to reach to the appropriate reading when interpreting unambiguous numerically quantified expressions. Recall that using similar unambiguous controls Frazier et al. (2005) have found that adults do not have difficulty in reaching the expected reading. Consequently, it is expected that in the unambiguously subset sentence type, in which the discourse contains the partitive construction of them (e.g., three cats… two of them…), adults will reach the appropriate subset reading. Similarly, adults are expected to reach the new-set reading in the unambiguous new-set sentence type which contains the expression other (e.g., three cats… two other cats…).

Nevertheless, previous research that examined children biases when interpreting ambiguous bare cardinals (e.g., two…) was not unambiguously informative of children’s preferred interpretation (i.e. Wijnen et al. 2004). Thus, it is still open for investigation whether children assign a subset or a new-set reading of ambiguous numerically quantified expressions. The results from research which investigated other types of anaphors (e.g., pronouns, the definite reference and inference generation)
appear to suggest that children will have difficulty to reach the adult-like subset reading (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). For instance recall the work of Karmiloff-Smith (1979; 1980) who investigated children’s processing of pronouns and the definite reference. She found that children younger than eight have a difficulty in forming links between an anaphor and its prior discourse context.

If the difficulty that has been obtained from these studies is not specific to the phenomena they investigated, then it is possible that children will find it difficult to integrate the meaning of the two sentences in the current experiment. This suggests that children will have a difficulty in establishing a subset reading of ambiguous numerically quantified expressions. Note that a necessary prerequisite of the subset reading is forming referential links between the numerically quantified expression contained in the second sentence and information found in the context sentence (i.e. first sentence). Thus, if children have an overall difficulty with integration, perhaps this will lead to a more general difficulty in reaching the subset reading.

Alternatively, it is also possible that children’s difficulty with integration does not apply to numerically quantified expressions. Perhaps children, similarly with adults, have a strong preference in analysing numerically quantified expressions following a subset reading, which was the finding of Wijnen et al.’s (2004) research. It is expected that the current experiment will provide some insight into six- to eight-year-olds interpretative preferences when analysing ambiguous and unambiguous quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…).
6.1.2. Experimental Design

6.1.2.1. Participants

Sixty-eight native Greek speaking children, from “Alpha” Primary School Aradippou, and forty postgraduate students, from the Cyprus International Institute of Management, took part in this experiment. The participants were divided into two groups. The first group consisted of thirty-four first graders mean age 7;3 and twenty adults. This group was presented with ambiguous and unambiguous discourses that contained quantified noun-phrases (e.g., two cats…). The second group consisted of thirty-four second graders, mean age 8;3, and twenty adults. This group was presented with discourses that contained bare cardinals (e.g., two…). The main reason that more children than adults were recruited for participants was because higher exclusion rates were anticipated for children than for adults.

6.1.2.2. Materials and Design

The participants were presented with fifteen experimental short discourses and five filler items in their native language, Greek. The fillers were used as an indication of whether participants and especially children were paying attention to the task. For these items, the first and second sentence referred to different sets of entities (e.g., four deer… two lions…) and participants selected between a picture that illustrated the correct number of entities performing the actions described in the discourse (e.g., four deer and two lions) and a picture that illustrated fewer entities than the ones described in the discourse (e.g., two deer and two lions).
In the experimental discourses, the first sentence introduced a set of entities (e.g., *three cats*) and the second sentence referred to the same set of entities, but included a quantified noun-phrase or bare cardinal that had lower cardinality than the one used in the first sentence (e.g., *two cats*). Additionally, the experimental discourses were divided into three sentence types; they were either ambiguous (52a), unambiguous towards a subset reading (52b), or unambiguous towards a new-set reading (52c).

52. a) Three cats were on a wall. Two caught a mouse.

   b) Three cats were on a wall. Two of them caught a mouse.

   c) Three cats were on a wall. Two others caught a mouse.

Additionally, two different sets of the fifteen experimental discourses were created. In one version, presented to the thirty-four children and twenty adults who formed the first group of participants, the entity was referred to using a quantified noun-phrase (e.g., *two cats*), whereas the other version, presented to the thirty-four children and twenty adults who formed the second group of participants, the entity was referred to using a bare cardinal (e.g., *two*). Note however, that despite the difference in the type of numerically quantified expression that was used, the discourses were identical in every other respect. Lastly, for each of the two groups of participants (i.e. quantified noun-phrase group and bare cardinal group) three files containing one version of each discourse with an equal number of unambiguously new-set, ambiguous and unambiguously subset discourses as well as fillers, was created. The files were presented to participants in a fixed order, with this order reversed for half of the participants in each group. In particular, from the thirty-four children that formed the first group of participants (i.e. the group that was presented with quantified noun-
eleven children were presented the first file, twelve children were presented with the second file, and eleven children were presented with the third file. From the twenty adults that formed the first group of participants seven viewed the first file, another seven saw the second file, and the remaining six saw the third file. As for the thirty-four children that formed the second group of participants (i.e. the group that was presented with quantified bare cardinals), twelve children were presented with the first file, another twelve were presented with the second file, and ten children were presented with the third file. From the twenty adults that formed the second group eight viewed the first file, six viewed the second file, and the remaining six viewed the third file. All of the discourses that were presented to the participants were paired with pictures; one represented a subset reading of the discourse and one represented a new-set reading of the discourse.

Figure 5, shows an experimental discourse that was presented to the two different groups of participants in this experiment. As it is shown the second sentence varied depending on the numerically quantified expression it contained (i.e. quantified noun-phrase or bare cardinal) with the noun *cats* omitted for discourses that contained bare cardinals.
As it is illustrated in Figure 5 both groups of participants had to select between two pictures. One picture depicted a situation in which the two cats that caught a mouse formed a subset of the ones that were on the wall (consistent with the subset reading) and the other picture depicted a situation in which the two cats that caught a mouse were a different set than the ones on the wall (consistent with the new-set reading).

In Experiment 1 there were three independent variables, sentence type (i.e. unambiguously new-set, ambiguous, and unambiguously subset), age group (i.e. children or adults) and type of numerically quantified expression (i.e. quantified noun-phrase or bare cardinal). The dependent variable was the frequency of time participants selected the picture which reflected a new-set interpretation in each of the three sentence types. Since participants were divided into two groups with one group been presented with quantified noun-phrases and the other group with bare cardinals, this variable was manipulated between participant and within items. Age group was between participants and within items, whilst sentence type was within participants and items.
6.1.2.3. Procedure

The same procedure was used for both groups of participants. Children that participated in this experiment were recruited from “Alpha Primary School Aradippou” and were tested within the school premises. Adults were postgraduate students who were tested in their college. Participants were tested individually in a quiet room, and each session lasted approximately twenty minutes.

Prior to the comprehension experiment a revised version of the seven arithmetic problems that were employed in the pilot study were presented to children with the task to be completed (See Appendix 2 for the arithmetic problems). These arithmetic problems were considered unnecessary for adults therefore were only presented to children. These problems tested children’s knowledge of counting as well as adding and subtracting a similar range of numerals that were used as quantifier items in the comprehensive experiment. Thus, the responses of children who failed to correctly reply to these problems were not included in the analysis of the results. When children completed the arithmetic problems they were then presented with the comprehension experiment.

At the start of each trial, children and adults were read aloud one by one the twenty two-sentence discourses. These discourses were selected from one of the three files that were created. Participants were then shown the two corresponding pictures and asked to indicate which of the pictures they considered matched the meaning of the discourse.
6.1.3. Results

Prior to analysing which of the two pictures participants preferred, children’s performance on the arithmetic problems and the filler items were examined. These problems were included in order to assess children’s arithmetic competency as these have important bearing on their performance in the experiment. The experimental data for the children who failed in correctly evaluating all of the arithmetic problems, or responded incorrectly to any of the filler items were excluded from the analysis. Similarly, adults’ performance on the filler items was also examined and data for those who failed to correctly evaluate all of the filler items were also excluded from analysis.

None of the adults failed on the filler items; however, from the sixty-eight children that participated, fifteen children failed the arithmetic problems, selected the incorrect picture for the filler items or failed both arithmetic and filler items. Data for these children’s scores were excluded from the analysis. Thus, the responses that were ultimately analysed were of forty adults and fifty-three children (mean age 7;8). Of these participants, twenty-five children and twenty adults belonged to the quantified noun-phrase group (e.g., three cats… two cats…) and the remaining twenty-eight children and twenty adults belonged to the bare cardinal group (e.g., three cats… two…).

Three variables were investigated. First, and most importantly, children’s and adults’ responses were compared by examining if they interpreted the short discourses similarly or not. Second, the type of numerically quantified expression (i.e. quantified noun-phrase or bare cardinal) was investigated, by comparing the responses of the two groups of participants. Lastly, the influence of sentence type (i.e. unambiguously new-
set, ambiguous and unambiguously subset) was examined by comparing participants’ responses in each of the three sentence types.

It was possible to analyse either the frequency of time participants selected the “new-set picture”, or the frequency of time participants selected the “subset picture”. It was chosen to analyse the frequency that children and adults selected the “new-set picture”. Data were analysed using two 2 (Age: children or adults) x 3 (Sentence Type: unambiguously new-set, ambiguous and unambiguously subset) x 2 (Numerically quantified expression: quantified noun-phrase or bare cardinal) mixed design ANOVAs. The first observation that came out of the analysis was that although there was a significant effect of sentence type ($F_1(2, 178) = 199.76, p < 0.05; F_2(2, 112) = 223.31, p < 0.05$) and a significant difference between sentence type and age group ($F_1(2, 178) = 141.34, p < 0.05; F_2(2, 112) = 152.33, p < 0.05$), there was no significant difference in the way participants treated the two types of numerically quantified expressions (i.e. quantified noun-phrase and bare cardinal) ($F_1(2, 178) = 1.13, p > 0.05; F_2(2, 112) = 0.39, p > 0.05$). Moreover, the results showed that the type of numerically quantified expression did not interact with any other variables, since there was no three way interaction between sentence type, numerically quantified expression, and age group ($F_1(2, 178) = 0.79, p > 0.05; F_2(2, 112) = 0.58, p > 0.05$). Therefore, the analysis showed that participants did not interpret the discourses that contained a quantified noun-phrase differently from the ones that contained a bare cardinal. This finding suggested that, at least for the current experiment, both children and adults interpreted discourses that contained both types of numerically quantified expressions (i.e. quantified noun-phrases or bare cardinals) similarly.

For this reason it was considered unnecessary to have separate analyses for these two groups of participants. Thus, the responses of the participants of the quantified
noun-phrase group and bare cardinal group were combined and a single analysis was conducted. This new analysis used a two 2 (Age: children or adults) x 3 (Sentence Type: unambiguously new-set, ambiguous and unambiguously subset) mixed design ANOVAs. Figure 6 illustrates the frequency with which children and adults selected the picture that depicted a new-set reading of the discourse, in the three different sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset) collapsed across the two types of numerically quantified expressions (i.e. quantified noun-phrase and bare cardinal).

Figure 6: Children’s and adults’ selection of the “new-set picture” in Experiment 1, with error bars representing the standard error of the mean.

Significantly, as it is clearly illustrated in Figure 6, children and adults responded differently in the three sentence types. The analysis revealed a significant main effect of sentence type ($F_1(2, 182) = 201.19, p < 0.05; F_2(2, 116) = 227.34, p < 0.05$). Furthermore, there was a significant interaction between sentence type and age group ($F_1(2, 182) = 140.275, p < 0.05; F_2(2, 116) = 155.071, p < 0.05$). Children had a strong preference in selecting the “new-set picture” when interpreting both ambiguous and unambiguous discourses, whereas adults had a strong preference for the same
picture only when they analysed discourses that were in the unambiguously new-set sentence type.

To further explore how children and adults responded to each of the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset) Tukey’s HSD post-hoc tests were computed. Starting with adult’s responses, post-hoc analysis showed that there were significant differences in adults’ frequency of selecting the “new-set picture” in all three sentence types. That is, adults selected significantly more times the “new-set picture” in the unambiguously new-set sentence type than in the other two sentence types ($p < 0.05$), and adults selected the “new-set picture” in the ambiguous sentence type more times than in the unambiguously subset sentence type ($p < 0.05$).

Children’s responses however, were different than those of adults. Post-hoc analysis showed that there were no differences in the frequency children selected the “new-set picture” in the unambiguously new-set and ambiguous sentence types ($p > 0.05$), but there were differences in the frequency of times children selected the “new-set picture” in the unambiguously new-set and unambiguously subset type, as well as ambiguous and unambiguously subset sentence types ($p < 0.05$).

Lastly, it was also considered important to test whether the frequency of participants’ responses were significantly different to chance. For this reason a one-sample t-test was computed for each of the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset). The t-tests compared participants’ mean to a test value of 50%. Since adults’ frequency of selecting the “new-set picture” across the three sentence types was very clear (i.e. 100% for unambiguously new-set sentence type, 27% for ambiguous sentence type and 0% for unambiguously subset sentence type), t-tests were computed only for children responses. Starting with the
unambiguously new-set sentence type, t-test analysis revealed that children’s responses were significantly different to the 50% chance level \(t(52) = 5.63, p < 0.05\). Similarly, children’s responses to the ambiguous sentence type were also significantly different to the 50% chance level \(t(52) = 5.28, p < 0.05\). Finally, the t-test which examined children’s responses for the unambiguously subset sentence type also showed significant effects \(t(52) = 2.15, p < 0.05\). Taken together the results of the t-test clearly show that children’s selection for the picture depicting a new-set reading of the discourse in all three sentence types was not due to chance, but rather it was a preference by children for the “new-set picture” when interpreting both ambiguous and unambiguous numerically quantified expressions.

6.1.4. Discussion

The aim of the first experiment was to examine children’s and adult’s interpretative preferences when analysing ambiguous and unambiguous discourses that contain numerically quantified expressions. Of particular importance was whether children and adults analyse such expressions similarly. A particularly striking effect has been obtained; children interpret discourses that contain quantified noun-phrases (e.g., two cats) and bare cardinals (e.g., two) in a non-adult manner. Whereas adults had a strong preference for the “new-set picture” only when they analysed discourses that were disambiguated towards a new-set reading (i.e. three cats… two other cats…), children had a strong preference for the same picture regardless of the sentence type (e.g., unambiguously new-set, ambiguous and unambiguously subset).

Another aim of the current experiment was to investigate whether there are differences in how the two types of numerically quantified expressions (i.e. quantified
noun-phrases and bare cardinals) are interpreted by readers. Children and adults were divided into two groups, one group was presented with quantified noun-phrases and the other with bare cardinals and the responses of the two groups were then compared. The results clearly showed that, at least in the current experiment, children and adults interpret these two types of numerically quantified expressions similarly. Thus, these expressions will be treated as equivalent in the remainder of this discussion.

To begin with, adults responded as expected in the two unambiguous sentence types. Specifically, adults always selected the “new-set picture” in the sentence type which was disambiguated towards a new-set reading (i.e. unambiguously new-set sentence type) and always selected the “subset picture” in the sentence type that was disambiguated towards a subset reading (i.e. unambiguously subset sentence type). This finding fits well with the findings of existing research in which by using similar unambiguous controls they have found that adults can switch between the two possible interpretations (i.e. subset and new-set reading) when needed (e.g., Frazier et al., 2005).

Furthermore, the current results showed a strong preference by adults for the “subset picture” when analysing ambiguous quantified noun-phrases and bare cardinals. Again this finding is in line with previous research which clearly showed that adults have a strong preference for the anaphoric subset reading when analysing numerically quantified expressions (i.e. Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan 2006).

Importantly however, children did not respond similarly to adults. The results showed that six- to eight-year-olds had a strong preference for the “new-set picture” when analysing numerically quantified expressions. The finding that six- to eight-year-olds do not interpret quantified noun-phrases and bare cardinals in terms of a subset analysis is particularly striking. The fact that children avoid the adult analysis of such
expressions is of particular interest and it will be the focus of the remainder of this research. The aim is to find an explanation of why children show such a strong preference for the “new-set picture”. At this point of this thesis some possible mechanisms that provide possible explanations for this preference can be considered.

One possible explanation is directly in line with the results of previous research which examined children’s processing of other types of anaphors (e.g., pronouns, the definite reference, and inference generation). In this research it has been widely demonstrated that children have a difficulty to form referential links when they interpret discourses, even when these discourses are explicitly anaphoric (e.g., Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). It appears that a similar explanation can be provided for the results of the current experiment. For explanation purposes consider the discourse shown in (53).

53. Three cats were on a wall. Two cats caught a mouse.

Recall that in order for the “new-set picture” to correspond to a new-set reading the entities described in the second sentence (for the above example two cats) formed a different set (or a new set) of entities than those described in the first sentence (for the above example three cats). Thus, inevitably this picture also corresponded to a non-integrative interpretation of the discourse. That is, it could be also selected if children analysed the separate meaning of the first sentence and the separate meaning of the second sentence. Therefore, perhaps children’s selection for the “new-set picture” that was observed in the current experiment, was not a reflection of a new-set analysis, but rather a difficulty or inability by children to integrate the meaning of the two sentences.
A closer examination of the frequency of time children selected the “new-set picture” in the three sentence types (i.e. unambiguously new-set, ambiguous, and unambiguously subset), provides support for such an explanation. First, there is a very interesting observation when the responses by children for the ambiguous and unambiguously new-set sentence types are compared. Recall that the unambiguously new-set sentence type contained the word *other* which disambiguated the discourse in favour of the new-set interpretation. The results showed that children responded as expected in this sentence type, selecting the “new-set picture” in a 70% frequency. Importantly however, this preference was very close with the 68% frequency that was obtained in the ambiguous sentence type. Crucially, this suggests that discourses with and without the word *other* have a similar effect on children’s interpretative preferences.

A difficulty or inability to integrate the meaning of the two sentences provides an explanation for this finding. Perhaps children selected the “new-set picture” in a similar frequency in these two sentence types (i.e. unambiguously new-set and ambiguous) because they analysed the individual meaning of each of the two sentences. This suggests that children selected the “new-set picture” in the unambiguously new-set sentence type not because they were influenced by the word *other*, but rather because the “new-set picture” corresponded to the individual meaning of the two sentences.

Further support for an inability or difficulty to form links between the two sentences comes from the results obtained from children’s performance in the unambiguously subset sentence type (e.g., *three cats… two of them…*). The data clearly showed that for six- to eight-year-olds the partitive construction of *them* was ineffective in disambiguating the discourse towards a subset reading. Whereas adults always selected the expected “subset picture” in this sentence type, children selected the
expected picture only 41% of the time. The low frequency of selecting the “subset picture” in this sentence type might be an indication that children analysed each of the two sentences separately. Perhaps the partitive construction of them did not influence children’s preferences because they analysed the meaning of the second sentence independent of the meaning of the first sentence, which unavoidably lead to accepting only the “new-set picture” as best describing the discourse.

A second closely related explanation that can account for the significant findings observed in the current experiment is that children have a difficulty in assigning a subset reading to numerically quantified expressions. Perhaps children’s difficulty with forming links between sentences has a direct consequence on their ability to follow the subset reading. Recall that a necessary prerequisite for the subset interpretation is to link the quantified noun-phrase of the second sentence (e.g., two cats) with the quantified noun-phrase of the first sentence (e.g., three cats), therefore, if children have a general difficulty with forming the referential links of numerically quantified expressions, then inevitably they will also have a difficulty to follow the subset reading. Thus, another possible reason that accounts for children’s strong preference for the “new-set picture” is that children have a difficulty in reaching to the anaphoric subset reading.

In the same line, it is also possible that children have a difficulty in reaching the subset interpretation, because integration incurs a processing cost for children. That is, unlike adults, in which it has been widely shown that forming links between sentences is a natural process that happens automatically (e.g., Clark & Haviland, 1977; Crain & Steedman, 1985; Ehrlich & Johnson-Laird, 1982; Johnson-Laird, 1983), perhaps children’s general difficulty in forming the referential links of anaphoric expressions leads to a processing cost associated with the anaphoric, subset reading. In other words, it might be more costly for children to follow the reading that demands integration (i.e.
subset reading) than the reading that no integration is necessary (i.e. new-set reading). Thus, following this alternative explanation of the present findings, children’s strong preference for the “new-set picture” was not because of a preference for the new-set interpretation, but a direct result of children’s failure or difficulty to reach the subset reading of numerically quantified expressions.

A further possible explanation of the current results is that children and adults assign different interpretative biases when they analyse ambiguous and unambiguous referentially interlinked discourses. Following this suggestion, children’s differences with adults are not because children have a difficulty to reach to the subset interpretation, but rather because they have a strong bias in interpreting numerically quantified expressions by adopting a new-set reading. This suggests that when children were presented with an ambiguous discourse that contained a quantified noun-phrase or bare cardinal, they acknowledged that it could be interpreted in both a new-set and a subset reading, but since they had to select only one picture, they selected the picture that matched their preferred interpretation; that is, the “new-set picture”. Following this possibility, if children were asked to judge whether both of these pictures corresponded to the meaning of the discourse then they would have indicated both pictures. Obviously such possibility was not the focus of this experiment, but clearly raises issues that need to be tackled in a future experiment.

Finally, one uninteresting alternative explanation of the significant findings that were obtained in Experiment 1 is that the current results are specific to the children who participated in this experiment and thus not replicable. Although it is strongly suggested that children’s preferences are well beyond a simple explanation like this, it was nevertheless vital to minimise such an alternative explanation. Thus, a critical step was to test whether similar responses by children could be obtained in another experiment.
This was the main reason Experiment 2 was carried-out. Specifically, Experiment 2 tested whether children would show the same preference for the picture that depicts a new-set reading under slightly different conditions. In particular, it was chosen to examine conditions in which children were presented with additional pictures to choose from.

In summary, the main finding of Experiment 1 was that children had a non-adult strong preference for the picture that depicted a new-set reading when they interpreted ambiguous and unambiguous quantified noun-phrases (e.g., *two cats*) and bare cardinals (e.g., *two*). Some possible explanations of this significant finding were briefly discussed. In the next experiment it was necessary to replicate the initial findings of Experiment 1 to be able to directly investigate the reasons behind children’s strong preference for the “new-set picture” when analysing numerically quantified expressions.

6.2. Experiment 2. Is children’s preference for the “new-set picture” replicable?

The aim of the current experiment was to test whether children’s strong preference for the “new-set picture” observed in the Experiment 1 could be replicated under conditions in which children were presented with four pictures to choose from. Similarly with the previous experiment, in Experiment 2 children’s preferences were tested using a forced-choice picture-selection task. However, in this experiment together with the two critical pictures (i.e. “subset picture” and “new-set picture”) children were presented with two additional pictures. These new pictures were distracting, since they illustrated a different entity performing the actions described in the discourse. For instance, for the discourse shown in (54) the distracting pictures illustrated dogs performing the actions depicted in the discourse (i.e. catching of mice).
54. Three cats were on a wall. Two cats caught a mouse.

Importantly however, although the two distracting pictures illustrated different entities, they were nevertheless identical with the two critical pictures in all other means. That is, one reflected a subset reading of the discourse by illustrating three entities on the wall (two of which with a mouse), and the other reflected a new-set reading by illustrating three entities on the wall and two different entities with a mouse. An example of these pictures is illustrated in Figure 7. As in the previous experiment, the current experiment examined children’s preferences when they were asked to indicate the picture they thought best described the discourse.

6.2.1. Predictions

The results of Experiment 1 showed that children have a strong preference in selecting the “new-set picture” when they analyse both ambiguous and unambiguous numerically quantified expressions. If the findings of Experiment 1 are specific to the children that participated in the previous experiment, then different effects should be obtained in this experiment. If however, the effects of the first experiment are replicated, then this will clearly show that children indeed have a preference for the “new-set picture”. Such finding will demand further investigations to examine possible reasons that might account for this preference.

It is expected that the findings of Experiment 1 will be replicated in the current experiment. The perception is that the findings observed in the first experiment are not specific to the children who participated, but rather are a result of a non-adult preference
by children. As mentioned previously, this preference is perhaps related with children employing different strategies than adults when they comprehend a text, or perhaps is a direct result of a general difficulty by children to form links between sentences when they comprehend a text.

6.2.2. \textit{Experimental Design}

6.2.2.1. \textit{Participants}

The results of Experiment 1 have shown that adults produced the expected pattern of performance, for this reason the current experiment tested only children. Specifically, thirty-eight native Greek speaking children took part in this experiment. All participants were first and second graders, mean age 6;7. Children were recruited from “Delta Primary School Aradippou”. None of the children that participated in this experiment participated in Experiment 1.

6.2.2.2. \textit{Materials and Design}

Since the previous experiment clearly showed that there were no differences in the way children (and adults) interpreted quantified noun-phrases (e.g., \textit{two cats}) and bare cardinals (e.g., \textit{two}) it was considered unnecessary to have discourses for both types of numerically quantified expressions. Therefore, in the current experiment children were presented with discourses that contained quantified noun-phrases. Similarly with Experiment 1 three files containing one version of each discourse with an equal number of unambiguously new-set, ambiguous, and unambiguously subset
discourses as well as fillers was created and presented to children. Half of the participants were presented with the file in a fixed order and the order was reversed for the other half of the participants. Specifically, from the thirty-eight children that participated in Experiment 2, twelve were presented with the first file, another twelve with the second file and the remaining fourteen with the third file.

Additionally, in this experiment children were presented with four pictures to choose from. Two of them were the critical pictures that were also used in the previous experiment (i.e. “subset picture” and “new-set picture”) whereas the other two were the two distracting pictures that were specifically developed for the current experiment. These four pictures were printed in a single-sided A3 paper and presented to children. One example of these four pictures is illustrated in Figure 7.
Three cats were on a wall. Two \( \text{other} \ / \text{of the} \ / \emptyset \) cats caught a mouse.

![Subset Picture](a) ![New-set Picture](b)

![Distracting (Subset) Picture](c) ![Distracting (New-Set) Picture](d)

**Figure 7:** Example of an experimental item used in Experiment 2

As it is clearly illustrated in Figure 7 pictures (a) and (b) are identical to the ones that were used in the previous experiment; picture (a) reflects a subset reading of the discourse and picture (b) reflects a new-set reading of the discourse. Additionally, the other two pictures (c) and (d) are identical with the critical pictures in all ways except the entities that are performing the actions depicted in the second sentence. As it is clearly illustrated in the above figure, the two distracting pictures illustrate dogs rather than cats playing with a mouse. Nevertheless, the number of entities that the “distracting subset picture” (c) illustrates, reflects the total of entities after the discourse is interpreted in a subset reading (i.e. three entities) and the number of entities that the
“distracting new-set picture” (d) illustrates, reflects the total after the discourse is interpreted in a new-set reading (i.e. five entities).

For the filler items the two distracting pictures contained two new entities that were not described in the discourse. For example, in one filler item about deer and lions, the distracting pictures illustrated dinosaurs and flying dragons. Similarly with the experimental discourses, each of the distracting filler reflected the cardinality of each of the two original pictures. That is, if the picture illustrated \( \text{four} \ x \) and \( \text{two} \ y \), the distracting picture also illustrated \( \text{four} \ x \) and \( \text{two} \ y \).

Additionally, there was another change in the materials of this experiment. Recall that in Experiment 1 the partitive construction of \textit{them} was used in the unambiguously subset sentence type to reinforce a subset reading of the discourse; strictly speaking however, a partitive phrase of the form of “\( x \ of \ the \ + \ entity \)” should have been used for discourses that contained a quantified noun-phrase (e.g., \( \text{two of the cats} \)). Therefore, in this experiment the unambiguously subset sentence type was changed and included the partitive construction of \( \text{the} \) (e.g., \( \text{two of the cats} \ldots \)).

In this experiment there was one independent variable, sentence type (i.e. unambiguously new-set, ambiguous and unambiguously subset) and one dependent variable, the frequency of time children selected the “new-set picture” in each of the three sentence types. The design of this experiment was within participants and items.

6.2.2.2. Procedure

The procedure was identical with the one used in Experiment 1, except that in this experiment children were also presented with the written form of the short discourse. Recall that in Experiment 1 participants had to choose the picture that best
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described the discourse after the experimenter read aloud the short discourse. In this experiment participants were also presented with the written form of the short discourse. Therefore, at the beginning of the comprehension experiment children were presented with a printed form of the short discourse and four pictures and then the short-discourse was read aloud by the experimenter.

6.2.3. Results and Discussion

Similarly with Experiment 1, before running the analysis children’s responses to the arithmetic problems and filler items were examined. The data revealed that from the thirty-eight children that participated in this experiment, fifteen children failed on these problems. Thus, a large percentage of children failed on these problems. It is suggested that the mistakes were a result of being presented with more pictures to choose from. Indeed a closer examination on children’s mistakes supports this suggestion.

Three of the children that were excluded failed in correctly replying to both the arithmetic problems and the filler items, whereas the other twelve children made mistakes only with the filler items. An interesting observation was that children’s mistakes with the filler items were mostly because they incorrectly selected one of the distracting pictures. That is, twelve out of the fifteen children rather than selecting the picture that illustrated the entities depicted in the discourse (e.g., deer and lions), selected the picture that depicted two different entities than the ones described in the discourse (e.g., dinosaurs and flying dragons). Additionally, nine of these children also selected a distracting picture for the experimental discourses. These findings support the proposal that the inclusion of more pictures to choose from led children to make more mistakes in this experiment.
Therefore, excluding the responses of the fifteen children who failed in the arithmetic problems and/or filler items, the total number of responses that were analysed, were of twenty-three children, mean age 6;9. For the results to be comparable with those observed in Experiment 1, the percentage of time children selected the picture that depicted a new-set relationship of the discourse in all three sentence types (i.e. unambiguously new-set, ambiguous, and unambiguously subset) was analysed. Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous, and unambiguously subset) x 1 (selection of the “new-set picture“) mixed design ANOVAs. Figure 8 illustrates the percentage of times children selected the “new-set picture” in each of the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset”. Note that the children who selected the distracting pictures were excluded from the analysis since as it was also mentioned earlier they also made mistakes with the arithmetic and or filler items.

As it is clearly illustrated in Figure 8, a similar pattern of results as the one observed in Experiment 1 was obtained; children had a strong preference for the picture that depicted the new-set reading for all three sentence types (i.e. unambiguously new-
set, ambiguous, and unambiguously subset). Analysis revealed a significant main effect of sentence type ($F_1(2, 44) = 9.80, p < 0.05; F_2(2, 28) = 7.74, p < 0.05$). To further examine this significant difference a Tukey HSD post-hoc test was carried out.

Post-hoc analysis showed that there were no differences in the frequency of time children selected the “new-set picture” in the unambiguously new-set and ambiguous sentence types ($p > 0.05$). Additionally there were also no differences in the frequency of time children selected the “new-set picture” in the ambiguous and unambiguously subset sentence types ($p > 0.05$). The results of the post-hoc analysis showed that there were differences only in the frequency of children’s selection of the “new-set picture” in the two unambiguous sentence types, with children selecting significantly more times the “new-set picture” in the unambiguously new-set sentence type than in the unambiguously subset sentence type ($p < 0.05$).

Thus, significantly the initial findings of Experiment 1 were replicated. Children were biased towards selecting the picture that depicted a new-set reading of the discourse regardless of whether the discourse was ambiguous or unambiguous. Nevertheless, if the two experiments are directly compared one difference between the two experiments can be noticed. The results of the post-hoc analysis showed that whereas in Experiment 1 there were significant differences in the frequency of time children selected the “new-set picture” in the ambiguous and unambiguously subset sentence types (68% for former, 59% for latter), in this experiment children’s frequency of selecting the “new-set picture” in these two sentence types was not significant. This difference appears to be because in the current experiment there was a small drop of children’s preference for the “new-set picture” in both of these sentence types. Nevertheless, since the aim of the current experiment was to replicate the findings of the initial experiment, it was important to run another ANOVA and directly compare
whether there are significant differences between the two experiments. Therefore, children’s preference for the picture that depicted a new-set reading in Experiment 1 and Experiment 2 were analysed using two 3 (Sentence Type: unambiguously subset, ambiguous, and unambiguously new-set) x 2 (Experiment: Experiment 1, Experiment 2) mixed design ANOVAs.

The results showed that there was a significant main effect of sentence type \( (F_1(2, 148) = 11.53, p < 0.05; F_2(2, 86) = 11.05, p < 0.05) \). This effect was expected since children in both experiments had a strong preference for the picture that depicted a new-set reading in all three sentence types (unambiguously subset, ambiguous, and unambiguously new-set). Importantly however, analysis did not reveal any significant interaction of sentence type and experiment \( (F_1(2, 148) = 1.83, p > 0.05; F_2(2, 86) = 1.41, p > 0.05) \). This shows that children responses in Experiment 1 did not differ from children responses in Experiment 2. Thus, although in this experiment there was a small drop of children’s selection of the “new-set picture” in ambiguous and unambiguously subset sentence types, this drop was not significant. Clearly, six- to eight-year-olds in the current experiment responded similarly to the children who participated in Experiment 1.

Regardless of not finding significant differences between Experiments 1 and 2 it was also considered important to test whether children’s selection of the picture depicting a new-set reading in Experiment 2 was significantly different to chance. Therefore, similarly to Experiment 1, a t-test analysis was computed for each of the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset) comparing children’s mean to a test value of 50%. For the unambiguously new-set sentence type, t-test analysis revealed that children performed significantly different to the 50% chance level \( (t(22) = 4.80, p < 0.05) \). Similarly children’s performance to the
ambiguous sentence type was also significantly different to chance ($t(22) = 3.49, p < 0.05$). However, the analysis that examined children’s responses to the unambiguously subset sentence type was not significantly different to the 50% chance level ($t(22) = 0.56, p > 0.05$). This finding suggests that it is not clear whether children’s choice for the picture depicting a new-set interpretation in the unambiguously subset sentence type, is a preference for this picture, or whether children select the “new-set picture” at chance. Nevertheless, whichever is the case children’s bias towards selecting the “new-set picture” more times than the other pictures when analysing unambiguously new-set and ambiguous numerically quantified expressions cannot be minimised.

The results of Experiment 2 are clear. The introduction of distracting pictures did not affect children’s strong preference for the picture that depicted a new-set reading of the discourse. The key findings of Experiment 1 were replicated; children (unlike adults) have a strong preference for the picture that depicts a new-set reading when analysing numerically quantified expressions. The results from the t-test analysis revealed that in the unambiguously subset sentence type children do not select the “new-set picture” significantly different to chance, nevertheless it is clear that children do frequently select the “new-set picture” rather than the “subset picture” in the unambiguously subset sentence type that contains the partitive construction of the and thus explicitly denotes that the discourse has to be analysed following a subset reading. Taken together, the results of Experiment 2 clearly show that the significant effects observed in Experiment 1 were not specific to the children who participated in that experiment, but rather strongly suggest that six- to eight-year-olds have a clear strong preference for the “new-set picture” when analysing numerically quantified expressions.

In summary, Experiment 2 was carried-out to examine whether the findings observed in Experiment 1 could be replicated in conditions in which children were
presented with four pictures to choose from. Importantly, the effects observed in Experiment 2 fit perfectly well with the effects obtained in Experiment 1; six- to eight-year-olds have a strong preference for selecting the picture that depicts a new-set reading when they analyse both ambiguous and unambiguous quantified noun-phrases. Thus, any possibility that the results obtained in Experiment 1 were one-time effects that could not be replicated is eliminated.

6.3. Summary of Chapter 6

This chapter reviewed two experiments that were conducted to examine children’s interpretative preferences when analysing numerically quantified expressions. The results that were obtained clearly show that children, unlike adults, have a strong preference for the picture that depicts a new-set reading when analysing both ambiguous and unambiguous numerically quantified expressions. Several possible reasons that could account for this significant effect were briefly discussed. The next chapter reports five experiments that were carried-out to test these possibilities.
Chapter 7:
Experiments 3-7: Possible Reasons for Children’s Strong Preference for the “New-Set Picture”

The previous chapter reported two experiments that investigated children’s and adults’ interpretative biases when analysing numerically quantified expressions. The results that were obtained from Experiment 1 showed that six- to eight-year-olds, unlike adults, have a strong preference in selecting the picture that depicts a new-set reading when interpreting ambiguous and unambiguous quantified noun-phrases (e.g., two cats) and bare cardinals (e.g., two). Experiment 2 replicated these effects in a condition in which children were presented with more pictures to choose from. Thus, the first two experiments clearly showed that six- to eight-year-olds have a strong preference for the “new-set picture” when analysing ambiguous and unambiguous numerically quantified expressions. This chapter reviews a series of five experiments that were conducted to explore possible reasons that could account for this preference.

7.1. Experiment 3. Possibility of Non-Integrative Analysis of the Discourse

One possibility that can account for children’s strong preference for the “new-set picture” when analysing numerically quantified expressions, is in line with the suggestions of previous research that investigated other types of anaphors, like pronouns, the definite reference and inference generation (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). Such research showed that young children have a difficulty to connect an anaphor with its referent found in the prior discourse context. Perhaps,
something similar is happening when children analyse discourses that contain numerically quantified expressions. Perhaps when children analyse ambiguous and unambiguous numerically quantified expressions, they find it difficult to integrate the meaning of the two sentences and thus select the picture that corresponds to the separate meaning of each sentence; that is the “new-set picture”. This suggests that children’s strong preference for the “new-set picture” observed in the previous two experiments was not a preference to analyse the discourse in a new-set reading, but rather a preference for the picture that reflected the independent meaning of the first sentence and the independent meaning of the second sentence.

In Experiment 3 it was vital to test this possibility. This was accomplished by presenting six- to eight-year-olds with the same task that was used in the previous two experiments, but in this experiment together with the two critical pictures (i.e. “new-set picture” and “subset picture”) children were presented with an additional picture. This picture was named “non-integrative” since it could be considered as true only by someone who failed to integrate the meaning of the two sentences. Specifically, the “non-integrative picture” was created in such a way that it reflected a separate analysis of the first sentence and a separate analysis of the second sentence, importantly however it was otherwise incongruous with both a new-set and subset reading. For explanation purposes consider the ambiguous discourse shown in (55).

55. Three cats were on a wall. Two cats caught a mouse.

Recall that following the new-set reading, the two cats that are described in the second sentence are interpreted as a different set of cats than those described in the first sentence. Therefore, the discourse is interpreted as describing five cats, a set of three
cats and another set of two cats. Conversely, following the subset reading, the two cats that are described in the second sentence are interpreted as being part of the three cats that are described in the first sentence; thus, the discourse is interpreted as describing a set of three cats on a wall, two of which are with a mouse. However, following a separate analysis of each of the two sentences, only the total of cats that each sentence describes must be satisfied. Thus, a picture that illustrates four cats could be potentially true if it illustrates three cats on a wall and two cats with a mouse.

This is indeed how the “non-integrative picture” was created. For the example shown in (55) the “non-integrative picture” illustrated four cats; three cats on a wall, one of which with a mouse (satisfying the meaning of the first sentence), and two cats with a mouse, one on the wall and another one on the ground (satisfying the meaning of the second sentence). Consequently, the “non-integrative picture” was potentially true only for someone who analyses the separate meaning of each of the two sentences (See Figure 9 for an example).

In Experiment 3 it was also important to examine adults’ choices when presented with the “non-integrative picture”. Adults served as control to validate the view that the “non-integrative picture” could not be selected by readers who do not have a difficulty with integration. It was therefore expected that adults would not select the “non-integrative picture” in any of the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset). The intuition is that readers who do not have a difficulty with integration will not analyse the separate meaning of each of the two sentences and thus, will not interpret the “non-integrative picture” as truly corresponding to the meaning of the discourse.
7.1.1. *Predictions*

The results obtained from the previous two experiments provide enough evidence to suggest that children would not have a strong preference for the picture that depicts a subset reading of the discourse in any of the three sentence types. However, it remains to be investigated whether six- to eight-year-olds’ preferences will be affected by the introduction of the “non-integrative picture”. If children in the previous experiments selected the “new-set picture” because of analysing the separate meaning of each of the two sentences, then they are equally likely to select the “non-integrative picture” in this experiment. In particular a strong preference for the “non-integrative picture” or a fairly even distribution of responses for both the “new-set picture” and the “non-integrative picture” will strongly suggest that the significant effects observed in the previous two experiments were because of a difficulty with integration. If however children still have a strong preference only for the “new-set picture” this will demand further exploration of other possible reasons that can account for this preference.

Existing research which examined children’s interpretation of other types of anaphors (e.g., pronouns, definite reference and inference generation) has consistently showed that children face a difficulty with integration (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). It is therefore possible that this difficulty is also present when children analyse the anaphors that are of interest for the present research. For this reason it appears likely that the introduction of the “non-integrative picture” might affect children’s choices, influencing children to select this picture also.

Lastly, it is expected that adult’s strong preference for the “subset picture” that was observed in Experiment 1, as well as previous research (e.g., Frazier *et al.* 2005;
Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan, 2006), will also be obtained in the current experiment. Since adults do not have a difficulty with integration it is expected that they will not select the “non-integrative picture” as corresponding to the meaning of the discourse. If the results show that adults select the “non-integrative picture”, this will be an indication that there is a problem with the “non-integrative picture” and thus, the way this picture was created must be reconsidered. Moreover, such preference could also be an indication that adults are also able to assign a non-integrative interpretation to numerically quantified expressions. Such finding will call into question previous findings suggesting that adults automatically form links between sentences.

7.1.2. Experimental Design

7.1.2.1. Participants

Fifty-one children, first and second graders, mean age 7;4 from “Delta Primary School Aradippou” and ten postgraduate students from the Cyprus International Institute of Management, took part in this experiment. All participants were native Greek speakers, and none of them participated in any of the earlier experiments.

7.1.2.2. Materials and Design

The same forced-choice picture-selection task that was used in the previous two experiments was also used in Experiment 3. Participants were presented with twenty two-sentence short discourses and three pictures, with the task to indicate the picture
that best described the discourse. In this experiment, together with the two critical pictures (i.e. “new-set picture” and “subset picture”), participants were also presented with a picture that reflected a non-integrative reading of the discourse. This picture was carefully constructed in order to reflect the separate meaning of the first sentence and the separate meaning of the second sentence, but to be otherwise incompatible with both a new-set and subset interpretation. An example of the three pictures that were presented to participants in Experiment 3 is illustrated in Figure 9.

Figure 9: Example of an experimental item used in Experiment 3
As it is illustrated in Figure 9 the “non-integrative picture” reflects the individual meaning of the first sentence, by illustrating three cats on the wall, and it also reflects the individual meaning of the second sentence, by illustrating two cats with a mouse. Importantly however, the “non-integrative picture” cannot be selected if the discourse is analysed in a new-set or subset reading. Following the new-set reading the set of two cats described in the second sentence is interpreted as being a different set of cats than those on the wall. Since the only picture that illustrates five cats (a set of three cats on the wall and another set of two cats with a mouse) is the “new-set picture”, then only this picture can be compatible with the new-set reading. Similarly, following the subset reading, the set of two cats described in the second sentence is analysed as being part of the set of cats that are on the wall; therefore the only picture that is in line with the subset reading is the “subset picture”, since it is the only picture that illustrates three cats. Thus clearly, since the “non-integrative picture” illustrates four cats it can only be selected by someone who fails or has difficulty integrating the meaning of the two sentences.

As in the previous two experiments, in this experiment participants were presented with fifteen experimental discourses mixed with five fillers. To ensure that a “non-integrative picture” could be created for all discourses, in this experiment it was necessary to change a number of experimental discourses that were used in the previous two experiments. In particular, five experimental discourses were removed and replaced with another discourse, and another three were slightly changed for this experiment. The same fillers that were used in the previous two experiments were also used in this experiment. For the fillers to be comparable with the experimental discourses participants were presented with three pictures to choose from. Two pictures were
identical to the ones used in Experiment 1 and 2, whereas the third was identical to one of the distracting pictures that were used in Experiment 2.

Similarly with Experiments 1 and 2 in this experiment there were again three files containing one version of each discourse with an equal number of ambiguous, unambiguously new-set and unambiguously subset sentence types, together with five fillers. As in previous experiments the participants were presented with the files in a fixed order, with this order reversed for half of the participants in each age group. The three files were equally presented to the fifty-one children that participated in the current experiment. That is, seventeen children were presented with each of the three files. From the ten adults that participated four were presented with the first file, three were presented with the second file, and the last three with the third file. The three pictures were printed on single sided A3 paper, with the order of the pictures randomised by the experimenter. In this experiment there were two independent variables, sentence type (i.e. unambiguously new-set, ambiguous and unambiguously subset) and age group (i.e. children and adults). Similarly with the previous experiment, the design of Experiment 3 for sentence type was within participants and items. For age group the design was between participants but within items. The dependent variable was again the frequency of time children selected the new-set picture in each of the three sentence types.

7.1.2.3. Procedure

The procedure was identical with the one used in Experiment 2.
7.1.3. *Results and Discussion*

To see whether the “non-integrative picture” could indeed be selected only by readers who have a difficulty with integrating the meaning of the two sentences, the responses of adults were first examined. None of the ten adults responded incorrectly to the filler items, thus Figure 10 illustrates the frequency of time the ten adults selected the “new-set picture” the “subset picture” and the “non-integrative picture” in the three sentence types (unambiguously new-set, ambiguous and unambiguously subset).

![Figure 10: Adults’ responses in Experiment 3. Error bars represent the standard error of the mean.](image)

As Figure 10 clearly illustrates, adults responded as expected. The results showed that adults never selected the “non-integrative picture” as corresponding to the discourse, in any of the three sentence types. Thus, it is clear that the “non-integrative picture” is not considered as correct by readers who do not analyse the individual meaning of each of the two sentences. As in Experiment 1 adults responded as expected in the two unambiguous sentence types. They always selected the “new-set picture” in the unambiguously new-set sentence type, and always selected the “subset picture” in the unambiguously subset sentence type.
Additionally, as it is clearly illustrated in Figure 10, adults were again found to have a strong preference for the “subset picture” when analysing ambiguous numerically quantified expressions. This finding is in line with the results obtained from Experiment 1, as well as the findings from previous research with adults (e.g., Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan, 2006). Also worth noting is the fact that the frequency at which adults selected the “subset picture” in this experiment is higher than the one observed in Experiment 1 (96% for former and 73% for latter). A possible explanation for this high frequency is the small sample of adults who participated in the current experiment (10 adults for this experiment versus 40 adults in Experiment 1).

Having established that the “non-integrative picture” is not selected by readers who do not fail to integrate the meaning of the two sentences, the attention is now turned to children’s responses. As in previous experiments, the responses of children who failed on the fillers and/or arithmetic problems were first examined. From the fifty-one children who participated in this experiment, it was found that twelve children incorrectly responded to the fillers or/and arithmetic problems. The responses of these children were excluded from the analysis. Therefore, the responses that were analysed were of thirty-nine children mean age 7;4. Figure 11 illustrates the frequency of time children selected each of the three pictures (i.e. “new-set picture”, “subset picture” and “non-integrative picture”) in the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset).
The first observation that is noticeable when looking at Figure 11 is that the introduction of the “non-integrative picture” did not affect children’s responses. The same strong preference for the “new-set picture” that was also observed in the previous two experiments emerged in this experiment as well. The frequency of time children selected the picture that depicted a new-set relationship of the discourse in all three sentence types (i.e. unambiguously new-set, ambiguous, and unambiguously subset) was put in ANOVA for analysis. Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous, and unambiguously subset) x 1 (selection of the “new-set picture”) mixed design ANOVAs. The analysis revealed a significant main effect of sentence type ($F_1(2, 76) = 4.97, p < 0.05; F_2(2, 28) = 6.40, p < 0.05$). Tukey’s HSD post-hoc tests were conducted for further exploring these significant effects.

Post-hoc analyses showed that there were not significant differences in children’s frequency of selecting the “new-set picture” when analysing unambiguously new-set and ambiguous sentence types ($p > 0.05$). Moreover, the frequency of time children selected the “new-set picture” in ambiguous and unambiguously subset sentence types was also not significant ($p > 0.05$). Post-hoc analyses showed that there were significant differences only in the frequency of time children selected the “new-set
picture” in the unambiguous sentence types, in which children selected the “new-set picture” significantly more times in the unambiguously new-set sentence type than in the unambiguously subset sentence type types ($p < 0.05$).

Additionally, in this experiment it was also important to examine children’s probability of choosing their least favour pictures; that is the “subset picture” and the “non-integrative picture”. Specifically, as in the previous two experiments it was important to test whether children’s choices for the “subset picture” and the “non-integrative picture” in each of the three sentence types (i.e. unambiguously new-set, ambiguous, and unambiguously subset) was significantly different to the 50% chance level. The main reason of running these extra tests was to assess whether there was any systematicity in the way children selected each of these options. Note here that as it is clearly illustrated in Figure 8 children’s choice for the “new-set picture” in each of the three sentence types is very clear and therefore it was considered unnecessary to run extra tests for this choice by children.

In the one-sample t-test that was computed, the cases in which children selected the “new-set picture” were removed and the t-test tested whether children’s selection between the “subset picture” and the “non-integrative picture” were significantly different to the 50% chance level. Starting with the unambiguously new-set sentence type, the t-test analysis showed that children did not perform significantly different to the 50% chance level when they selected between the “subset picture” and the “non-integrative picture” ($t(20) = 1.90$, $p > 0.05$). The t-test that examined children’s selection between the two pictures in the ambiguous sentence type however, revealed significant differences to chance ($t(20) = 2.39$, $p < 0.05$). Similarly, significant differences to the 50% chance level were also obtained in the unambiguously subset sentence type ($t(26) = 3.37$, $p < 0.05$). Thus, t-tests analyses clearly showed that in the
unambiguously new-set sentence type children selected between the “subset picture” and the “non-integrative picture” not different to chance. In other words when six- to eight-year-olds did not select the “new-set picture” in this sentence type they did not have a clear preference for either the subset or non-integrative option. However, this is not the case in the other two sentence types in which the analysis clearly showed that when the “new-set picture” was not selected children had an above chance preference for the “subset picture” than the “non-integrative picture”. It will be interesting to observe whether these significant differences to chance level will be also present in successive experiments.

The results of Experiment 3 are clear; the same pattern of responses observed in the previous two experiments was obtained. Six- to eight-year-olds had a strong preference for the picture that depicted a new-set reading when analysing both ambiguous and unambiguous numerically quantified expressions. Existing research that investigated children’s processing of other types of anaphors (e.g., pronouns, the definite reference and inference generation) consistently showed that children have a difficulty with referentially connecting an anaphor with information found in the prior discourse context (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). It appeared that a similar difficulty could be responsible for the significant effects observed in the current research. That is, it appeared possible that children selected the “new-set picture” when interpreting ambiguous and unambiguous numerically quantified expressions because of analysing the individual meaning of the first sentence and the individual meaning of the second sentence.

The current results however, minimise such possibility. In the current experiment a picture that reflected the separate meaning of each of the two sentences
was created and presented to children as a choice. Children however, only rarely selected that picture; rather, children’s bias for the “new-set picture” was even greater in this experiment with respect to the one observed in the previous two experiments. This finding clearly shows that children were not affected by the inclusion of the “non-integrative picture”. Thus, it appears that the reason behind children’s strong preference for the “new-set picture” is not because children fail or find it difficult to integrate the meaning of the two sentences.

Nevertheless, to further support the possibility that children’s preference for the “new-set picture” is not because of a difficulty to integrate the meaning of the two sentences, it was considered important to leave the “non-integrative picture” as a choice in the remaining of the current research. This was to test whether other manipulations of the task that will be performed in subsequent experiments will have any effect on children’s preference for this picture.

In summary, Experiment 3 examined whether children’s preference for the “new-set picture” reflected an inability or difficulty to integrate the meaning of the two sentences. This possibility was tested by presenting children with a picture that could only be selected if children analysed the separate meaning of the two sentences. The results of the current experiment do not support such possibility. Children’s strong preference for the “new-set picture” was not influenced by the introduction of the “non-integrative picture”; children still had a strong preference for the “new-set picture” when analysing both ambiguous and unambiguous numerically quantified expressions. The current findings suggest that other possibilities must be tested for better understanding of the reasons behind children’s strong preference for the “new-set picture”.
7.2. Experiment 4: Possibility of an Addition Strategy by Children

In three experiments a persistent strong preference of six- to eight-year-olds to select the “new-set picture” when analysing ambiguous and unambiguous numerically quantified expressions was obtained. Experiment 3 was the first attempt to examine possible reasons behind this preference by children. Specifically, Experiment 3 tested whether this preference was a reflection of a difficulty or inability by children to integrate the meaning of the two sentences. This was accomplished by presenting children with an additional picture that could only be selected if they analysed the separate meaning of each of the two sentences. However, the results showed that children only rarely selected the “non-integrative picture”. Rather similarly to the results of Experiments 1 and 2, children were again found to have a strong preference for the “new-set picture”. This suggested that children’s preferences were stemming from a reason other than a difficulty to form links between the two sentences.

Experiment 4 tested another possible reason that could account for children’s preferences. Specifically, it was possible that children selected the “new-set picture” because of an explicit counting strategy. For this reason, the current experiment aimed at ruling-out such a possibility. Recall that the discourses that were employed in the current research always contained two numerical expressions; one numerical expression was introduced in the first sentence (e.g., *three cats*), and another numerical expression was introduced in the second sentence (e.g., *two cats*). A possible problem of using two numerical expressions is that it could cause children to adopt some sort of unexpected counting strategy. That is, it could cause children to add or subtract the numerical expressions found in the two sentences.
An addition of the two numerals could explain children’s strong preference for the “new-set picture”. In order for the “new-set picture” to reflect a new-set reading it always illustrated the total of entities after the two numerals are added together; thus inevitably this picture could also be selected if children followed an addition strategy. Although there is no specific reason of why children would have followed such an addition strategy, it was nevertheless important to rule out any possibility that children were following a counting strategy in their responses. For this reason in Experiment 4 the numerical expression of the first sentence was changed to a natural language quantifier (e.g., three cats was changed to some cats) and children’s preferences were tested.

7.2.1. Predictions

It is not clear why children would adopt an addition and not a subtraction strategy in their responses. For this reason it is expected that changing the numerical expression to a natural language quantifier (e.g., some, many) will not have an effect on children’s strong preference for the “new-set picture”. It is believed that children’s strong preference for the “new-set picture” is well beyond a simple explanation like this; the consistent preference by children for the “new-set picture” observed in the last three experiments suggests that the reason behind this preference is directly related to how six- to eight-year-olds comprehend language.

Nevertheless, the possibility that the current findings are a result of a counting strategy cannot be excluded. If this is indeed the reason children select the “new-set picture” then it is expected that the manipulation of the numerical expression will have
an influence on their responses. Such possibility will be supported if a different pattern of results is obtained in the current experiment.

7.2.2. Experimental Design

7.2.2.1. Participants

Thirty-eight children first and second graders, mean age 7;4, took part in this experiment. Children were recruited from “Gamma Primary School Aradippou” and were all native Greek speakers. As in the previous experiments all children participated for the first time in this experiment.

7.2.2.2. Materials and Design

The materials in this experiment were changed. The numeral of the first sentence was removed and was replaced by the natural language quantifiers some, many and the expression a group of. The natural language quantifiers and the expression a group of were equally distributed to each of the fifteen experimental discourses. That is, the first sentence of five experimental contained the natural language quantifier some, the other five experimental discourses contained the natural language quantifier many, and the rest five experimental contained the expression a group of. As in the previous experiments, the fifteen experimental discourses were divided into three files, having in each file an equal number of unambiguously new-set, ambiguous and unambiguously subset sentence types. In particular from the thirty-eight children that participated in Experiment 4, thirteen children were presented with the first file, another thirteen with
the second file and the remaining twelve children were presented with the third file. Recall that half of the participants were presented with the file in a fixed order and the order was reversed for the other half of the participants. Also, the same filler items that were used in Experiment 3 were also used in the current experiment.

Furthermore, for the current experiment, the pictures that corresponded to the discourses that contained the natural language quantifier *many* and the expression *a group of* were changed to reflect the non-numerical quantifier that the first sentence depicted. Specifically, for these discourses the entities illustrated in the pictures were increased. The pictures that corresponded to the discourses that contained the natural language quantifier *some* remained the same to those used in Experiment 3.

Moreover, similarly with the previous experiment, together with the two critical pictures (i.e. “new-set picture” and “subset picture”) children in the current experiment were also presented with the “non-integrative picture”. The main reason was to examine whether the removal of the numerical expression would have any influence on children’s preference for this picture. Figure 12 illustrates how the usual cat example was presented to children who participated in Experiment 4.
As it is clearly illustrated in Figure 12 the pictures that were used for this specific experimental discourse were identical with the ones used in Experiment 3. The only difference was that in the current experiment the numerical quantifier of the first sentence \textit{three cats} was changed to the natural language quantifier \textit{some cats}.

A within participant and item design was employed in Experiment 4. The independent variable was sentence type (i.e. unambiguously new-set, ambiguous, and unambiguously subset) and similarly with the previous experiments the independent
variable was the frequency of time children selected the picture depicting a new-set reading in each of the three sentence types.

7.2.2.3. Procedure

The procedure that was followed in this experiment was identical to the one used in Experiments 2 and 3.

7.2.3. Results and Discussion

As in the previous experiments the responses of the children who failed to correctly evaluate the arithmetic problems and/or filler items were excluded from the analysis of the results. From the thirty-eight children who participated in this experiment, two children failed on the arithmetic problems and/or filler items and therefore their responses were excluded from the analysis. Thus, the results that were analysed were of thirty-six children mean age 7;3. Figure 13 illustrates the percentage of time children selected the “new-set picture”, the “subset picture” and the “non-integrative picture” in the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset).
Importantly, as it is clearly illustrated in Figure 13 the same pattern of responses observed in the previous three experiments was also obtained for Experiment 4. Children selected significantly more times the picture that depicted a new-set reading in all three sentence types. As in the previous experiments the frequency of time children selected the “new-set picture” in the three sentence types was put to ANOVA for analysis. Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous, and unambiguously subset) x 1 (selection of the “new-set picture”) mixed design ANOVAs. The analysis revealed a significant main effect of sentence type ($F_1(2, 70) = 7.68$, $p < 0.05$; $F_2(2, 28) = 3.86$, $p < 0.05$). Six- to eight-year-olds selected significantly more “new-set pictures” in the unambiguously new-set sentence than in the other two sentence types.

To further explore how children responded in each of the three sentence types Tukey HSD post-hoc tests were conducted. The results of the post-hoc analysis showed that there were no significant differences in the frequency of time children selected the “new-set picture” in the unambiguously new-set and ambiguous sentences types ($p > 0.05$). There were however significant differences in children’s frequency of selecting the “new-set picture” in ambiguous and unambiguously subset sentence types ($p <$
0.05), with children selecting the “new-set picture” more times in the ambiguous than in the unambiguously subset sentence type. Lastly, there were also significant differences in the frequency of time children selected the “new-set picture” in the two unambiguous sentence types ($p < 0.05$); children selected the “new-set picture” more times in the unambiguously new-set sentence type than in the unambiguously subset sentence type.

The results of Experiment 4 clearly showed that children’s strong preference for the picture depicting a new-set reading of the discourse observed in the previous experiments was not because of an addition strategy. In the current experiment the numerical expression of the first sentence was changed to a natural language quantifier and examined whether this change will have an effect on children’s performance. Importantly, the same effects observed in the previous four experiments emerged in Experiment 4. Children had a strong preference in selecting the “new-set picture” when analysing both ambiguous and unambiguous numerically quantified expressions. Therefore, the possibility that children are following an addition strategy when analysing the discourses that the current research examines is ruled out. It appears that a more possible explanation of children’s non-adult strong preference for the “new-set picture” reflects the processes that children employ when they comprehend language.

Nevertheless, there is one aspect of the current results that needs to be explored further. In comparison with the post-hoc analyses of the previous experiment, the results for the current experiment showed that there were significant differences between children’s selection of the “new-set picture” in ambiguous and unambiguously subset sentence type. As it is shown in Figure 13, this significance appears to be because in the current experiment there was a small drop of children’s preference for the “new-set picture” in the unambiguously subset sentence type. In particular, children who participated in the current experiment selected the “new-set picture” 7% fewer times
than children who participated in Experiment 3 (66% frequency in Experiment 3 versus 59% frequency in Experiment 4). This difference appears to be because the children who participated in the current experiment selected the “non-integrative picture” more times than the children who participated in Experiment 3. Although the difference between the two experiments does not appear to be significant, nonetheless it was considered important to run another ANOVA and directly compare the percentage of time children selected the “new-set picture” in Experiment 3 and the percentage of time children selected the “new-set picture” in Experiment 4.

Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous, and unambiguously subset) x 2 (Experiment: Experiment 3 and Experiment 4) mixed design ANOVAs. The analysis revealed a significant main effect of sentence type ($F_1(2, 146) = 12.61, p < 0.05; F_2(2, 56) = 9.33, p < 0.05$), showing that children selected more times the “new-set picture” in the unambiguously new-set sentence type than the other two sentence types. Importantly however, there was no significant interaction between sentence type and experiment ($F_1(2, 146) = 0.28, p > 0.05; F_2(2, 56) = 0.03, p > 0.05$). This clearly shows that children who participated in Experiment 3 responded similarly to children who participated in Experiment 4. Therefore, the 7% drop of children’s preference for the “new-set picture” observed in the current experiment was not significant and needs no more exploration.

Furthermore, as in previous experiments one-sample t-tests were also computed to examine whether children’s choices were significantly different to the 50% chance level. As in Experiment 3, the cases in which children selected the “new-set picture” were removed and t-tests were computed for children’s choice between the “subset picture” and the “non-integrative picture. The t-test analysis showed that children’s selection between the “subset picture” and the “non-integrative picture” in all three
sentence types were significantly different to the 50% chance level. In particular, in the unambiguously new-set sentence type t-test revealed that children responded significantly different to the 50% chance level ($t(21) = 6.09, p < 0.05$). In the ambiguous sentence type t-test analysis also showed significant differences to chance level ($t(26) = 2.15, p < 0.05$). Similarly, significant differences to the 50% chance level were also found in the unambiguously subset sentence type ($t(31) = 5.08, p < 0.05$). Similarly with the previous experiment, t-tests analyses clearly showed that when children’s selection for the “new-set picture” is removed six- to eight-year-olds have an above chance preference for the subset option than the non-integrative option.

In Summary, the results of Experiment 4 ruled out an alternative explanation of six- to eight-year-olds preference for the “new-set picture”. The current experiment clearly showed that children’s strong preference for the picture depicting a new-set reading is not because of an addition strategy. Even when the numerical quantifier of the first sentence was replaced with a natural language quantifier, children still had a strong preference for the “new-set picture” when analysing both ambiguous and unambiguous numerically quantified expressions. It is therefore vital in subsequent experiments to test other possible reasons that could account for children’s consistent preference for the “new-set picture” when analysing ambiguous and unambiguous numerically quantified expressions.

7.3. Experiment 5. Possibility of Artefact of the Forced-Choice Picture-Selection Task

The previous four experiments clearly showed that six- to eight-year-olds had a consistent preference to select the “new-set picture” when analysing ambiguous and unambiguous numerically quantified expressions. In Experiments 3 and 4 two reasons
that could account for this preference by children were investigated. Experiment 3 tested the possibility that this preference by children was because of a difficulty or inability to integrate the meaning of the two sentences. The results minimised such possibility; children only rarely selected the picture that illustrated the separate meaning of each of the two sentences (i.e. “non-integrative picture”). Experiment 4 tested whether the effects obtained were because of an explicit counting strategy that emerged because both sentences contained numerical expressions. Importantly, this possibility was ruled out; children had the same strong preference for the “new-set picture” even when the numerical expression was replaced with a natural language quantifier (e.g., *some, many*).

In the current experiment it was considered important to test an alternative explanation of the current findings; it could be argued that the significant effects observed in the current research were not reflecting children’s preferences, but were a direct result of an artefact of the forced-choice picture-selection task. Recall that the main reason this specific task was employed was because previous research clearly showed that this task is successful in testing children’s interpretative preferences during comprehension (e.g., Paterson *et al.* 2003). Nevertheless, it was still possible that the nature of this task was somehow reinforcing children towards selecting the “new-set picture”.

Although it is strongly believed that six- to eight-year-olds non-adult preferences are directly related to children’s language processing strategies, it was nevertheless important to minimise the possibility that the nature of the task was producing the significant effects obtained in the current research. For this reason the current experiment tested whether children’s preferences would be replicated using a variant of the forced-choice picture-selection task. In particular in the current
experiment rather than asking children to select the picture that best describes the discourse, children were encouraged to select more than one picture.

There were two versions of Experiment 5; in Experiment 5a children were asked to indicate all of the pictures that correctly corresponded to the discourse and in Experiment 5b any of the pictures that did not correspond to the discourse. The reason of having two versions of this experiment was to examine whether the instruction would affect children’s choices. For instance, it is possible to be more difficult for children to reject a picture rather than accept one.

Importantly, this manipulation of the task also enabled an investigation of yet another possible reason behind children’s strong preference for the “new-set picture”. Specifically, asking children to select more than one picture also helped to explore whether children acknowledge that both the “subset picture” and the “new-set picture” are true descriptions of an ambiguous discourse. Recall that since in previous experiments children were only allowed to choose one picture it was not possible to determine whether children strongly preferred the “new-set picture” after they acknowledged that the “subset picture” could be also true, or whether they selected that picture because it was the only one they acknowledged as true.

Existing research which investigated adults preferences when analysing numerically quantified expressions (e.g., Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan, 2006), as well as the results of the current research, clearly showed that adults have a strong preference for the subset reading when they analyse ambiguous numerically quantified expressions. Importantly, this preference by adults is because they have a strong tendency to analyse numerically quantified expressions following a subset reading and not because they do not acknowledge that the new-set reading is also a possible interpretation. Recall that Frazier et al. (2005) as
well as Kaan and colleagues (Kaan et al. 2007; Wijnen & Kaan, 2006) research has shown that although it is more processing for adults to follow the new-set reading, they can still reach for this interpretation when it is the only possible reading. For instance, Kaan et al. (2007) showed that adults can achieve the new-set reading when they are presented with discourses like “four flowers were put in the vase. Six had a broken stem and were trashed”. Thus, it was vital to examine whether children, similarly with adults, can switch between the two interpretations.

7.3.1. Predictions

The main reason that the current experiment was employed was to examine whether the results obtained in the previous experiments were a result of an artefact of the forced-choice picture-selection task. It is expected that this possibility will be rejected. The previous four experiments showed a consistent strong preference from six- to eight-year-olds for the “new-set picture”. It is believed that this preference is not a result of the nature of the task that was employed, but rather reflects children’s language comprehension. Thus, it is expected that children’s strong preference for the “new-set picture” will be also present in Experiment 5.

Additionally, the results of the last two experiments appear to suggest that children do not analyse the individual meaning of each of the two sentences; it has been shown that children only rarely select the picture that depicts a non-integrative meaning of the discourse (i.e. “non-integrative picture”). If in the current experiment children still do not show a preference for the “non-integrative picture” this will further support the view that children’s selection of the “new-set picture” is not because of analysing the separate meaning of each of the two sentences. If however, children begin to show a
preference for this picture, this will be an indication that this possibility has to be reconsidered.

Furthermore, asking children to select more than one picture also enabled an examination of whether children acknowledge that numerically quantified expressions can be analysed in both a new-set and subset reading. Although, the results of the current experiments are not informative of whether children, similarly to adults, can switch between the two possible interpretations, nevertheless the findings of existing research that examined other types of anaphors (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976) appear to suggest that children will have a difficulty in reaching the subset reading which demands forming links between the two sentences.

As it was repeatedly stated in this thesis, much of the existing research has shown that children have a difficulty in forming links between an anaphor and its prior discourse context (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). Recall that a necessary prerequisite of the subset reading is to connect the numerically quantified expression with information found in the prior discourse context. Thus, if children’s difficulty with integration is also present with the type of anaphors that the current research investigates, then it is possible that children will have a difficulty in connecting the numerically quantified expression with information from prior discourse, to reach the subset reading of the discourse. If this is indeed the case, then in the current experiment even though children will be allowed to select another picture together with their strongly preferred “new-set picture”, they will still not select the “subset picture”. On the contrary this possibility will be rejected if children select both the “new-set picture” and the “subset picture” in this experiment. Such finding will strongly suggest
that children acknowledge that ambiguous numerically quantified expressions can be analysed following both a new-set and subset reading.

Lastly, it is also possible for children to select all three pictures in the current experiment. Such finding will suggest that there is a problem with the experimental task. Recall that the “non-integrative picture” can only be selected by a reader who analyses the separate meaning of each of the two sentences. In Experiment 3 where adult’s preferences were also tested, it has been clearly shown that adults never select the “non-integrative picture”. This finding supports the view that this picture is rejected by readers who can form links between sentences. Consequently, if children are indeed able to form links between sentences and select the “subset picture” then they are not expected to select also the “non-integrative picture”. Thus, a more likely explanation if children select all three pictures in this experiment would be that children found the task difficult to perform.

7.3.2. Experiment 5a

In the first version of Experiment 5 children were asked to select all of the pictures that corresponded to the meaning of the discourse.

7.3.2.1. Experimental Design

7.3.2.1.1. Participants

Fourteen children, native speakers of Greek, first and second graders, mean age 7;3, from “Gamma Primary School Aradippou” took part in this experiment. Similarly
with all previous experiments, none of these children participated in any of the previous experiments.

7.3.2.1.2. Materials and Design

Since Experiment 4 showed that children’s preference for the “new-set picture” was not influenced by the numerical expressions that were contained in the discourses, Experiment 5a employed the same discourses and pictures that were used in Experiment 3. That is, discourses that both the first and second sentence contained a numerical expression (e.g., \textit{three cats}… \textit{two cats}…). As in all previous experiments children were presented with three files containing an equal number of unambiguously new-set, ambiguous, and unambiguously subset discourses as well as fillers. The files were presented to children in a fixed order with this order reversed for half of the children. Specifically, from the fourteen children that participated in the current experiment four children were presented with the first file, five with the second file, and the remaining five with the third file. Similarly with the previous experiment the design of Experiment 5a was within subjects and items. The independent variable of this experiment was again sentence type (i.e. unambiguously new-set, ambiguous, and unambiguously subset). The dependent variable was the frequency of time children selected the three pictures (i.e. “new-set picture”, “subset picture” and “non-integrative picture”) in each of the three sentence types.
7.3.2.1.3. Procedure

The procedure was identical to the one used in previous experiments; except that in this experiment, rather than asking children to select the picture that best matched the meaning of the discourse, children were asked to select all of the pictures that corresponded to the correct meaning of the discourse. Note that it was considered important to stress to children that they could select more than one picture. For this reason before running the comprehension experiment, the experimenter emphasised to children that there may be cases where more than one picture could be corresponding to the correct meaning of the discourse, and in those cases they should indicate all of these pictures.

7.3.2.2. Results and Discussion

From the fourteen children who participated in this experiment two children failed to correctly evaluate the filler items, and thus their responses were not included in the analysis of the results. The responses that were analysed were of twelve children, mean age 7;3. Figure 14 illustrates the frequency of time children selected the three pictures (i.e. “new-set picture”, “subset picture” and “non-integrative picture”) in each of the three sentence types (i.e. unambiguously new-set, ambiguous and unambiguously subset). Note here that the results showed that four out of the twelve children selected multiple pictures.
As it is clearly illustrated in Figure 14 even when children can select an additional picture together with their preferred one, they still have an overwhelmingly strong preference for selecting only the “new-set picture”. As in all previous experiments the frequency of time children selected the picture that depicted a new-set relationship of the discourse in all three sentence types was put in ANOVA for analysis. Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous, and unambiguously subset) x 1 (selection of the “new-set picture”) mixed design ANOVAs. The analysis revealed that there was no significant main effect of sentence type ($F_1(2, 22) = 1.37, p > 0.05; F_2(2, 28) = 2.49, p > 0.05$), showing that children selected the “new-set picture” in a similar frequency in all three sentence types. Note here that in this experiment one-sample t-tests could not be computed since children could select more than one picture as corresponding to the meaning of the discourse.

Importantly, similarly with all previous experiments the results obtained in Experiment 5a show that children have a strong preference for the “new-set picture” in all three sentence types. Thus, even though in the current experiment children could select more than one picture, the results clearly show that children have a strong

**Figure 14**: Children’s responses in Experiment 5A, with error bars representing the standard error of the mean.
preference only for the picture depicting a new-set interpretation of the discourse. Nevertheless, the results of the current experiment are different than those observed in previous experiments in two respects. The analysis showed that whereas in the previous four experiments significant effects were observed in the way six- to eight-year-olds selected the picture depicting a new-set reading of the discourse in the three sentence types, in the current experiment children selected the “new-set picture” in a similar frequency. It is suggested that the main reason behind these differences is the small sample of children that participated in the current experiment. Recall that only twelve six- to eight-year-olds took part in Experiment 5a, therefore, it is possible that this sample of children was too small to capture any significant effects.

Importantly, the current experiment provides strong evidence against the possibility that the significant effects observed in the preceding experiments were a result of an artefact of the forced-choice picture-selection task. Children had a strong preference for the “new-set picture” even when they could select more than one picture. Additionally, the current results provide further support against the possibility that children’s strong preference for the “new-set picture” is because they analyse the individual meaning of each of the two sentences. Children only rarely selected the “non-integrative picture” together with their preferred “new-set picture”, which suggests that they do not consider this picture as a correct description of the discourse.

Furthermore, the current results appear to support the possibility that children have a difficulty to reach the subset reading of numerically quantified expressions. Even though children could select another picture together with the “new-set picture” children still selected the “subset picture” numerically fewer times than the “new-set picture”. Importantly, as in all previous experiments, children’s lack of preference for the “subset picture” was also present in conditions that were disambiguated in favour of the subset
reading. Specifically, six- to eight-year-olds did not have a strong preference for the “subset picture” even in the unambiguously sentence type which contained the partitive construction of the and thus explicitly denoted that a subset reading should be assigned.

Perhaps in line with the suggestions of previous research that investigated other types of anaphors (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976) children have a difficulty in forming the referential links between sentences containing numerically quantified expressions in order to achieve the subset reading. Nevertheless, before considering the significance of this finding, it was first important to examine whether similar effects will be also obtained in Experiment 5b.

7.3.3. Experiment 5b

This version of Experiment 5 asked children to select any of the pictures that do not correspond to the meaning of the discourse.

7.3.3.1. Experimental Design

7.3.3.1.1. Participants

Twenty-two children, first and second graders, native speakers of Greek, mean age 7;1, from “Gamma Primary School Aradippou” took part in this study. As in all previous experiments, the children participated in the current research for the first time.
7.3.3.1.2. Materials and Design

The materials were identical to those used in Experiments 3 and 5a. For this experiment the three files of discourses that were used were divided in such a way that from the twenty-two children who participated, seven children were presented with the first file, eight children were presented with the second file, and the remaining seven children with the third file. A within subject and items design was also employed in the current experiment. The independent variable was sentence type (i.e. unambiguously new-set, ambiguous, and unambiguously subset). The dependent variable was the frequency of time children did not select the “new-set picture”, the “subset picture” and the “non-integrative picture”) in each of the three sentence types.

7.3.3.1.3. Procedure

The procedure was similar to the one used in the previous experiments, with the exception that in the current experiment children were asked to indicate any of the pictures they thought did not correspond to the meaning of the discourse. For the task to be clearly understood by children, the experimenter emphasised to the children that the pictures they considered as correctly reflecting the meaning of the discourse should not be selected. It was also stressed to the children that they were allowed not to select any picture if they believed that all of them corresponded to the meaning of the discourse.
7.3.3.2. Results

In the current experiment children were asked to indicate any of the pictures they believed did not correspond to the meaning of the discourse. Therefore, unlike previous experiments in which children were asked to indicate their preferred picture, the current experiment asked children to indicate the pictures they did not like. Thus, for the results of Experiment 5b to be comparable with the results obtained from previous experiments, rather than recording the pictures children selected (as it was done in all previous experiments), the experimenter recorded the pictures that children did not select. For instance, if a child selected the “non-integrative picture” in Experiment 5b, the experimenter recorded as the child’s preferred pictures the “new-set picture” and the “subset picture”.

Following the same procedure as previous experiments, the responses of children who failed to correctly evaluate any of the filler items or/and arithmetic problems were not included in the analysis. From the twenty-two children who participated in this experiment four children failed to correctly evaluate the filler items and thus their responses were excluded. Worth noting is that seven out of the eighteen children who participated in the current experiment selected multiple pictures. Figure 15 illustrates the frequency of time the eighteen children did not select the “new-set picture”, the “non-integrative picture” and the “subset picture” in the three sentence types (i.e. unambiguously new-set, ambiguous, and unambiguously subset). Note again that in the current experiment the pictures that children did not select represented the pictures that children considered to be correctly corresponding to the meaning of the discourse.
Importantly, the same pattern of responses was obtained in yet another experiment. As it is clearly illustrated in Figure 15 children were found to have a strong preference for the “new-set picture” in both ambiguous and unambiguous sentence types. The frequency that children did not select the “new-set picture” was put in ANOVA for analysis. Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous, and unambiguously subset) x 1 (frequency of not selecting the “new-set picture”) mixed design ANOVAs. The analysis revealed that there was no significant main effect of sentence type \( (F_1(2, 34) = 2.22, p > 0.05; F_2(2, 28) = 1.93, p > 0.05) \), showing that the frequency that children did not select the “new-set picture” was similar in all three sentence types. Similarly with Experiment 5a in this experiment one-sample t-tests could not be computed since children could select as not corresponding to the discourse more than one picture.

Significantly, the results of Experiment 5b showed that similarly with all previous experiments children had an overwhelmingly strong preference for the “new-set picture” in all three sentence types. Nevertheless, similarly with Experiment 5a no significant effects were found in the frequency that children did not select the “new-set
picture” in the three sentence types. As in Experiment 5a it is suggested that the reason behind not finding significant effects lies in the fact that only a small group of children were recruited for participants. In the current experiment only eighteen children participated, thus it is possible that significant effects would have been found with a larger sample of participants.

Taken together, the results of Experiment 5b clearly showed that the instruction did not influence children’s responses. That is, asking children to select the pictures they did not like did not have an effect on their strong preference for the “new-set picture” when analysing numerically quantified expressions. The results showed that children selected numerically more times the “subset picture” and the “non-integrative picture” as not corresponding to the discourse, showing a clear strong preference only for the “new-set picture”. Since similar findings were obtained from Experiments 5a and 5b the discussion that follows reviews the key findings for both of these experiments.

7.3.4. Discussion of the Results of Experiments 5a and 5b

Importantly, the same pattern of performance by six- to eight-year-olds was obtained in Experiments 5a and 5b; children had a strong preference for selecting the “new-set picture” when analysing numerically quantified expressions, regardless of the fact that children could select more than one picture. This finding minimised the possibility that the nature of the task was producing the significant effects observed in the current research. Children’s strong preference for the “new-set picture” was obtained even though the current experiment used a variant of the forced-choice picture-selection task.
Furthermore, in line with the findings of the previous two experiments that included the “non-integrative picture”, the current results also suggest that children’s preference for the “new-set picture” does not reflect a separate analysis of each of the two sentences. Even though in the current experiment children could select both the “new-set picture” and the “non-integrative picture” as truly corresponding to the discourse, children nevertheless selected the “non-integrative picture” only a few times.

Significantly, the current results appear to support the possibility that children have a difficulty in acknowledging that ambiguous numerically quantified expressions can be analysed with both a subset and new-set reading. Although children were allowed to select the “subset picture” together with their strongly preferred “new-set picture”, they nevertheless selected the “subset picture” in a lower frequency than the “new-set picture”.

This finding can be explained in terms of previous suggestions from researchers that investigated other types of anaphors (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). Recall that this research consistently showed difficulty by children in referentially connecting an anaphor (e.g., pronoun, the definite article and inference generation) with information from prior discourse context. It appears that a similar difficulty could account for the findings obtained in the current research. Perhaps children have a difficulty in referentially linking the numerically quantified expression with information from prior discourse context, which inevitably results in a difficulty by children to achieve the subset reading of the discourse.

Although the findings of the current experiment make some important suggestions concerning children’s analysis of numerically quantified expressions, it is nevertheless possible that the specific task that was employed in the current experiment
was not sensitive enough to capture children’s interpretative biases. Perhaps children do not have a difficulty in acknowledging that the subset reading is also a possible description of the discourse, but the specific task that was employed was not influential enough to reveal this knowledge. Thus, before considering the importance of the current findings, it was also crucial to examine whether the same effects will be obtained with yet another task.

In summary, Experiment 5 was employed to test the possibility that the effects observed in the current research reflected an artefact of the picture-selection task. The results of the current experiment minimise such possibility, the same pattern of results was obtained even though children could select more than one picture. Additionally, Experiment 5 also tested whether children acknowledge that numerically quantified expressions can be interpreted following both a subset and new-set interpretation. The current results appear to suggest that children, unlike adults, have a difficulty in reaching the subset reading when analysing numerically quantified expressions. In the next experiment this possibility will be further explored.

7.4. Experiment 6. Possibility of a Difficulty in Reaching the Subset Reading

In five experiments it was clearly shown that six- to eight-year-olds have a strong preference for the “new-set picture” when analysing ambiguous and unambiguous numerically quantified expressions. The findings of Experiments 3-5 suggest that children’s strong preference for the “new-set picture” is not because of analysing the individual meaning of each of the two sentences. It was consistently shown that children do not have a preference for the “non-integrative picture”. Additionally, the results of Experiment 5 clearly suggest that the significant effects
obtained in the current research are not a result of an artefact of the forced-choice picture-selection task. Rather what appears to be a possible reason behind children’s strong preference for the “new-set picture” is that children have a difficulty in acknowledging that ambiguous numerically quantified expressions can be analysed in a subset reading. The current experiment aimed at further exploring these suggestions.

In particular, the current experiment aimed at testing two possibilities. First it was conducted to minimise further any possibility that the current effects were a product of the nature of the task; for this reason the current experiment employed another task. Specifically, Experiment 6 used a picture evaluation task, in which children were asked to evaluate whether each of the three pictures (i.e. “subset picture”, “new-set picture” and “non-integrative picture”) were truly describing the discourse. Second, by employing this task it was possible to further examine the possibility that children have difficulty in achieving the subset reading. This is because, similarly with Experiment 5, this task does not test children’s preferred picture (which clearly is the “new-set picture”), but rather the pictures that children consider to be truly describing the discourse.

7.4.1. Predictions

The results of the previous experiments make some clear suggestions on what should be expected to be found in this experiment. First it is clear by now that six- to eight-year-olds have a strong preference for the “new-set picture” when analysing numerically quantified expressions. The previous experiment showed that this significant effect is not a result of an artefact of the task; children’s responses were replicated even with a task that children could select more than one picture. Thus, it is
expected that the strong preference by children for the “new-set picture” will be also obtained in the current experiment.

Second, the results of the last three experiments that included the “non-integrative picture” appear to suggest that children will not evaluate as correct the “non-integrative picture”. If children do not show a strong preference for the “non-integrative picture” in this experiment also, this will strongly support the view that children’s choice for the “new-set picture” is not because of analysing the individual meaning of each of the two sentences.

Furthermore, the findings of Experiment 5 appear to suggest that a possible reason behind children’s strong preference for the “new-set picture” is a difficulty by children to achieve the subset reading of an ambiguity. Recall that even though in Experiment 5 children could select the “subset picture” together with their preferred “new-set picture”, they still showed a strong preference only for the “new-set picture”. This appears to suggest that children do not acknowledge that numerically quantified expressions can be also analysed in a subset reading. If children indeed do not recognise that the “subset picture” is also a true description of the discourse, then they are not expected to evaluate as correct the “subset picture” in the current experiment. Such a finding will strongly support the suggestions of previous research which examined other types of anaphors and showed consistently that children have difficulty in integrating together different parts of a text (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976).

Nevertheless, it is possible that the picture evaluation task is more effective in testing children’s interpretative preferences and therefore different effects might be obtained from the current experiment. If this is indeed the case then children will be expected to evaluate as correct both the “new-set picture” and “subset picture” in the
current experiment. Such a finding will suggest that the reason behind children’s preference for the picture that depicts a new-set reading, obtained in the previous experiments, is because children, unlike adults, analyse numerically quantified expressions following a new-set reading.

Finally, it is also possible that children will evaluate as correct all three pictures in this experiment. As it became clear from adult responses in Experiment 3, the “non-integrative picture” is not selected by readers who do not have a difficulty with integration. Thus, the most plausible explanation of such finding will be that there is a problem with the experimental task that was employed in the current experiment, which influenced children towards this particular pattern of performance.

7.4.2. Experimental Design

7.4.2.1. Participants

Twenty-seven first and second graders, native Greek speakers, of mean age 7;3, were recruited from “Gamma Primary School Aradippou” to take part in this experiment. As in all the previous experiments, children that participated in the current experiment did not participate in any of the previous experiments.

7.4.2.2. Materials and Design

Experiment 6 employed a picture-evaluation task; therefore, the materials and design that were used in previous experiments were changed for this experiment. Unlike previous experiments, in Experiment 6 children were not presented with all three
pictures (i.e. “new-set picture”, “subset picture” and “non-integrative picture”) at once, but each picture was printed in a different single sided A4 paper and was individually presented to children. This was done in order for children to evaluate whether each of the three pictures was corresponding to the description of the discourse. Because of this change however, it was obvious that the running time of the experiment would be greater than that of previous experiments.

To minimise the running time of the experiment and minimise the possibility that this experiment would be exhausting for children, it was necessary to minimise the number of discourses that children would be presented with. Thus, although the same materials with Experiments 3 and 5 were used in the current experiment, in this experiment four discourses were randomly removed. Specifically, one experimental discourse from each sentence type (i.e. unambiguously new-set, ambiguous and unambiguously subset) and one filler item were removed; this minimised the number of discourses to sixteen (i.e. four fillers and twelve experimental discourses). It was expected that the removal of these discourses would bring the running time of Experiment 6 in similar levels with previous experiments; that is, approximately twenty minutes.

Similarly with the previous experiments, three files containing one version of each discourse with an equal number of unambiguously new-set, ambiguous, and unambiguously subset discourses, as well as filler items, was prepared. Note however, that whereas in previous experiments there were five discourses for each type, this time the discourses of each type were four. Participants were presented with the files in a fixed order, with this order been reversed for half of the participants. In particular from the twenty-seven children that participated in this experiment, each file was presented to nine children. As in the previous five experiments, the order that the pictures were
presented to children was randomised by the experimenter for each child. For instance, for one child the “new-set picture” could have been presented first, whereas for another could have been presented as second or third.

The design of Experiment 6 was within participants and items. There was one independent variable, sentence type (i.e. unambiguously new-set, ambiguous, and unambiguously subset). The dependent variable was the frequency of time children evaluated the picture reflecting a new-set reading as correctly corresponding to the meaning of the discourse in each of the three sentence types.

7.4.2.3. Procedure

Since the task in Experiment 6 was different, the procedure was slightly different than the one used in previous experiments. The instruction given to children changed; whereas in previous experiments children were asked to select between pictures, in this experiment children were asked to evaluate if each of the pictures corresponded to the correct meaning of the discourse. Also importantly, in this experiment children were not presented with all of the three pictures at once, but rather with one picture at a time. Specifically, the procedure in the current experiment was as follows: at the start of each trial children were presented with a discourse together with one picture and they were asked to evaluate if that picture corresponded to the short discourse; after evaluating the first picture children were then shown the second picture which they also had to evaluate; after their response children then had to evaluate the third picture. As in Experiment 5, it was emphasised to children that they could accept more than one picture as corresponding to the correct meaning of the discourse. The
experimenter moved to the second discourse only after all three pictures were evaluated by children.

7.4.3. *Results and Discussion*

Similarly with the previous experiments the responses of children who failed on the filler items and/or arithmetic problems were removed from analysis. The data showed that six children failed to correctly evaluate the filler items, and therefore their responses were not included in the analysis. Thus, from the twenty-seven children who participated in this experiment, the responses that were ultimately analysed were of twenty-one children mean age 7;3. The frequency of time children evaluated the “new-set picture” as correctly corresponding to the meaning of the discourses in each of the three sentence types (i.e. unambiguously new-set, ambiguous, and unambiguously subset) was put to ANOVA for analysis. Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous, and unambiguously subset) x 1 (Response: evaluation of the “new-set picture” as correctly corresponding to the discourse) mixed design ANOVAs. Figure 16 illustrates children’s responses for this experiment. Importantly note here that fifteen out of twenty-one children selected multiple pictures for this experiment.
Figure 16: Children’s responses in Experiment 6 with error bars showing the standard error of the mean.

As it is clearly illustrated in Figure 16, the same pattern of responses obtained in previous experiments was found in yet another experiment. Children had a clear strong preference for selecting the picture depicting a new-set reading when analysing both ambiguous and unambiguous quantified noun-phrases. The analysis revealed a significant effect of sentence type \( F_1(2, 40) = 6.41, p < 0.05; F_2(2, 22) = 3.95, p < 0.05 \). This significance was explored further by conducting Tukey HSD post-hoc tests.

The results of the post-hoc showed that as observed in all previous experiments there were no significant differences in the frequency that children selected the “new-set picture” in the unambiguously new-set and ambiguous sentence types \( p > 0.05 \). Thus, the post-hoc analyses clearly show that the 4% higher frequency of selecting the “new-set picture” in the ambiguous sentence type as opposed to the unambiguously new-set sentence type (i.e. 90% for unambiguously new-set sentence type versus 94% in the ambiguous sentence type) is not significant. There were significant differences however, in children’s frequency of selecting the “new-set picture” in the ambiguous as opposed to the unambiguously subset sentence type \( p < 0.05 \). Lastly, there were also significant differences in the frequency children selected the “new-set picture” in the two unambiguous sentence types \( p < 0.05 \); children selected the “new-set picture”
more times for discourses that were presented in the unambiguously new-set sentence type than discourses that were presented in the unambiguously subset sentence type. Similarly with Experiments 5a and 5b one-sample t-test could not be computed for this experiment since children could evaluate as corresponding to the discourse more than one pictures.

Importantly, the same pattern of results observed in the previous five experiments was also obtained in Experiment 6. Children had a strong preference for the picture depicting a new-set reading when analysing ambiguous and unambiguous numerically quantified expressions. Clearly then, the possibility that the effects observed in the current research are a product of an artefact of the task can be ruled out. Although two different tasks were employed in the last two experiments, children’s strong preference for the “new-set picture” is still observed.

Additionally, the current experiment minimises further the possibility that children’s strong preference for the “new-set picture” is because children are analysing the separate meaning of each of the two sentences. Although in the current experiment children could evaluate both the “new-set picture” and “non-integrative picture” as truly corresponding to the meaning of the discourse, children still only rarely evaluated as correctly corresponding to the meaning of the discourse the “non-integrative picture”. Thus, similarly with the results of the previous three experiments, in which the “non-integrative picture” was presented to children as a choice, children do not appear to interpret this picture as a true description of the discourse.

Significantly, the current experiment supports the possibility put forward in Experiment 5. The current findings appear to suggest that children do not acknowledge that ambiguous numerically quantified expressions can be analysed following both a subset and a new-set reading. Although fifteen out of twenty-one children evaluated as
correctly corresponding to the discourse more than one pictures, nevertheless children still did not show a strong preference for the “subset picture”. Rather as in all previous experiments children selected the “new-set picture” even in conditions which were disambiguated towards the subset interpretation (e.g., three cats… two of the cats…).

This finding can be explained in terms of previous suggestions of researchers that examined other types of anaphors, like pronouns and the definite reference. Much of this research has showed that children have a difficulty in referentially linking an anaphor with information from prior discourse context (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). Perhaps this is one of the reasons that children have a strong preference for the “new-set picture” in the current research.

According to this possibility, children find it difficult to anaphorically link the numerically quantified expression with information from the referential context. This inevitably leads to a difficulty by children to reach the subset reading when analysing such expressions. Thus, children strongly prefer the “new-set picture” since it does not demand any referential links between the two sentences. This is an extremely important suggestion, if this difficulty is indeed one of the reasons responsible for children’s strong preference for the “new-set picture”, this will provide an important contribution to our knowledge of the strategies that children employ when comprehending a text. It is vital therefore, to further examine this possibility. The next experiment goes a step forward and directly examines whether six- to eight-year-olds can ever reach to the subset reading.

In summary, Experiment 6 was conducted to examine further the possibility that children have a difficulty to achieve the subset reading of numerically quantified expressions. Importantly, the current results support this possibility. The same pattern of
performance observed in all previous experiments was also obtained in the current experiment. Children evaluated the “new-set picture” as correctly corresponding to the meaning of the discourse, numerically more times than the “subset picture”. This shows that children do not only have a preference for the new-set reading when analysing numerically quantified expressions, but also importantly that they are less likely to even consider the subset reading as corresponding to the meaning of the discourse. This appears to suggest that children have a difficulty in referentially linking the numerically quantified expression with information from previous discourse context in order to reach to the subset reading. Additionally, since the same pattern of preferences by children was still observed in an experiment that employed a different task, it is clear that there is no possibility that the significant effects observed in the current research are a product of the nature of the task that was used in the current research.

7.5. Experiment 7. Possibility that Children Never Reach the Subset Reading

A consistent pattern of results was obtained in six experiments. Six- to eight-year-olds have a clear strong preference for the “new-set picture” when analysing ambiguous and unambiguous numerically quantified expressions. The results of the previous two experiments clearly showed that this preference by children is not a product of the nature of the task. The same pattern of responses was obtained in Experiment 5 where children could select more than one picture, and Experiment 6 in which children were given a picture evaluation task. Additionally, the results of Experiments 3-6 provide support against the possibility that children select the “new-set picture” because of analysing the individual meaning of the two sentences. Children only rarely interpreted the “non-integrative picture” as correctly corresponding to the
discourse. This effect was observed even in cases where children were allowed to select, or evaluate as correct, another picture together with their strongly preferred “new-set picture”.

Importantly, what appears to be one possible reason behind children’s strong preference for the “new-set picture” is a difficulty by children to reach the subset reading when they analyse numerically quantified expressions. The results of the last two experiments appear to suggest that children do not consider the “subset picture” as truly corresponding to the meaning of the discourse. Children did not select the “subset picture” in a similar frequency with the “new-set picture” in Experiment 5, and they did not evaluate as correct the “subset picture” in a similar frequency with the “new-set picture” in Experiment 6.

The current experiment aimed at exploring this possibility further. If children indeed have a difficulty in acknowledging the subset reading, this suggests that they will not be able to reach to the subset reading even in cases where this reading will be the only one available to follow. This is because even under these conditions children will not be able to referentially link the numerically quantified expression with information from the prior discourse context in order to reach the subset reading of the discourse. This possibility is directly tested in the current experiment. Specifically, Experiment 7 examines children’s preferences when their strongly preferred “new-set picture” is unavailable.

The results of the previous experiments clearly showed that the task had nothing to do with children’s preferences; for this reason the current experiment returned to using the forced-choice picture-selection task. Importantly however, in this experiment in the two sentence types in which children did not respond in the same manner as adults the “new-set picture” was removed. That is, in the ambiguous sentence type (e.g.,
three cats… two cats…) and in the unambiguously subset sentence type (e.g., three cats… two of the cats…) children had to choose between the “subset picture” and the “non-integrative picture”. Thus, in the current experiment it was possible to examine whether children will have a preference for the “subset picture” when their most favoured option (i.e. “new-set picture”) is removed.

7.5.1. Predictions

The results of the preceding experiments make some clear predictions on what should be expected to be found in this experiment. It is clear by now that six- to eight-year-olds have a strong preference for the “new-set picture” when analysing numerically quantified expressions. It should be therefore expected that in the unambiguously new-set sentence type that the “new-set picture” will be available, children will respond in the same manner observed in previous experiments. That is, they are expected to select the “new-set picture” significantly more times than the “non-integrative picture”.

Nevertheless, it remains to be investigated how children will behave in the two sentence types that the “new-set picture” will be unavailable (i.e. ambiguous and unambiguously subset sentence types). The results obtained from the last four experiments that included the “non-integrative picture” showed that children rarely select this picture. This appears to suggest that children’s preference for the “new-set picture” is not because of analysing the separate meaning of the two sentences. If the results of Experiment 7 show that children begin to have a preference for the “non-integrative picture”, when their strongly preferred “new-set picture” is removed, this will suggest that the possibility that children have a difficulty in integrating the meaning
of each of the two sentences has to be reconsidered. This is because such a finding will support the possibility that children’s preference for the “new-set picture”, observed in all previous experiments, might be a reflection of an individual analysis of the meaning of each of the two sentences.

Furthermore, the results of Experiments 5 and 6 appear to suggest that one possible reason behind children’s strong preference for the “new-set picture” is a difficulty by children in achieving the subset interpretation. Support for such possibility will be obtained if children in the current experiment still do not show a preference for the “subset picture”. This is because in the current experiment the “new-set picture” will be unavailable, thus the only possible interpretation will be the subset reading. On the contrary, if children begin to show a preference for the “subset picture” in this experiment, this will suggest that children’s preference for the “new-set picture” observed in the preceding experiments was not because of not acknowledging that the subset reading exists. Rather, such finding will suggest that, similarly with adults, children know that numerically quantified expressions can be analysed in both a new-set and subset reading, but unlike adults strongly prefer to analyse such expressions following the new-set reading. The results of the one-way t-tests that were computed in Experiments 3 and 4 appear to support this possibility. Recall that it was found that children select between the “subset picture” and the “non-integrative picture” significantly different to the 50% chance level.

Lastly, it is also possible that children will not have a preference for either of the two pictures (i.e. “subset picture” and “non-integrative picture”) when their strongly preferred “new-set picture” is removed. This will be a tremendous finding which will suggest that both a difficulty to achieve the subset reading and a difficulty to connect the meaning of the two sentences are equally likely to be accountable for the significant
effects observed in the current research. Clearly however, such finding will also demand an explanation of the reason children did not have a preference for the “non-integrative picture” in the first place. Additionally, no preference between the “subset picture” and the “non-integrative picture” might also be an indication that when children’s preferred “new-set picture” is removed children don’t think that either picture corresponds to the meaning of the discourse and thus begin responding at chance. Importantly, whichever are the results of Experiment 7, they will provide a potential explanation of the reason or reasons behind children’s strong preference for the “new-set picture” when analysing numerically quantified expressions.

7.5.2. Experimental Design

7.5.2.1. Participants

Twenty-nine children, first and second graders, native Greek speakers, mean age 7;5, were recruited from “Gamma Primary School Aradippou”. Similarly with all previous experiments, children that participated in this experiment did not take part in any of the previous experiments.

7.5.2.2. Materials and Design

Experiment 7 returned to using the forced-choice picture-selection task. Thus, unlike Experiment 6 in which four discourses were removed to minimise the running time of the experiment, the current experiment employed the same twenty discourses (fifteen experimental discourses and five filler items) that were used in Experiments 3
and 5. Importantly however, in the current experiment there was a manipulation of the pictures that children were presented with. In the ambiguous and unambiguously subset sentence types children’s preferred “new-set picture” was removed, and children were asked to choose between the two pictures they do not like. In particular for these sentence types children were presented with the “non-integrative picture” and the “subset picture”, printed in an A3 paper. Children’s task was to select the picture they believed best matched the meaning of the discourse. Figure 17 illustrates the two pictures that children were presented with for these two sentence types.

![Figure 17: Example of an experimental item used in Experiment 7 for ambiguous and unambiguously subset sentence types](image)

As it is clearly illustrated in Figure 17, the pictures that children were presented with are identical with those employed in all previous experiments. The only difference is that the “new-set picture” in the current experiment is unavailable. Since however, in the unambiguously new-set sentence type children responded in the same manner to adults, the picture that was unavailable for this sentence type was the “subset picture”.
As it is shown in Figure 18, for this sentence type children had to select the picture they considered best described the discourse when presented with the “new-set picture” and the “non-integrative picture”.

![Figure 18: Example of an experimental item used in Experiment 7 for unambiguously new-set sentence type](image)

Additionally, it was also necessary for children to be presented with the same number of pictures for the filler items also. Thus, children were presented with two pictures for fillers also. These pictures were identical with those employed in Experiment 1. Specifically, one illustrated the correct meaning of the discourse, whereas the other illustrated a wrong number of entities performing the actions depicted in the discourse. For instance for the filler “four deer were in the forest. Two lions were resting”, one picture illustrated four deer and two lions and the second picture illustrated two deer and two lions.

As in all previous experiments, three files of discourses were created, ensuring that the same discourse was presented in all three sentence types (i.e. unambiguously new-set, ambiguous, and unambiguously subset), to different participants. From the
twenty-nine children that participated, ten children were presented with the first file, another ten with the second file and the remaining nine with the third file. For the current experiment it was also necessary to have three different set of pictures. Each set of pictures corresponded to each of the three files of discourses. This was to ensure that for the unambiguously subset and ambiguous sentence types, children would be presented with the “subset picture” and the “non-integrative picture” and for the unambiguously new-set sentence type children would be presented with the “new-set picture” and the “non-integrative picture”.

Similarly with previous experiments the design that was employed in Experiment 7 was within participants and items. There were two independent variables, sentence type for new-set responses (unambiguously new-set) and sentence type for subset responses (ambiguous and unambiguously subset). There were also two dependent variables in the current experiment. The first dependent variable was the frequency of time children evaluated the “new-set picture” as correctly corresponding to the meaning of the discourse in the unambiguously new-set sentence type. The second dependent variable was the frequency of time children evaluated the “subset picture” as correctly corresponding to the meaning of the discourse in the ambiguous and unambiguously subset sentence types.

7.5.2.2. Procedure

Since the current experiment employed a forced-choice picture evaluation task, the procedure was identical to the one employed in Experiments 2-4
7.5.3. Results and Discussion

Following the same procedure as in all previous experiments, from the twenty-nine children that participated in this experiment, four children failed to correctly evaluate the fillers or/and arithmetic problems; thus, their responses were not included in the computation of the results. The responses that were analysed were of twenty-five children, of mean age 7;4.

To do comparisons across conditions, the frequency of time children selected the adult-preferred picture were put to analysis. Specifically, the frequency of time children selected the “new-set picture” for the unambiguously new-set sentence type, and the frequency children selected the “subset picture” for the ambiguous and unambiguously subset sentence types. Data were analysed using two 3 (Sentence Type: unambiguously new-set, ambiguous and unambiguously subset) x 1 (Response: selection of the “new-set picture” for unambiguously new-set sentence types and selection of the “subset picture” for ambiguous and unambiguously subset sentence types) mixed design ANOVAs. Figure 19 illustrates children responses in the three sentence types.

Figure 19: Children’s responses in Experiment 7. Error bars represent standard error of the mean.
Significantly, as it is illustrated in Figure 19, when children’s preferred “new-set picture” is removed, it appears that at least in the ambiguous sentence type children do not have a clear preference for selecting either of the two remaining pictures (i.e. “subset picture” and “non-integrative picture”). The analysis revealed a significant main effect of sentence type ($F_1(2, 48) = 3.67, p < 0.05; F_2(2, 28) = 4.72, p < 0.05$). That is, children selected the “new-set picture” for the unambiguously new-set sentence type, significantly more times than they selected the “subset picture” for the ambiguous and unambiguously subset sentence types. It is important to examine this significance further.

First, as it is clearly illustrated in Figure 19 in the unambiguously new-set sentence type children selected the “non-integrative picture” only a few times. Thus, as expected, children’s preference for the “new-set picture” observed in all previous experiments was obtained in the current experiment also. Of main interest for the present experiment however, was to examine how children responded in the ambiguous and unambiguously subset sentence types, in which the “new-set picture” was unavailable. For this reason it was necessary to compute one-sample t-tests and as in previous experiments, compare children’s mean to the 50% chance level. Any significant differences would be informative of whether children responses were due to chance.

The first one-sample t-test that was computed examined children’s choices in the ambiguous sentence type. Analysis revealed that children’s choices for the “subset picture” were not significantly different to the 50% chance level ($t(24) = 1.99, p > 0.05$). Therefore, the analysis showed that in the ambiguous sentence type when children’s preferred “new-set picture” is removed children select at chance between the “subset picture” and the “non-integrative picture”. A second one-sample t-test was computed to
examine children’s choices in the unambiguously subset sentence type. The analysis revealed a significant difference to the 50% chance level ($t(24) = 2.92, p < 0.05$). Thus, in the unambiguously subset sentence type when children’s mostly preferred “new-set picture” is removed six- to eight-year-olds have an above chance preference for the “subset picture”.

There are two important effects that were observed in the current experiment. First, the results clearly show that in the ambiguous sentence type children do not have a clear preference for either of the two remaining pictures (i.e. “subset picture” and “non-integrative picture”) when their preferred “new-set picture” is removed. Thus, significantly it appears that the removal of their most preferred picture in the ambiguous sentence type creates an additional difficulty, such that children have no clear preference for which picture to choose. Nevertheless, the results of the unambiguously subset sentence type show that children are biased towards selecting the “subset picture”, than the “non-integrative picture”, in this sentence type. Therefore, it appears that the removal of the “new-set picture” influences children to follow the adult interpretation and select the “subset picture” in sentences that contain the partitive construction of the.

The current findings support the possibility the current experiment investigated. It appears that similarly with previous research that examined other types of anaphors (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976), children also have a difficulty when they need to referentially link an ambiguous quantificational expression with information from prior discourse context. Apparently children’s difficulty with integration leads to a difficulty in reaching the subset reading of ambiguous numerically quantified expressions. The results of the current experiment showed that in ambiguous
cases where the new-set reading cannot be followed, children still do not have a clear preference for the subset reading of the discourse.

Significantly, the current findings also support another possible reason that can account for children’s preferences. Contrary to the results of previous experiments that showed that children only rarely select the “non-integrative picture”, the current experiment showed that children in the ambiguous sentence type selected this picture in similar frequency with the “subset picture”. This suggests that the possibility that children analyse the separate meaning of each of the two sentences needs to be reconsidered.

One possible explanation of this finding is that in addition to a separate analysis of the two sentences, children might be also analysing the events described in each sentence separately. In particular it is possible that children analysed the event described in the first sentence (e.g., three cats are on the wall) as a separate event than that described in the second sentence (e.g., two cats caught a mouse). This suggests that children’s preference for the “new-set picture” reflects a preference for the picture that illustrates the individual meaning of the two events described in the discourse. This explanation will be extensively discussed in the next chapter.

Also importantly, this experiment showed that with unambiguous quantificational expressions when children do not have another choice they can achieve the subset reading. Children’s responses in the unambiguously subset sentence type showed that when children’s mostly favoured option is removed children are capable of analysing the quantified expression as an anaphor that refers back to a previous mentioned entity. Nevertheless, children’s bias for selecting the “subset picture” is only present when the “new-set picture” is removed, this shows the great difficulty that
children face when they have to referentially link a sentence with information from prior discourse context.

In summary, Experiment 7 was conducted to examine whether children’s preference for the “new-set picture” reflected a difficulty by children in achieving the subset reading. Crucially, the results from the ambiguous sentence type support this possibility. Children did not have a clear strong preference for the “subset picture”, even though this picture was the only one that truly corresponded to the meaning of the discourse. Rather children were found to be equally likely to select also the “non-integrative picture” as truly describing the discourse. Additionally, the current results also show that, at least for unambiguous quantificational expressions, when children do not have the choice of their favoured picture they can achieve the subset interpretation. The implications of these findings will be discussed in the next chapter.

7.6. Summary of Chapter 7

The current chapter discussed five experiments that were conducted to explore possible reasons behind children’s non-adult reference for the picture depicting a new-set reading when analysing ambiguous and unambiguous numerically quantified expressions. Five possible reasons that could account for this preference by children were explored. The results of Experiment 3 minimised the possibility that the effects observed in the current research were a result of children’s difficulty in analysing the integrative meaning of each of the two sentences. Experiment 4 ruled out the possibility that children’s preferences were based on an addition strategy. Experiments 5 and 6 employed a variant of the forced-choice picture selection task and clearly showed that the current effects do not reflect the nature of the task. Also the results of Experiments 5
and 6 showed that a possible reason behind children’s preferences was a difficulty by children to reach to the subset reading of the discourse. The final experiment showed that children have a general difficulty in reaching the subset reading when analysing ambiguous numerically quantified expressions that appears to be because children have a difficulty in integrating the meaning of the two sentences. Additionally, in Experiment 7 it was also shown that when six- to eight-year-olds are analysing unambiguous subset quantificational expressions and are not given the choice of the “new-set picture”, they are biased towards selecting the “subset picture” more frequently than the “non-integrative picture”. This shows that, when their options are restricted, children are able to reach the subset reading of unambiguously subset numerically quantified expressions. The significance of these findings will be explored in the next chapter that discusses two explanations that account for the current effects.
Chapter 8:

General Discussion

The aim of the present study was to assess how children (and adults) interpret ambiguous and unambiguous discourses that contain quantified noun-phrases (e.g., *two cats...*) and bare cardinals (e.g., *two...*). Discourses that contain numerically quantified expressions are often ambiguous between interpretations in which the expressions can either refer to an established discourse referent from the previous sentence (i.e. subset reading) or introduce a new referent to discourse (i.e. new-set reading). Thus, by studying children’s interpretative preferences when analysing such discourses is a step towards a better understanding of the processes that govern children’s language comprehension.

Existing research that has examined how adults interpret ambiguous numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals) has shown that adults have a strong preference for the subset reading of the ambiguity (e.g., Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan, 2006). That is, adults analyse the quantified expression or bare cardinal as an anaphor that refers back to a previous mentioned entity. The focus of the research in this thesis has been on how children interpret these expressions and whether they exhibit the same interpretative preferences as adults. This was important to determine since possible deviations from adults’ interpretative preferences would be informative about children’s language strategies when attempting to understand text.

The seven experiments reported here show convincingly that there are differences in how adults and children interpret discourses that contain numerically quantified expressions. These studies show very clearly that whereas adults show the
same interpretative preferences as revealed in previous research on this topic (e.g., Frazier et al., 2005; Kaan et al., 2007; Paterson et al., 2008b; Wijnen & Kaan, 2005), and therefore exhibit a strong preference for the subset reading of an ambiguity, six- to eight-year-olds have shown a strikingly different pattern of responses, in which they appear to reveal a strong preference for the new set reading of the ambiguity. Importantly, this preference by children was not only observed when they analysed ambiguous numerically quantified expressions (e.g., three cats... two cats...), but also when presented with discourses that were supposedly grammatically disambiguated in favour of the subset reading (e.g., three cats... two of the cats...). This is a striking finding which suggests that children and adults employ qualitatively different strategies when analysing this type of expression, even when it is supposedly unambiguous. Identifying the reasons why children show such a strong preference for the new-set reading of this form of expression, even when it is unambiguous to adults, may provide important insight into the nature of the processing strategies that children employ when attempting to understand discourse.

This chapter begins with a review of the main findings from each of the seven reported experiments. These are then discussed in some detail in an attempt to provide an account of how children process numerically quantified expressions. As should become clear from that discussion, there appears to be two particularly likely explanations of the findings. The first is that children have particular difficulty in processing anaphoric relations that exist between expressions in a discourse and this explanations seems to be in line with previous psycholinguistic research that has shown that children have similar difficulties when processing other types of anaphoric expressions (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). The second possible
account of children performance in experiments may relate to a more general cognitive
difficulty that young children have in processing set-subset relations, and may bare
similarities with observations concerning the difficulties first observed by Piaget and his
colleagues (Piaget, 1952; Inhelder & Piaget, 1964) on how children evaluate
relationships between sets of objects. Both of these accounts of children’s performance
will be expanded upon later in this chapter. Finally, some promising future directions
for the current research will be discussed.

8.1. Summary of the Main Experimental Findings

Experiment 1 was an initial attempt to explore how children and adults interpret
discourses that contain ambiguous quantified noun-phrases (e.g., two cats…) and bare
cardinals (e.g., two…). The experiment tested six- to eight-year-olds and adults’
preferences for different possible interpretations of the ambiguity using a forced-choice
picture-selection task, in which participants were presented with two-sentence
discourses like the ones shown in (56) – (58), together with two pictures. Participants’
task was to indicate which of the two pictures they believed best matched the meaning
of the discourse. One picture illustrated a situation that was consistent with a subset
interpretation of the ambiguity (i.e. that the two cats that were playing with a mouse
were among the three cats that were on the wall), and the other picture illustrated a
situation consistent with a new-set reading of the ambiguity (i.e. that the two cats that
were playing with a mouse were two new cats, different from those on the wall).
56. Three cats were on a wall. Two cats caught a mouse.

57. Three cats were on a wall. Two of the cats caught a mouse.

58. Three cats were on a wall. Two other cats caught a mouse.

Experiment 1 examined children’s and adult’s interpretative preferences when analysing both types of numerically quantified expressions. That is, participants were presented with both quantified noun-phrases (e.g., *two cats…*) and bare cardinals (e.g., *two…*). In Experiment 1 it was important to determine whether these expressions were interpreted differently by children or adults, because it was possible for these expressions to differ in their likelihood of receiving an anaphoric interpretation. However, the findings from Experiment 1 ruled out this possibility and showed that children and adults interpreted quantified noun-phrases and bare cardinals in the same manner, although the children and adults responded very differently to each other. In particular, the results showed that six- to eight-year-olds had a strong preference for the picture that illustrated a new-set reading of the discourse irrespective of whether the sentence was ambiguous, disambiguated in favour of the new-set reading, or even when it was disambiguated in favour of the subset reading, while adults selected this picture only for discourses disambiguated in favour of a new-set reading, like the one in (58). Moreover, the children showed a very similar preference for the new-set reading irrespective of whether the discourse contained a quantified noun-phrase or a bare cardinal, and adults also produced a very similar pattern of responses for these two types of expression.

Having established that children strongly prefer the “new-set picture” when analysing numerically quantified expressions, Experiment 2 tested whether this effect could be replicated in a condition in which children were presented with more pictures...
to choose from. Therefore, in this experiment together with the two critical pictures (i.e. “subset picture” and “new-set picture”) children were also presented with two distracting pictures. As in Experiment 1, the children’s task was to select the picture they considered best matched the meaning of the discourse. Importantly Experiment 2 produced the same pattern of findings as Experiment 1 and children in this experiment showed a similar strong preference for the picture illustrating a new-set reading, for both ambiguous and unambiguous numerically quantified expressions. Thus, it was clear that the effects obtained in Experiment 1 could be replicable and that children indeed exhibit a strong preference for the “new-set picture” when faced with this form of ambiguity.

Given that these effects showed such a strong and unexpected pattern of results, considering that children did not respond similarly to adults, the next step was to explore possible reasons for the children’s strong preference for the “new-set picture”. One possibility was that children selected the picture that illustrated a new-set reading because of a difficulty in integrating the meaning of the two sentences, which resulted in the children analysing the meaning of each of the two sentences separately. Experiment 3 attempted to assess this possibility by introducing another picture into the forced-choice picture-selection task. This picture was called the “non-integrative picture” because it depicted a situation that while veridical for each sentence in the discourse, nevertheless did not match the overall meaning of the discourse. That is to say, the picture depicted a situation in which each sentence was true (e.g., there were three cats on the wall and two cats were playing with a mouse), but the picture was not consistent with either a subset or new-set reading of the ambiguity. It was thought that children participants might choose this picture if they processed the discourse by evaluating the meaning of each sentence separately. Thus, a key question addressed in
this experiment was whether the introduction of this new picture would influence children’s performance on the task, or whether the children would still show the same strong preference for the picture corresponding to the new-set reading.

The results of Experiment 3 showed that children hardly ever selected the “non-integrative picture”. Rather, essentially the same pattern of effects as observed in Experiments 1 and 2 were obtained and children showed a strong preference for the picture that depicted a new-set reading of the discourse when interpreting both ambiguous and unambiguous expressions. Therefore, the results of this third experiment suggested that children’s preference for the “new-set picture” was not driven by a failure to integrate the meaning of each of the two sentences which would lead to a situation in which they evaluated the meaning of the sentences separately.

The next possibility that was tested was whether the numerical expressions used in these experiments had caused children to adopt some sort of counting strategy when forming judgements about the sentences. That is, children might have believed that they were being tested on their ability to add together the numerals in the sentences, and therefore may well have selected the “new-set picture” because it illustrated the total of entities created by adding the two numerals together. Although it is not clear why children would adopt an addition strategy, rather than for example a subtraction strategy, it was nevertheless important to rule out such a possibility.

This was accomplished in Experiment 4, in which the quantified noun-phrase of the first sentence (e.g., *three cats…*) in each discourse was replaced by a natural language quantifier (e.g., *some, many*) and which therefore removed the possibility of the participants employing a counting strategy based on either addition or subtraction. For example, in this experiment the discourses that children were presented with were of the form “*some cats… two cats…*” rather than “*three cats…. two cats…*”. The focus
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of this experiment was therefore to examine whether children’s strong preference for the “new-set picture” would be affected by this change. Importantly however, the results showed that this change in the form of the quantifiers used did not influence children’s preferences, but rather the same strong bias for the picture that depicted a new-set reading was still found.

At this point in the research it appeared possible to rule out two possible explanations of the findings. First it appeared that it was possible to rule out an explanation in which children were simply selecting the “new-set picture” because they had analysed the meaning of the each sentence in the discourse separately, as Experiment 3 showed that children did not have a preference for the picture that was veridical for the individual meaning of each sentence (i.e. “non-integrative picture”). Second, it was also possible to rule out an explanation that attributed children’s performance to the adoption of a counting strategy that might well be task specific, and so not informative about process that occurs normally in children’s language comprehension. Experiment 4 showed that this could not be the case, because the same pattern of performance was observed when the opportunity to employ a counting strategy was removed.

The next critical step was to eliminate yet another alternative possible explanation of the findings. Specifically, since the previous experiments employed a forced-choice picture-selection task it could be argued that the effects obtained did not reflect children’s actual interpretative preferences, but instead were an artefact of the specific task that was used. Although, it seemed unlikely that this was the case, it was nevertheless valuable to eliminate such possibility by testing whether the same effects could be obtained when using a different variant of the picture-selection task. This was done in Experiment 5 in which six- to eight-year-olds were given a picture-selection
task, only this time they were encouraged to select more than one picture. The purpose of this experiment was to examine whether children’s overwhelmingly strong preference for the new-set reading would be affected by using a variant of the task and whether the other possible reading of the ambiguity (i.e. subset reading) is available at all. Specifically, by encouraging children to select more than one picture enabled to examine whether children were aware that both the “subset picture” and “new-set picture” correspond to possible meanings of ambiguous (and unambiguous) expressions.

However, the results of Experiment 5 clearly showed that the nature of the task had not unduly affected children’s performance, as essentially the same pattern of performance, as obtained in the previous experiments, was also found in Experiment 5. That is, the children still showed a strong preference for the “new-set picture” when interpreting either ambiguous or unambiguous expressions. The finding that children do not select the “subset picture” to a similar extent as the “new-set picture”, even though children were encouraged to select more than one picture in Experiment 5, was very important since it suggested that children do have an overwhelmingly strong preference for the new-set reading and also importantly, the results suggested that the subset reading is difficult to be reached by children.

Experiment 6 tested this possibility further by using yet another variant of the picture-selection task. In particular, whereas the previous experiment used a picture-selection task, this experiment employed a picture evaluation task in which children had to evaluate whether each of the three pictures (i.e. “subset picture”, “new-set picture” and “non-integrative picture”) corresponded to the meaning of the discourse. Importantly, similarly to Experiment 5 it was emphasised to children that they could accept more than one picture as corresponding to the correct meaning of the discourse.
Crucially, even with yet another change to the task a pattern of results that was broadly similar to the previous experiments was obtained. Children still had a strong preference for the “new-set picture” and judged it to be true much more often than the other two pictures (i.e. “subset picture” and “non-integrative picture”). Thus, at this stage it became clear that the strong preference by children was probably not due to the experimental task that was employed. Instead, it seemed clear that the results clearly reflected the difficulty that children had in interpreting discourse.

Finally, Experiment 7 went a step further and directly examined whether children can ever reach the subset reading in this sort of experimental situations. Since the nature of the task appeared not to be responsible for the effects observed in the previous experiments, Experiment 7 returned to using the forced-choice picture-selection task. In this experiment however, in the two sentence types that children did not respond in the same manner to adults, the “new-set picture” was removed and thus, in the unambiguously subset (e.g., *three cats... two of the cats...*) and ambiguous (e.g., *three cats... two cats...*) sentence types children had to select between the “subset picture” and the “non-integrative picture”. Of particular importance was to examine how children respond when their strongly preferred picture is unavailable.

Significantly, the results of Experiment 7 showed that in the ambiguous sentence type when the “new-set picture” was removed, six- to eight-year-olds did not have a clear preference for either of the two remaining pictures. Instead the results showed that children did not have a significant preference for either the “subset picture” or the “non-integrative picture” as corresponding to the meaning of ambiguous discourses. Thus, apparently even under conditions in which children are unable to select the new-set picture, they are still not strongly predisposed to select the picture that corresponds to the subset reading. Nevertheless, the results from the unambiguous subset sentence type
clearly show that children are able to achieve the subset reading. In this sentence type it was shown that when the “new-set picture” was removed children were influenced from the partitive construction of the and were biased towards selecting the “subset picture”. Therefore, it appears that at least for unambiguously subset quantificational expressions, when children do not have another choice they are able to analyse a discourse following the subset interpretation. The implications of these findings are discussed in the next section.

8.2. Possible Reasons for Children’s Strong Preference for the “New-set Picture”

The results of the experiments reported here suggest that when the picture that depicts a new-set reading is made available, children have a very strong preference for selecting this picture when analysing ambiguous and unambiguous discourses that contain quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…). A question that arises from this finding is why children differ so markedly from adults in the way they analyse numerically quantified expressions? This section aims to answer this question by first discussing some possible alternative explanations that were ruled out from the results of the current experiments, and then discussing two possible explanations that may well account for children’s non-adult preference.

8.2.1. Alternative Possible Explanations Eliminated from the Current Results

The first possibility that can be eliminated is that the findings of the current research are an artefact of the methodology used in these experiments. The results of the seven experiments suggest that it is not the nature of the experimental task that was
producing the observed results, since a very similar pattern of performance was produced by six- to eight-year-olds regardless of various modifications to the task. Children had the same strong preference for the “new-set picture” when they were given a picture-selection task, a task in which they could select more than one picture, as well as a picture evaluation task. Thus, the possibility that children’s preference for the picture that depicted a new-set reading is because of the methodology used in this study can be ruled out.

Additionally, another possibility that can be eliminated is that children’s responses were based on a simple addition strategy that encouraged a new-set reading of the ambiguity. Experiment 4 clearly showed that the same strong preference for the “new-set picture” is present even when children are presented with numerically quantified expressions that contain a natural language quantifier (e.g., some, many). Clearly therefore, children’s strong preference for the “new-set picture” is not because of either an addition or subtraction strategy.

The current results also eliminated the possibility that children have a preference for the subset reading when analysing discourses that contain numerically quantified expressions. In seven experiments it was consistently shown that six- to eight-year-olds have clear strong preference for the “new-set picture” when analysing quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…). Thus, the results of the current research challenge the suggestion put forward by Wijnen et al. (2004) who claimed to demonstrate that children do not have a difficulty with discourse integration but instead, similarly with adults, they have a strong preference in analysing ambiguous bare cardinals following the subset reading. The current data do not support such view since it has been established that children do not have a preference for the subset reading even in ambiguous conditions where this reading is the only one available to
choose (i.e. Experiment 7). Note here that the differences between the current experiments’ results and the results of Wijnen et al. are discussed in more detail later.

In particular, two key findings of the current research provide strong supportive evidence against a subset preference by children. First, children’s strong preference for the “new-set picture” was not only found when children analysed ambiguous numerically quantified expressions (e.g., three cats... two cats...), but also when they analysed discourses that were disambiguated in favour of a subset reading. That is, children strongly preferred the “new-set picture” even in the sentence type that contained the partitive construction of the, the use of which was intended to grammatically disambiguate the discourse towards a subset reading. The main reason this unambiguous sentence type was included was to study children’s interpretative preferences under unambiguous reading conditions. Therefore finding that children do not select the “subset picture” even in control conditions shows the magnitude of children’s lack of preference for this interpretation of the discourse.

The second key finding that questions the likelihood that children have a preference for the subset reading is related to how children responded in the ambiguous sentence type of Experiment 7. Recall that in this sentence type, children’s preferred “new-set picture” was unavailable and children had to choose between the “subset picture” and the “non-integrative picture”. Therefore, if six- to eight-year-olds, like adults, can switch between interpretations then they would be expected to have a strong preference for the subset reading under such conditions. However, the results showed that even under these conditions children were still not strongly predisposed to select the picture that corresponded to the subset reading. Instead, when children were analysing ambiguous sentence types, in Experiment 7, they begun responding at chance and their responses were fairly evenly spread between the two remaining pictures (i.e.
“subset picture” and “non-integrative picture”). Perhaps this is an indication of just how
difficult children find it to assign a subset reading to an expression. Note however, that
it is not claimed that children can never reach the subset reading. The results of the
unambiguous subset sentence type of Experiment 7, clearly showed that when six- to
eight-year-olds do not have the choice of their mostly preferred “new-set picture” they
can reach the subset reading of unambiguously subset numerically quantified
expressions.

Note also, that as mentioned earlier, it cannot be the case that the findings
obtained in the present experiments were due to the task used, because the same basic
pattern of preferences by children was obtained using a range of different tasks. Also,
the same pattern of results was obtained in Experiment 6 in which children were given a
picture evaluation task, a task which was very similar to the one Wijnen et al. (2004)
used in their study. Yet, contrary to the findings of Wijnen and colleagues, the results of
Experiment 6 showed that even though children could evaluate both the “new-set
picture” and the “subset picture” as corresponding to the meaning of the discourse,
children nevertheless did not judge the “subset picture” as corresponding to the
discourse in similar frequency as the “new-set picture”. Therefore, some explanation is
needed for why Wijnen and colleagues obtained findings that are at odds with the
findings of the present research.

The differences between the current results and those obtained by Wijnen et al.
(2004) seem most likely to be due to differences in experimental design. Critically, the
current experiments differed from those of Wijnen and colleagues by including control
conditions, which enabled the study of children’s interpretations of numerically
quantified expressions under unambiguous reading conditions. Wijnen et al. lacked
these control conditions and they instead assessed children’s evaluation of stories that
always contained an ambiguous bare cardinal. When children evaluated a picture that corresponded to the subset reading as correct, Wijnen et al. interpreted this as evidence that they had a strong preference for the subset reading. Importantly however, a counterpart unambiguous discourse could reveal children’s interpretative preferences more clearly.

Specifically, an alternative explanation that is in line with the findings of the current research is that children in Wijnen et al. (2004) study did not have a preference for the “subset picture” because of analysing the discourse following a subset reading, but because only viewing stories that contained an ambiguous bare cardinal highlighted the nature of the ambiguity that was being investigated and therefore may have caused children to adopt a task-specific strategy and was manifest in children’s performance as an apparent preference for the subset reading of the ambiguity. This is the main reason the current research employed both ambiguous and unambiguous discourses.

It is also important to note that Wijnen et al. (2004) observed a surprisingly strong preference for the subset reading by child participants that was substantially greater than the preference for this reading shown by adult participants in other research. That is, the children in Wijnen et al. experiments appear to have an even stronger preference for the subset reading than adults do, which is rather peculiar in the context of the present findings, and may be indicative of the children adopting a task-specific strategy in this particular experiment. The children in Wijnen and colleagues experiment showed an 84.4% preference for the subset reading, which is substantially greater than the 65% preference for the subset reading shown by adults in Frazier et al.’s (2005) experiment, or the 51.7% preference observed in Wijnen and Kaan’s (2006) sentence completion experiment. Thus, it is clear that the apparent preference that children showed for the subset reading in Wijnen et al. study is far greater than the preference shown by adults.
in other studies, and so may not accurately reflect how children normally interpret this form of ambiguity.

8.2.2. *Possibility of a Difficulty in Integrating the Events Described in the Discourse*

Having ruled out several possible explanations of the current findings it is now important to consider why children appear to be showing this strong preference for the new-set interpretation. Previous research that has investigated how children process other types of anaphors (e.g., pronouns, the definite reference and inference generation) has shown that children have difficulty in connecting an anaphor with information from prior discourse context (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976). For instance, recall the work of Krämer (2002) who investigated children’s ability to use prior discourse context when interpreting pronouns and the definite article. Kramer’s results showed that children have substantial difficulty in using the referential context to establish the referent of either a pronoun or a definite noun. This led her to suggest that children’s difficulties in comprehending discourse might be because of a failure by children to interpret a pronoun or definite noun as referring anaphorically to a previous mentioned entity.

The present findings may provide yet another indication of the difficulty that children have in assigning anaphoric interpretations to linguistic expressions. A possible explanation for the current findings is that children consistently adopted a new-set interpretation because of a failure or difficulty in integrating the meaning of the two sentences. That is, the children selected the picture corresponding to this analysis because they evaluated the meaning of each sentence in the discourse separately.
Importantly, the discourses that were employed in the current research always described two events. One event was introduced in the first sentence (e.g., three cats are on a wall) and another event was introduced in the second sentence (e.g., two cats caught a mouse). Thus, a plausible account of children’s difficulty with integration is that children had a difficulty in connecting the event described in the first sentence with the event described in the second sentence, which resulted in each of the two events described in the discourse being mentally represented independently of each other.

A question that arises from this account is why then children did not select the “non-integrative picture” in Experiment 3 (and also used in subsequent experiments), as this was included to test the possibility that children evaluated the meaning of each sentence separately, and depicted events that were veridical of each sentence but inconsistent with either a subset or new set reading. The results of the experiments that employed this picture showed that children only rarely select the “non-integrative picture” as corresponding to the meaning of the discourse, and therefore suggested that children did not employ a strategy of separately analysing the meaning of each sentence. Indeed, children’s willingness to accept this picture was only present in the ambiguous sentence type of Experiment 7 where their most strongly favoured response (i.e. the “new-set picture”) was unavailable. The results showed that when the “new-set picture” was removed children did not have a preference for either the “subset picture” or the “non-integrative picture”, rather children selected between these two pictures at chance. Therefore, there must be an explanation of the reason children do not have a preference for the “non-integrative picture”.

The answer to this question lies in the differences between the “new-set picture” and the “non-integrative picture”. Whereas both of these pictures are equally likely to be selected by someone who analyses separately the two events described in the
discourse, nevertheless the “new-set picture” is an archetypal example of a situation in which the events described by each sentence are depicted separately, whereas the “non-integrative” picture is not. That is to say, in the “new-set picture” the separate meaning of each of the two sentences is more clearly illustrated than in the “non-integrative picture”. For explanatory purposes consider the usual cat example shown in (59).

59. Three cats were on a wall. Two cats caught a mouse.

For the picture to be compatible with a new-set reading of the ambiguity shown in (59) the “new-set picture” illustrated a situation in which the set of cats mentioned in the first sentence were clearly different than the set of cats mentioned in the second sentence. In particular, the “new-set picture” illustrated three cats on the wall and two different cats, not on the wall, but playing with a mouse. On the other hand, the “non-integrative picture” illustrated three cats on the wall, one of whom was playing with a mouse, and another cat not on the wall playing with a mouse. Thus, clearly, the “new-set picture” was a simpler representation of the separate meaning of the two sentences than the “non-integrative picture”. Consequently, if children find it difficult to connect the two events described in each of the two sentences they are more likely to select the “new-set picture” than the “non-integrative picture”, since in the “new-set picture” each event described in the discourse can be more easily identified than in the “non-integrative picture”. In the account that is advocated in this thesis, this is the main reason children strongly prefer the “new-set picture” and not the “non-integrative picture”, even though both pictures correspond to an interpretation consistent with an analysis of the two events described in each sentence separately. Crucially therefore, the current account fits perfectly well with the effects observed in the current experiments.
Importantly, such an account also explains why children do not have a preference for the “subset picture” when analysing numerically quantified expressions (i.e. quantified noun-phrases and bare cardinals). Clearly, this is because the “subset picture” is only consistent with an interpretation of the discourse in which the two events described in each sentence are integrated. Thus, the “subset picture” cannot be selected if children are interpreting the two sentences as describing two separate events. Apparently, children’s difficulty in connecting the two events described in the discourse leads to yet another difficulty; that is, a general difficulty in assigning a subset reading to numerically quantified expressions. A prerequisite of the subset reading is to referentially link the numerically quantified expression with information found in prior discourse context. Therefore, if children have an overall difficulty with integrating the events described in the discourse, then inevitably they will also have a difficulty in assigning a subset reading to a numerically quantified expression.

In the present research it has been consistently shown that children do not select the “subset picture” even in conditions in which the relation between the two sentences is explicitly stated, such as when the discourse contains the partitive construction of the, which explicitly denotes that the subset reading has to be assigned. Although the results of Experiment 7 have shown that in the unambiguously subset sentence type children select the “subset picture” significantly more times than the “non-integrative picture”, importantly however the other six experiments showed consistently that when the “new-set picture” is available children do not accept the “subset picture” as corresponding to the meaning of the discourse. Also significantly, the results of the current research showed that children do not select the picture depicting a subset reading of the discourse even in cases where they are encouraged to select another picture together with their strongly preferred “new-set picture” (i.e. Experiments 5 and 6), or in ambiguous cases
where the “subset picture” is the only picture that truly corresponds to the meaning of the discourse (i.e. Experiment 7). Even under these conditions children do not show a preference in selecting the picture corresponding to the subset reading of the ambiguity. Thus apparently, children’s difficulty with integrating the events described in the discourse has a direct consequence on children’s ability to follow the subset reading.

As it was reviewed in Chapter 4, the constraints of the optimality theoretic semantics (Hendriks & de Hoop, 2001), and the principle of Minimal Lowering (Frazier, 1999; 2000; Frazier et al. 2005), explicitly suggest that adult readers would have a strong preference for the subset reading when analysing ambiguous quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…). According to Minimal Lowering principle this is because the new-set reading demands “lowering” the phrase into a new syntactic position at LF to reach the intended interpretation, whereas according to the Hendriks and de Hoop (2001) account this is because adults have a general preference for numerically quantified expressions to refer to the current discourse topic (see Chapter 4 for more details on these suggestions). Research which examined adults’ preferences provided support for these suggestions and showed that adults strongly prefer to analyse ambiguous numerically quantified expressions following the subset interpretation (e.g., Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan, 2006).

Adult participants in the current research responded in line with this sort of account. Experiments 1 and 3 clearly showed a strong preference by adults for the subset interpretation. Crucially however, the above proposals do not provide a convincing account of children’s interpretative preferences, as the present research has shown consistently that when the new-set reading is available six- to eight-year-olds do not adopt the subset reading of an ambiguity. Indeed, when children are given the
choice of the “new-set picture” they do not select the “subset picture” even in cases where the discourse is disambiguated towards a subset reading (e.g., three cats… two of the cats…). Thus, it appears that children have a particular difficulty in reaching a subset reading of an ambiguous numerically quantified expression. It has been shown that it is only when children’s most preferred “new-set picture” is removed that they begin to consider the “subset picture” as corresponding to the meaning of the discourse, and importantly this is only true for unambiguously subset sentence types (i.e. three cats… two of the cats…) since in ambiguous sentence types even under such conditions children still do not show a preference for the “subset picture”.

The finding that children do not analyse discourses in the same manner to adults, suggests that children employ qualitatively different strategies when comprehending a text. As it was noted in Chapter 2, several accounts have been developed in an attempt to explain how adults comprehend a text and the main theme that came out of this discussion was that adults are naturally forming links between the current sentence and information from prior discourse context during comprehension (e.g., Altmann & Steedman, 1988; Avrutin, 1999; Crain & Steedman, 1985; Johnson-Laird, 1983; Sanford & Garrod, 1981). This enables adult readers and listeners to have an integrated representation in their discourse model, which they can later use to successfully comprehend succeeding sentences. Importantly, it has been widely demonstrated that integration for adults happens automatically, as soon as they read or hear a text and not only do adult’s form links between information that is explicitly stated in the text, but also attempt to do so even when an inference is required to support such an interpretation (e.g., Clark & Haviland, 1977; Crain & Steedman, 1985; Haviland & Clark, 1974; Johnson-Laird, 1983).
Crucially, the current findings suggest that these accounts do not provide a good account of strategies employed during children’s language comprehension and the results of the experiments described here suggest that children do not form links between the current sentence and information in the prior discourse context routinely when processing text. On the contrary, the current results appear to suggest that children have considerable difficulty in integrating text. This key aspect of the present finding leads to a more general consideration of how children mentally represent information in their discourse model. It appears that children and adults differ in the way they construct mental representations of discourse. Whereas adults automatically construct representations that integrate the information contained in each successive sentence, children may instead construct representations that represent separately the events described in each sentence. This appears to be because of a general difficulty by children in forming links between sentences, which in the experiments reported here, may well lead to more processing cost for the children in assigning a subset reading to discourses that contain numerically quantified expressions.

Importantly, note here that it is not argued that children never construct representations that integrate the information in a text. Rather as it was shown, in unambiguously subset cases when children do not have the choice of the “new-set picture” they are able to assign the interpretation that demands integration between information found in one sentence and its discourse context (i.e. subset reading). What is proposed here is that six- to eight-year-olds have more difficulty than adults in forming the necessary links between information in successive sentences, and therefore, children are more likely to construct a non-integrative representation of meaning of those sentences when they are constructing their discourse model.
Recall that the research that has examined adults’ interpretative preferences when analysing numerically quantified expressions, clearly suggests that adults preference for the subset reading is a result of a processing cost associated with the new-set reading. According to Frazier (1999; 2000; Frazier et al. 2005) and the principle of Minimal Lowering, for reasons of processing economy, readers avoid interpretations that demand changing the syntactic structure of a phrase into LF. Thus, readers avoid the new-set reading. On the other hand, Kaan et al. (2007; see also Paterson et al. 2008b) suggested that there are costs related to new referent introductions. Thus, more processing time is needed by adults to follow the new-set reading that involves introducing new entities into play.

The current results appear to suggest that the opposite is true for children. It appears that children’s strategy of analysing the two events described in the discourse separately may mean that for children it is more difficult to construct a mental representation that integrates information from different sentences (to reach the subset reading of an ambiguity), than to construct a discourse model that represents these events separately (to reach the new-set reading of an ambiguity). Thus, inevitably children do not have a preference for the reading that demands integration, but rather may strongly prefer the reading that is in line with the individual meaning of the events described in each sentence; in this case, the new-set reading.

The explanation for the current findings is as follows. As with the suggestions put forward from existing research that has examined other types of anaphors (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden, 1976), children have a difficulty in integrating sentences that contain quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…). This difficulty appears to be because children find it hard to integrate the events
described in each of the two sentences and thus, seek a response which they can produce by evaluating the meaning of the sentences separately. For this reason they select the “new-set picture” because it provides the best illustration of the separate meaning of the two sentences. Additionally, children’s difficulty with integrating the events described in the discourse appears to directly affect children’s ability to referentially link numerically quantified expressions with information from prior discourse. Thus, children have a difficulty in constructing a mental representation that represents an integrative meaning of the text. Consequently, this leads to a difficulty in adopting the subset reading even in cases where this reading is the only acceptable interpretation, like in conditions which the discourse is grammatically disambiguated in favour of a subset reading (e.g., three cats… two of the cats…).

Adults on the other hand have a strong preference for adopting a subset reading when analysing ambiguous numerically quantified expressions. This preference by adults is either because adults automatically form links between sentences (e.g., Altmann & Steedman, 1988; Avrutin, 1999; Clark & Haviland, 1977; Crain & Steedman, 1985; Ehrlich & Johnson-Laird, 1982; Haviland & Clark, 1974; Johnson-Laird, 1983) or because of costs associated with the new-set reading (e.g., Frazier, 1999; 2000; Frazier et al. 2005; Kaan et al. 2007; Paterson et al. 2008b; Wijnen & Kaan, 2006). Thus, the current proposal suggests that six- to eight-year-olds difficulty with integration directs them into adopting strategies that are qualitatively different with those employed by adults.

The approach to numerically quantified expressions proposed in this thesis has much in common with the approach taken by other researchers who have examined children’s processing of other types of anaphors (e.g., Avrutin & Coopmans, 2000; Kail & Hickmann, 1992; Karmiloff-Smith, 1979; 1980; Krämer, 2002; Tyler, 1983; Warden,
1976). Like them, it has been proposed in this thesis that young children and specifically six- to eight-year-olds face difficulty in using an anaphoric device as a means of connecting information found in different sentences of a text.

More tentatively, it appears that there are links between the current findings and the suggestions put forward by Trueswell et al. (1999) investigating how children interpret syntactically ambiguous sentences. As described in Chapter 2, Trueswell and colleagues’ study showed that children made a lot of errors with sentences like “put the frog on the napkin in the box”. Specifically, Trueswell and colleagues found that children were unable to employ the principle of Referential Success to govern their syntactic decisions and thus children failed to use the referential context to resolve the syntactically ambiguous sentence. Trueswell and colleagues suggested that children’s difficulties were because of an inability to entertain an alternative interpretation of the initial syntactic commitments. Just as Trueswell et al. found that young children fail to revise initial commitments, perhaps children in the current experiments, because of a general difficulty with integration, failed to revise their initial new-set interpretation and thus failed to consider that ambiguous numerically quantified expressions can be also analysed in a subset reading.

Additionally, the effects observed in the current research appear to have links with accounts that have suggested that there are representational costs associated in constructing mental models that contain alternative sets (e.g., Paterson et al. 2003). Similarly to these researchers the current research showed that there are representational costs associated with children’s construction of discourse models, but in the current research these costs are attributed to a difficulty in constructing a discourse model that contains the integrative version of the two events described in the discourse.
Finally, the current findings can be related to broader considerations of children’s processing of other types of quantifiers than the ones concerned in the current research. As already been described, much of this research suggested that children interpret sentences that contain quantifiers in a different manner to adults. For instance, existing research showed that children have a general difficulty in processing sentences that contain the universal quantifier every (e.g., Drozd, 2001; Drozd & van Loosbroek, 1998; Meroni et al. 2000; 2004; Philip, 1995). Similarly, other research has also indicated that children have difficulty in considering the alternative possible analyses of scopally ambiguous sentences (e.g., Lidz & Musolino, 2002; Musolino et al. 2000). For instance, the work of Lidz and Musolino’s (2002), who investigated young children’s processing of scopally ambiguous sentences that contained negation and numeric quantifiers, like “the detective didn’t find two guys”, suggests that whereas adults have no difficulty in considering the alternative possible analyses of an ambiguity, children are far less capable of doing so.

It is reassuring that the explanation given to the findings from the research reported here appears to have links with many other areas that investigated children’s language comprehension. Nevertheless, there is an alternative explanation of the current findings. The effects obtained in the current research have also much in common with the effects described by Piaget and his colleagues (Piaget, 1952; Inhelder & Piaget, 1964) when investigating children’s reasoning. They proposed that children younger than eight have a general difficulty with class subclass relationships. Perhaps this difficulty is an additional reason responsible for the current findings. The next section discusses the similarities between the significant effects found in the current research and children’s difficulty to resolve class inclusion problems.
8.2.3. *Children’s Difficulty in Resolving Class-Subclass Relationships*

As described in Chapter 3, Piaget’s (1952; Inhelder & Piaget, 1964) cognitive development theory describes four stages that children go through until they achieve cognitive growth. For current purposes, the most critical stage of Piaget’s theory is the second stage, which he called the preoperational stage. This is because this stage encompasses the same range of chronological ages that the current research has been concerned with, and is the stage in which Piaget noticed that among the many cognitive tasks (related to their knowledge of various concepts like space, time, number and many others) that children have difficulty in performing, children also failed in correctly replying to the class inclusion question which tested their knowledge of class-subclass relationships.

Knowledge about class-subclass relationships is crucial for the current research. This is because for children to adopt a new-set or subset reading of an expression largely depends on how they process class memberships. For the phrase *two cats* in a discourse like the one shown in (60) to be interpreted in terms of a new-set reading, it is necessary for each sentence to be analysed as referring to two subclasses of entities. That is, one subclass of cats that is described in the first sentence “cats that are on the wall” and another subclass of cats described in the second sentence “cats that caught a mouse”. On the contrary, for *two cats* to receive a subset reading, the second sentence of (60) should be interpreted as describing a subclass of entities “cats that caught a mouse”, which is part of a more general class of cats “cats that are on the wall”.

60. Three cats were on a wall. Two cats caught a mouse.
Piaget and his colleagues (Piaget, 1952; Inhelder & Piaget, 1964) tested children’s knowledge of class-subclass memberships by examining children’s performance on the class inclusion task. As it has been described already, in this task children were presented with a number of objects that simultaneously belonged to the same category. For instance, they could be presented with fifteen animal toys from which ten were toy cats, and five toy dogs, and the children’s task was to perform an act-out request by the experimenter. Piaget noticed that while children younger than eight could correctly divide the animals into two subclasses (e.g., cats and dogs), as well as act-out requests that involved comparisons of the two subclasses (e.g., divide the animals into dogs and cats), they nevertheless failed on the class inclusion question that involved a comparison between a class and its subclass. Specifically, children were unable to correctly reply to the class inclusion question “are there more cats or more animals”.

Piaget (1952; Inhelder & Piaget, 1964) noticed that children understood the question as asking to compare the two subclasses, “cats” and “dogs”. Thus, mostly children responded to the question by saying the subclass that contained the most objects, for the above example “cats”. Piaget proposed that children’s errors on this task stemmed from an inability to recognise that a subclass of objects could be included in a more general class, but did not exhaust it. The difficulty with the class inclusion task was also replicated by other researchers (e.g., Carpendale et al. 1996; Shipley, 1979; Steinberg & Anderson, 1975; Winer, 1974).

Importantly, the results of this research fit perfectly well with the effects observed in the current research. As mentioned previously, whereas the new-set reading demands a comparison between two subclasses, the subset reading demands a comparison between a general class and its subclass. Thus, crucially, if children
younger than eight indeed have a difficulty in recognising that a subclass of entities can be part of a more general class of entities, as Piaget (1952; Inhelder & Piaget, 1964) and other researchers have found (e.g., Carpendale et al. 1996; Shipley, 1979; Steinberg & Anderson, 1975; Winer, 1974), then inevitably children will also have a difficulty in adopting a subset reading when analysing numerically quantified expressions. For explanation purposes consider the discourse shown in (61), which illustrates an example of the unambiguously new-set sentence type that was used in the current research.

61. Three cats were on a wall. Two other cats caught a mouse.

The first sentence of this discourse describes a class of cats, “cats that are on a wall”, the second sentence since it contains the word other, indicates that the class of cats “cats that caught a mouse” are a different subclass of cats than those described in the first sentence. Thus, the discourse should be analysed as containing two subclasses of cats; one subclass of cats “cats that are on the wall” and another subclass of cats “cats that caught a mouse”. Therefore, in order to reach the intended interpretation (i.e. new-set reading) a comparison between the two subclasses needs to be accomplished. Similarly with what Piaget (1952; Inhelder & Piaget, 1964) observed when he asked children to divide objects into two subclasses, children in the current experiments did not have any difficulty in dividing the animals into two subclasses, and thus found it easy to select the “new-set picture”.

Importantly however, a different class-subclass relationship has to be resolved for discourses like the one shown in (62). This example contains the partitive construction of the, which explicitly denotes that the class of cats described in the second sentence “cats that caught a mouse” is a subclass of the more general class of
cats described in the first sentence “cats that are on a wall”. Thus, for the discourse to be analysed in the expected subset reading it is necessary for children to resolve class inclusion relationships.

62. Three cats were on a wall. Two of the cats caught a mouse.

The results of the current experiments showed consistently that children did not have a preference for the “subset picture” when analysing unambiguous discourses like the one shown in (62). This finding is in line with the results obtained by Piaget in the class inclusion task. Perhaps children did not select the expected “subset picture” because of difficulty in understanding that a subclass of entities (in this case the “cats that caught a mouse”) can be included in a more general class of entities (i.e. the cats that were on a wall). For this reason they strongly preferred the “new-set picture” because it is the picture that illustrates the two subclasses and no comparison between a class and its subclass need to be performed.

Therefore, following the alternative explanation that is in line with the observations of Piaget (1952; Inhelder & Piaget, 1964), the results of the current experiments can be explained as follows. Because children have a general difficulty in recognising that a subclass of entities can be also part of a more general class of entities, they have difficulty in reaching the subset reading when analysing ambiguous and unambiguous numerically quantified expressions. Consequently, children have a strong preference for the “new-set picture”, since this is the picture that illustrates the entities as belonging to two different subclasses. In Experiment 7 in which the “new-set picture” was removed, children were forced to try and establish the relationship between a class and its subclass. In the unambiguously subset sentence types that contained the
partitive construction of the children were able to do this and they were found to select the “subset picture”, however their general difficulty did not allow them to do the same in the ambiguous sentence type. In ambiguous conditions children’s difficulty with class-subclass relations resulted in having a difficulty choosing between the “subset picture” and the “non-integrative picture” the one that corresponded to the meaning of the discourse and thus, children responded at chance.

It appears that this alternative explanation can account for effects observed in children’s performance in the current research. Importantly, it is possible that children’s difficulty with class-subclass relations is not the only reason responsible for the effects observed in the current research. Perhaps children have both a difficulty in resolving class-subclass relationships and a difficulty in connecting each of the events described in the discourse, and this inevitably leads to a difficulty by children in considering the “subset picture” as truly corresponding to the meaning of the discourse.

8.2.4. Section Summary

In summary this section has suggested two possible explanations for children’s strong preference for the “new-set picture” when evaluating the meaning of discourses that contain numerically quantified expressions. The first account proposes that the effects observed in children’s performance in the present research are a result of a general difficulty experienced by children in integrating the information contained in successive sentences in a discourse. This difficulty leads children to analyse the sentences separately and so understand the discourse as describing two separate events. As a consequence, children fail to represent the subset interpretation of numerically quantified expressions in the sort of discourses investigated in the research reported
here, and instead show an overwhelming strong preference for the new set reading of quantified ambiguities, because such a reading is consistent with having analysed the meaning of the sentences separately.

Alternatively, children’s strong preference for the “new-set picture” may be explained by a general difficulty by six- to eight-year-olds in performing class inclusion relations. Following this explanation, children may have a strong preference for the “new-set picture”, because this picture does not demand a comparison between a class and its subclass. At present, the results cannot make any discrimination on which of the two possibilities is the one responsible for the current findings. It could also be that children have difficulties with both integration and establishing the relationships between a class and its subclass, and thus both of these explanations account for the significant effects observed in the current research. Whether this is indeed the case however, is something that needs to be assessed in future research.

8.3. Future Directions

This study has been the first attempt to thoroughly examine children’s interpretative preferences when analysing discourses that contain numerically quantified noun-phrases (e.g., *two cats*…) and bare cardinals (e.g., *two*…). The research has provided important insights into children’s interpretative preferences when evaluating the meaning of these expressions and has implications for researchers interested in children’s language comprehension. Nevertheless, some issues need to be assessed in future research.

The current research has shown that six- to eight-year-olds evaluate discourses that contain numerically quantified expressions differently to adults, yet the
developmental stage at which children’s interpretative biases shift and become like adults was not investigated in the present research and remains to be determined. Clearly it is important for future research to determine when children begin to act like adults. Previous research looking at other areas of anaphora suggests that after the age of eight children’s interpretations gradually shift and become similar with those of adults (e.g., Kail & Hickmann, 1992; Karmiloff-Smith 1979; 1980; Warden, 1976). Thus, it is important for future research to explore whether this is also the case when children analyse numerically quantified expressions.

A developmental study that will employ a wider range of ages than the ones investigated in the current research could be informative about the stage in which children’s interpretation shifts and becomes like that of adults. For instance future research could assess the performance on a sentence-picture comparison task of at least five groups of participants: preschoolers, first and second graders, third and fourth graders, adolescents and adults. Such a study would provide some indication of how children’s language processing strategies change as they mature.

Besides potentially informing investigations concerning children’s processing of numerically quantified expressions the results of the present research are relevant to more general considerations of children’s language acquisition. Indeed, the findings from the present research can be directly related to the notion that children have limits in the cognitive processing capabilities that prevent them from performing like adults (e.g., Avrutin & Coopmans, 2000; Avrutin, 1999; Paterson et al. 2003; Trueswell et al. 1999). According to this view, children and adults share the same grammatical knowledge, but differ in the way they implement this knowledge.

For instance, Trueswell et al. (1999) suggested that children cannot revise their initial syntactic commitments when interpreting syntactically ambiguous sentences,
whereas Avrutin’s (1999) suggested that limited processing capacity limits children’s ability to draw necessary inferences about other speaker’s representation of the discourse. For the current investigation, children may initially reach the new-set reading and because of some processing limitations, fail to depart from this initial commitment. Clearly further work is needed to determine whether these processing limitations can be related with children’s preferences observed in the current research.

Additionally, the current experiments did not directly examine whether the constraints of Minimal Lowering (e.g., Frazier, 1999; 2000) and of the optimality theoretic semantics (e.g., Hendriks & de Hoop, 2001) directly influence children’s performance when evaluating the meaning of numerically quantified expressions. Although the finding that children do not have a preference for the subset reading of the quantifiers assessed in the present research, suggests that children do not process language in line with these constraints when interpreting quantifiers, it is nevertheless important to establish why that is the case. In the present research it has been suggested that this is because children employ qualitatively different strategies to adults when comprehending a text. Nevertheless, it is valuable to examine whether children are influenced by structural principles that Frazier and her colleagues have identified to be important when assigning a referential interpretation to quantifiers during text comprehension (Frazier, 1999; Frazier et al., 2005). Therefore, future research could examine how children interpret quantifiers that are in different syntactic positions.

Recall that according to the principle of Minimal Lowering (Frazier, 1999; 2000) phrases which are in the object position (e.g., five ships appeared on the horizon. Pirates sank three ships) are interpreted in a new-set reading, whereas phrases which are in the subject position (e.g., five ships appeared on the horizon. Three ships were sunk by pirates) if not “lowered” should receive a subset reading. It is not yet established
whether children are also sensitive to these grammatical cues and whether they will interpret such discourses similarly to adults. Thus it is important for future research to examine if children analyse discourses that are in different syntactic structure differently.

One final relevant investigation concerns more direct examinations of children’s understanding of expressions that explicitly denote a relation between two sets, like the partitive construction of the. The current research clearly showed that children were only influenced by the partitive construction of the in the case of Experiment 7 in which the “new-set picture” was not available as a choice. On the contrary, the results of Experiments 1-6 showed that children processed unambiguous discourses containing the partitive construction of the (e.g., three cats… two of the cats…) similarly to ambiguous ones (e.g., three cats… two cats…). This finding is relevant to the results of previous research that has shown that children have an overall difficulty in forming explicit referential links between sentences (e.g., Karmiloff-Smith, 1979; 1980; Krämer, 2002). Thus, more detailed investigation concerning children’s processing of the partitive construction of the will provide better understanding of children’s processing strategies when comprehending connected discourse.

8.4. Conclusions

The present research documents the first attempt to thoroughly assess how children analyse ambiguous and unambiguous discourses that contain numerically quantified expressions; that is quantified noun-phrases (e.g., two cats…) and bare cardinals (e.g., two…). Importantly, like other types of anaphors (e.g., pronouns, the definite reference and inference generation) these quantifiers play a crucial role in text
integration, because readers often can only understand these expressions by assigning an anaphoric reading to an expression and by integrating the information in successive sentences. The present research examined and compared the responses of six- to eight-year-olds and adults when interpreting ambiguous and unambiguous discourses that contained such expressions.

It was clearly shown that whereas adults predominately interpret the quantifiers by connecting the two sentences of the discourse, children often interpret these expressions non-anaphorically. In particular, it was clearly shown that children only rarely interpret these expressions with respect to their referent found in prior discourse context. This is a critical finding which clearly shows the differences between the strategies that children and adults employ when they comprehend a text. Whereas adults naturally and automatically integrate the meaning of sentences, discourse integration is something that children have difficulty in achieving. For children forming links between sentences is not something that happens automatically, rather as the current research clearly shows discourse integration incurs a processing difficulty in children’s successful comprehension of a text.

The present research aimed at providing an insight into a very interesting area that has only recently received attention by researchers. As should be evident from the thesis, quantifiers play an important role in language, and often pose an important challenge to the child who is trying to understand their meaning. The present research has revealed one particular aspect of that challenge, but more research is needed to more fully reveal the challenges that quantifiers pose during language comprehension and the strategies that children use to comprehend them. Thus, future research should be aimed at examining this topic in more detail, since only in this way it would be possible to
obtain a more detailed picture of the strategies that children employ when processing language.
Notes for the Appendices

The materials of the present study were presented in participant’s native language, Greek. The pictures were always black and white.

In the following sections the discourses will be presented in three versions:

Version A is the original discourse in Greek

Version B is a direct translation of the discourse in English

Version C is the English counterpart of the discourse.

The discourses that the direct and English counterpart version is the same will be referred to as BC.
APPENDIX 1:
Materials for Pilot Study

Arithmetic Problems

Counting Task:

A) Μπορείτε να μου πείτε πόσες μπάλες έχει στην εικόνα?
B) Can you to me tell you how many balls are in the picture?
C) Can you tell me how many balls are in the picture?

![Picture with balls]

Addition & Subtraction Problems:

A) Μπορείτε να μου πείτε πόσα μας κάνουν…?
B) Can you to me tell you how much is…?
C) Can you tell me how much is…?

\[
\begin{array}{ll}
8 + 4 = & 8 - 4 = \\
6 + 3 = & 6 - 3 = \\
5 + 3 = & 5 - 3 = \\
\end{array}
\]
Filler Items:

1. A) Οχτώ αγόρια πήγαν σινεμά. Τέσσερα κορίτσια έτρωγαν ποπκόρν.

B & C) Eight boys went to the cinema. Four girls were eating pop-corn.

2. A) Έξι κορίτσια πήγαν στη βιβλιοθήκη. Τρία αγόρια διάβαζαν από ένα βιβλίο.

B) Six girls went to the library. Three boys were reading from one book.

C) Six girls went to the library. Three boys were reading a book.
3.  

A) Έξι γουρούνια έπαιζαν στη λάσπη. Τρεις κότες έτρωγαν.

B & C) Six pigs were playing in the mud. Three chickens were eating.

4.  

A) Πέντε γυναίκες κολυμπούσαν στη θάλασσα. Τρεις άντρες έκαναν ηλιοθεραπεία.

B & C) Five women were swimming at the sea. Three men were sun tanning.
5. A) Πέντε ελάφια ήταν στο δάσος. Τρία λιοντάρια ξεκουράζονταν.

B & C) Five deer were in the forest. Three lions were resting.

<table>
<thead>
<tr>
<th>(a) Correct Picture</th>
<th>(b) Wrong Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Correct Picture" /></td>
<td><img src="image2" alt="Wrong Picture" /></td>
</tr>
</tbody>
</table>

Experimental Items:

1. A) Οχτώ αεροπλάνα ήταν στον ουρανό. Τέσσερα (άλλα αεροπλάνα / από αυτά / αεροπλάνα) προσγειώθηκαν.

B & C) Eight airplanes were in the sky. Four (other airplanes / of them / airplanes) landed.

<table>
<thead>
<tr>
<th>(a) Subset Picture</th>
<th>(b) New-Set Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Subset Picture" /></td>
<td><img src="image4" alt="New-Set Picture" /></td>
</tr>
</tbody>
</table>
2. A) Οχτώ λαγοί πήγαν στο δάσος. Τέσσερις (άλλοι λαγοί / από αυτούς / λαγοί) βρήκαν από ένα καρότο.

B) Eight rabbits went to the forest. Four (other rabbits / of them / rabbits) found from one carrot.

C) Eight rabbits went to the forest. Four (other rabbits / of them / rabbits) found a carrot.

3. A) Οχτώ άλογα ήταν στη φάρμα. Τέσσερα (άλλα άλογα / από αυτά / άλογα) ēτρωγαν.

B & C) Eight horses were in the farm. Four (other horses / of them / horses) were eating.
4. A) Οκτώ δελφίνια ήταν σε μία πισίνα. Τέσσερα (άλλα δελφίνια / από αυτά / δελφίνια) πήδηξαν για μία μπάλα.

B) Eight dolphins were in to one pool. Four (other dolphins / of them / dolphins) jumped for one ball.

C) Eight dolphins were in the pool. Four (other dolphins / of them / dolphins) jumped for a ball.

5. A) Οκτώ ελέφαντες περπάταγαν στο δάσος. Τέσσερις (άλλοι ελέφαντες / από αυτούς / ελέφαντες) κουβάλαγαν από ένα άντρα.

B) Eight elephants were walking in the forest. Four (other elephants / of them / elephants) were carrying from one man.

C) Eight elephants were walking in the forest. Four (other elephants / of them / elephants) were carrying a man.
6. A) Έξι σκύλοι ήταν στον κήπο. Τρεις (άλλοι σκύλοι / από αυτούς / σκύλοι) τρώγανε από ένα κόκαλο.
B) Six dogs were in the garden. Three (other dogs / of them / dogs) were eating from one bone.
C) Six dogs were in the garden. Three (other dogs / of them / dogs) were eating a bone.

7. A) Έξι παιδιά πήγαιναν στο σχολείο. Τρία (άλλα παιδιά / από αυτά / παιδιά) ήταν με το ποδήλατο τους.
B) Six kids were going to the school. Three (other kids / of them / kids) were with the bicycle them.
C) Six kids were going to school. Three (other kids / of them / kids) were with their bicycle.
8. A) Έξι άντρες ήταν στο ποτάμι. Τρεις (άλλοι άντρες / από αυτούς / άντρες) έπιασαν από ένα ψάρι.

B) Six men were at the river. Three (other men / of them / men) caught from one fish.

C) Six men were at the river. Three (other men / of them / men) caught a fish.

9. A) Έξι αγόρια ήταν στο πάρκο. Τρία (άλλα αγόρια / από αυτά / αγόρια) έπαιζαν μπάσκετ.

B & C) Six boys were in the park. Three (other boys / of them / boys) were playing basketball.
10. A) Έξι πίθηκοι πήγαν στο δάσος. Τρεις (άλλοι πίθηκοι / από αυτούς / πίθηκοι) έτρωγαν μια μπανάνα.

B) Six monkeys went to the forest. Three (other monkeys / of them / monkeys) were eating from one banana.

C) Six monkeys went to the forest. Three (other monkeys / of them / monkeys) were eating a banana.

11. A) Πέντε γάτοι ήταν σε ένα τοίχο. Τρεις (άλλοι γάτοι / από αυτούς / γάτοι) έπιασαν από ένα ποντίκι.

B) Five cats were on one wall. Three (other cats / of them / cats) caught from one mouse.

C) Five cats were on a wall. Three (other cats / of them / cats) caught a mouse.
12. A) Πέντε πουλιά κάθονταν πάνω σε ένα κλαδί. Τρία (άλλα πουλιά / από αυτά / πουλιά) έτρωγαν από ένα σκούληκι.

B) Five birds were sitting on to one branch. Three (other birds / of them / birds) were eating from one worm.

C) Five birds were sitting on a branch. Three (other birds / of them / birds) were eating a worm.

13. A) Πέντε αστυνόμοι ήταν έξω από μία τράπεζα. Τρεις (άλλοι αστυνόμοι / από αυτούς / αστυνόμοι) ήταν πάνω σε μία μοτοσυκλέτα.

B) Five policemen were outside from one bank. Three (other policemen / of them / policemen) were on to one bike.

C) Five policemen were outside a bank. Three (other policemen / of them / policemen) were on a bike.
14. A) Πέντε παιδιά ήταν στη παραλία. Τρία (άλλα παιδιά / από αυτά / παιδιά) έχτισαν από ένα κάστρο στην άμμο.
B) Five kids were at the beach. Three (other kids / of them / kids) build from one castle in the sand.
C) Five kids were at the beach. Three (other kids / of them / kids) build a sand-castle.

15. A) Πέντε αυτοκίνητα ήταν στον αγώνα. Τρία (άλλα αυτοκίνητα / από αυτά / αυτοκίνητα) τράκαραν.
B & C) Five cars were in the race. Three (other cars / of them / cars) crushed.
APPENDIX 2:

Arithmetic Problems

The following arithmetic problems were employed in Experiments 1-7

*Counting Task:*

Can you tell me how many balls are in the picture?

![Picture of balls]

*Addition & Subtraction Problems:*

Can you tell me how much is....?

\[
\begin{array}{ll}
4 + 3 = & 4 - 3 = \\
4 + 2 = & 4 - 2 = \\
3 + 2 = & 3 - 2 = \\
\end{array}
\]
APPENDIX 3:

Experiment 1

The filler items that were used in Experiment 1 were identical for both the Quantified Noun-Phrase Group and Bare Cardinal Group.

1. A) Τέσσερα αγόρια πήγαν σινεμά. Τρία κορίτσια έτρωγαν ποπκόρν.

B & C) Four boys went to the cinema. Three girls were eating pop-corn.

2. A) Τέσσερα κορίτσια πήγαν στη βιβλιοθήκη. Τρία αγόρια διάβαζαν από ένα βιβλίο.

B) Four girls went to the library. Three boys were reading from one book.

C) Four girls went to the library. Three boys were reading a book.
3. A) Τρία γουρούνια έπαιζαν στη λάσπη. Δύο κότες έτρωγαν.

B & C) Three pigs were playing in the mud. Two chickens were eating.

4. A) Τρεις γυναίκες κολυμπούσαν στη θάλασσα. Δυο άντρες έκαναν ηλιοθεραπεία.

B & C) Three women were swimming at the sea. Two men were sun tanning.
5. A) Τέσσερα ελάφια ήταν στο δάσος. Δύο λιοντάρια ξεκουράζονταν.

B & C) Four deer were in the forest. Two lions were resting.

![Correct Picture](image1) ![Wrong Picture](image2)

*Experimental Items Presented to the Quantified Noun-Phrase Group*

1. A) Τέσσερα αεροπλάνα ήταν στον ουρανό. Τρία (άλλα αεροπλάνα / από αυτά / αεροπλάνα) προσγειώθηκαν.

B & C) Four airplanes were in the sky. Three (other airplanes / of them / airplanes) landed.

![Subset Picture](image3) ![New-Set Picture](image4)
2. A) Τέσσερις λαγοί πήγαν στο δάσος. Δύο (άλλοι λαγοί / από αυτούς / λαγοί) βρήκαν από ένα καρότο.

B) Four rabbits went to the forest. Two (other rabbits / of them / rabbits) found from one carrot.

C) Four rabbits went to the forest. Two (other rabbits / of them / rabbits) found a carrot.

3. A) Τέσσερα άλογα ήταν στη φάρμα. Δύο (άλλα άλογα / από αυτά / άλογα) έτρωγαν.

C & D) Four horses were in the farm. Two (other horses / of them / horses) were eating.
4. A) Τρία δελφίνια ήταν σε μία πισίνα. Δύο (άλλα δελφίνια / από αυτά /
δελφίνια) πήδηξαν για μία μπάλα.
B) Three dolphins were in to one pool. Two (other dolphins / of them /
dolphins) jumped for one ball.
C) Three dolphins were in the pool. Two (other dolphins / of them /
dolphins) jumped for a ball.

5. A) Τέσσερις ελέφαντες περπάταγαν στο δάσος. Τρεις (άλλοι ελέφαντες /
apό αυτούς / ελέφαντες) κουβάλαγαν από ένα άντρα.
B) Four elephants were walking in the forest. Three (other elephants / of
them / elephants) were carrying from one man.
C) Four elephants were walking in the forest. Three (other elephants / of
them / elephants) were carrying a man.
6.  
A) Τέσσερις σκύλοι ήταν στον κήπο. Τρεις (Άλλοι σκύλοι / από αυτούς / σκύλοι) τρώγανε από ένα κόκαλο.
B) Four dogs were in the garden. Three (other dogs / of them / dogs) were eating from one bone.
C) Four dogs were in the garden. Three (other dogs / of them / dogs) were eating a bone.

7.  
A) Τρία παιδιά πήγαιναν στο σχολείο. Δύο (Άλλα παιδιά / από αυτά / παιδιά) ήταν με το ποδήλατο τους.
B) Three kids were going to the school. Two (other kids / of them / kids) were with the bicycle them.
C) Three kids were going to school. Two (other kids / of them / kids) were with their bicycle.
8.  A) Τρεις άντρες ήταν στο ποτάμι. Δύο (άλλοι άντρες / από αυτούς / άντρες) έπιασαν από ένα ψάρι.
B) Three men were at the river. Two (other men / of them / men) caught from one fish.
C) Three men were at the river. Two (other men / of them / men) caught a fish.

9.  A) Τρία αγόρια ήταν στο πάρκο. Δύο (άλλα αγόρια / από αυτά / αγόρια) έπαιζαν μπάσκετ.
B & C) Three boys were in the park. Two (other boys / of them / boys) were playing basketball.
10. A) Τέσσερις πίθηκοι πήγαν στο δάσος. Τρεις (άλλοι πίθηκοι / από αυτούς / πίθηκοι) έτρωγαν μια μπανάνα.

B) Four monkeys went to the forest. Three (other monkeys / of them / monkeys) were eating from one banana.

C) Four monkeys went to the forest. Three (other monkeys / of them / monkeys) were eating a banana.

11. A) Τρεις γάτοι ήταν σε ένα τοίχο. Δύο (άλλοι γάτοι / από αυτούς / γάτοι) έπιασαν από ένα ποντίκι.

B) Three cats were on one wall. Two (other cats / of them / cats) caught from one mouse.

C) Three cats were on a wall. Two (other cats / of them / cats) caught a mouse.
12. A) Τέσσερα πουλιά κάθονταν πάνω σε ένα κλαδί. Δύο (άλλα πουλιά / από αυτά / πουλιά) ēτρωγαν από ένα σκουλήκι.

B) Four birds were sitting on to one branch. Two (other birds / of them / birds) were eating from one worm.

C) Four birds were sitting on a branch. Two (other birds / of them / birds) were eating a worm.

13. A) Τέσσερις αστυνόμοι ήταν έξω από μία τράπεζα. Δύο (άλλοι αστυνόμοι / από αυτούς / αστυνόμοι) ήταν πάνω σε μία μοτοσυκλέτα.

B) Four policemen were outside from one bank. Two (other policemen / of them / policemen) were on to one bike.

C) Four policemen were outside a bank. Two (other policemen / of them / policemen) were on a bike.
14. A) Τέσσερα παιδιά ήταν στη παραλία. Δύο (άλλα παιδιά / από αυτά / παιδιά) έχτισαν από ένα κάστρο στην άμμο.
B) Four kids were at the beach. Two (other kids / of them / kids) build from one castle in the sand.
C) Four kids were at the beach. Two (other kids / of them / kids) build a sand-castle.

15. A) Τέσσερα αυτοκίνητα ήταν στον αγώνα. Δύο (άλλα αυτοκίνητα / από αυτά / αυτοκίνητα) τράκαραν.
B & C) Four cars were in the race. Two (other cars / of them / cars) crushed.
The pictures that were presented to the participants of the Bare Cardinal Group were identical with those presented to the Quantified Noun-Phrase Group. The experimental discourses that were presented to the Bare Cardinal Group are shown below:

1. **A)** Τέσσερα αεροπλάνα ήταν στον ουρανό. Τρία (άλλα / από αυτά / Ø) προσγειώθηκαν.
   
   **B & C)** Four airplanes were in the sky. Three (others / of them / Ø) landed.

2. **A)** Τέσσερις λαγοί πήγαν στο δάσος. Δύο (άλλοι / από αυτούς / Ø) βρήκαν από ένα καρότο.
   
   **B)** Four rabbits went to the forest. Two (others / of them / Ø) found from one carrot.
   
   **C)** Four rabbits went to the forest. Two (others / of them / Ø) found a carrot.

3. **A)** Τέσσερα άλογα ήταν στη φάρμα. Δύο (άλλα / από αυτά / Ø) έτρωγαν.
   
   **B & C)** Four horses were in the farm. Two (others / of them / Ø) were eating.

4. **A)** Τρία δελφίνια ήταν σε μία πισίνα. Δύο (άλλα / από αυτά / Ø) πηδήξαν για μία μπάλα.
   
   **B)** Three dolphins were in to one pool. Two (others / of them / Ø) jumped for one ball.
   
   **C)** Three dolphins were in the pool. Two (others / of them / Ø) jumped for a ball.
5.  A) Τέσσερις ελέφαντες περπάταγαν στο δάσος. Τρεις (άλλοι / από αυτούς / Ø) κουβάλαγαν από ένα άντρα.
    B) Four elephants were walking in the forest. Three (others / of them / Ø) were carrying from one man.
    C) Four elephants were walking in the forest. Three (others / of them / Ø) were carrying a man.

6.  A) Τέσσερις σκύλοι ήταν στον κήπο. Τρεις (άλλοι / από αυτούς / Ø) τρώγανε από ένα κόκαλο.
    B) Four dogs were in the garden. Three (others / of them / Ø) were eating from one bone.
    C) Four dogs were in the garden. Three (others / of them / Ø) were eating a bone.

7.  A) Τρία παιδιά πήγαιναν στο σχολείο. Δύο (άλλα / από αυτά / Ø) ήταν με το ποδήλατο τους.
    B) Three kids were going to the school. Two (others / of them / Ø) were with the bicycle them.
    C) Three kids were going to school. Two (others / of them / Ø) were with their bicycle.

8.  A) Τρεις άντρες ήταν στο ποτάμι. Δύο (άλλοι / από αυτούς / Ø) έπιασαν από ένα ψάρι.
    B) Three men were at the river. Two (others / of them / Ø) caught from one fish.
    C) Three men were at the river. Two (others / of them / Ø) caught a fish.
9. A) Τρία αγόρια ήταν στο πάρκο. Δύο (άλλα / από αυτά / Ø) έπαιζαν μπάσκετ.

B & C) Three boys were in the park. Two (others / of them / Ø) were playing basketball.

10. A) Τέσσερις πίθηκοι πήγαν στο δάσος. Τρεις (άλλοι / από αυτούς / Ø) έτρωγαν μια μπανάνα.

B) Four monkeys went to the forest. Three (others / of them / Ø) were eating from one banana

C) Four monkeys went to the forest. Three (others / of them / Ø) were eating a banana.

11. A) Τρεις γάτοι ήταν σε ένα τοίχο. Δύο (άλλοι / από αυτούς / Ø) έπιασαν από ένα ποντίκι.

B) Three cats were on one wall. Two (others / of them / Ø) caught from one mouse.

C) Three cats were on a wall. Two (others / of them / Ø) caught a mouse.

12. A) Τέσσερα πουλιά κάθονταν πάνω σε ένα κλαδί. Δύο (άλλα / από αυτά / Ø) έτρωγαν από ένα σκουλήκι.

B) Four birds were sitting on to one branch. Two (others / of them / Ø) were eating from one worm.

C) Four birds were sitting on a branch. Two (others / of them / Ø) were eating a worm.
13. A) Τέσσερις αστυνόμοι ήταν έξω από μία τράπεζα. Δύο (άλλοι / από αυτούς / Ø) ήταν πάνω σε μία μοτοσυκλέτα.

B) Four policemen were outside from one bank. Two (others / of them / Ø) were on to one bike.

C) Four policemen were outside a bank. Two (others / of them / Ø) were on a bike.

14. A) Τέσσερα παιδιά ήταν στη παραλία. Δύο (άλλα / από αυτά / Ø) έχτισαν από ένα κάστρο στην άμμο.

B) Four kids were at the beach. Two (others / of them / Ø) build from one castle in the sand.

C) Four kids were at the beach. Two (others / of them / Ø) build a sand-castle.

15. A) Τέσσερα αυτοκίνητα ήταν στον αγώνα. Δύο (άλλα / από αυτά / Ø) τράκαραν.

B & C) Four cars were in the race. Two (others / of them / Ø) crushed.
APPENDIX 4:

Materials for Experiment 2

Filler Items

1.  A) Τέσσερα αγόρια πήγαν σινεμά. Τρία κορίτσια έτρωγαν ποπκόρν.

   B & C) Four boys went to the cinema. Three girls were eating pop-corn.
2. A) Τέσσερα κορίτσια πήγαν στη βιβλιοθήκη. Τρία αγόρια διάβαζαν από ένα βιβλίο.

B) Four girls went to the library. Three boys were reading from one book.

C) Four girls went to the library. Three boys were reading a book.
3. A) Τρία γουρούνια ἐπαιζαν στη λάσπη. Δύο κότες ἠτρωγαν.

   B & C) Three pigs were playing in the mud. Two chickens were eating.
4. A) Τρεις γυναίκες κολυμπούσαν στη θάλασσα. Δυο άντρες έκαναν ηλιοθεραπεία.

B & C) Three women were swimming at the sea. Two men were sun tanning.
5. A) Τέσσερα ελάφια ήταν στο δάσος. Δύο λιοντάρια ξεκουράζονταν.

B & C) Four deer were in the forest. Two lions were resting.
Experimental Items

1. A) Τέσσερα αεροπλάνα ήταν στον ουρανό. Τρία (άλλα / από τα / Ø) αεροπλάνα προσγειώθηκαν.

B & C) Four airplanes were in the sky. Three (other / of the / Ø) airplanes landed.
2. A) Τέσσερις λαγοί πήγαν στο δάσος. Δύο (άλλοι λαγοί / από τους λαγούς / λαγοί) βρήκαν από ένα καρότο.

B) Four rabbits went to the forest. Two (other / of the / Ø) rabbits found from one carrot.

C) Four rabbits went to the forest. Two (other / of the / Ø) rabbits found a carrot.
3. A) Τέσσερα άλογα ήταν στη φάρμα. Δύο (άλλα / από τα / Ø) άλογα έτρωγαν.

B & C) Four horses were in the farm. Two (other / of the / Ø) horses were eating.
4. A) Τρία δελφίνια ήταν σε μία πισίνα. Δύο (άλλα / από τα / Ø) δελφίνια πήδηξαν για μία μπάλα.

B) Three dolphins were in to one pool. Two (other / of the / Ø) dolphins jumped for one ball.

C) Three dolphins were in the pool. Two (other / of the / Ø) dolphins jumped for a ball.
A) Τέσσερις ελέφαντες περπάταγαν στο δάσος. Τρεις (άλλοι / από τους / Ø) ελέφαντες κουβάλαγαν από ένα άντρα.

B) Four elephants were walking in the forest. Three (other / of the / Ø) elephants were carrying from one man.

C) Four elephants were walking in the forest. Three (other / of the / Ø) elephants were carrying a man.
6. A) Τέσσερις σκύλοι ήταν στον κήπο. Τρεις (άλλοι σκύλοι / από τους σκύλους / σκύλοι) τρώγανε από ένα κόκαλο.

B) Four dogs were in the garden. Three (other / of the / Ø) dogs were eating from one bone.

C) Four dogs were in the garden. Three (other / of the / Ø) dogs were eating a bone.
7. A) Τρία παιδιά πήγαιναν στο σχολείο. Δύο (άλλα / από τα / Ø) παιδιά ήταν με το ποδήλατο τους.

B) Three kids were going to the school. Two (other / of the / Ø) kids were with the bicycle them.

C) Three kids were going to school. Two (other / of the / Ø) kids were with their bicycle.
8.  
A) Τρεις άντρες ήταν στο ποτάμι. Δύο (άλλοι / από τους / Ø) άντρες έπιασαν από ένα ψάρι.
B) Three men were at the river. Two (other / of the / Ø) men caught from one fish.
C) Three men were at the river. Two (other / of the / Ø) men caught a fish.
9. (a) Τρία αγόρια ήταν στο πάρκο. Δύο (άλλα / από τα / Ø) αγόρια έπαιζαν μπάσκετ.

B & C) Three boys were in the park. Two (other / of the / Ø) boys were playing basketball.
10. **A)** Τέσσερις πίθηκοι πήγαν στο δάσος. Τρεις (άλλοι πίθηκοι / από τους πίθηκους / πίθηκοι) έτρωγαν μια μπανάνα.

**B)** Four monkeys went to the forest. Three (other / of the / Ø) monkeys were eating from one banana.

**C)** Four monkeys went to the forest. Three (other / of the / Ø) monkeys were eating a banana.
11. A) Τρεις γάτοι ήταν σε ένα τοίχο. Δύο (άλλοι γάτοι / από τους γάτους / γάτοι) έπιασαν από ένα ποντίκι.

B) Three cats were on one wall. Two (other / of the / Ø) cats caught from one mouse.

C) Three cats were on a wall. Two (other / of the / Ø) cats caught a mouse.
12.  
A) Τέσσερα πουλιά κάθονταν πάνω σε ένα κλαδί. Δύο (άλλα / από τα / Ø) πουλιά έτρωγαν από ένα σκουλήκι.

B) Four birds were sitting on to one branch. Two (other / of the / Ø) birds were eating from one worm.

C) Four birds were sitting on a branch. Two (other / of the / Ø) birds were eating a worm.
13. A) Τέσσερις αστυνόμοι ήταν έξω από μία τράπεζα. Δύο (άλλοι αστυνόμοι / από τους αστυνόμους / αστυνόμοι) ήταν πάνω σε μία μοτοσυκλέτα.

B) Four policemen were outside from one bank. Two (other / of the / Ø) policemen were on to one bike.

C) Four policemen were outside a bank. Two (other / of the / Ø) policemen were on a bike.

 Subset Picture

 New-set Picture

 Distracting (Subset) Picture

 Distracting (New-Set) Picture
14. A) Τέσσερα παιδιά ήταν στη παραλία. Δύο (άλλα / από τα / Ø) παιδιά έχτισαν από ένα κάστρο στην άμμο.

B) Four kids were at the beach. Two (other / of the / Ø) kids build from one castle in the sand.

C) Four kids were at the beach. Two (other / of the / Ø) kids build a sand-castle.
15. Α) Τέσσερα αυτοκίνητα ήταν στον αγώνα. Δύο (άλλα / από τα / Ø) αυτοκίνητα τράκαραν.

B & C) Four cars were in the race. Two (other / of the / Ø) cars crushed.
Note that the filler item illustrated in (5) was not presented to the children who participated in Experiment 6.

Filler Items

1. A) Τέσσερα αγόρια πήγαν σινεμά. Τρία κορίτσια έτρωγαν ποπκόρν.

   B & C) Four boys went to the cinema. Three girls were eating pop-corn.
2. A) Τέσσερα κορίτσια πήγαν στη βιβλιοθήκη. Τρία αγόρια διάβαζαν από ένα βιβλίο.

B) Four girls went to the library. Three boys were reading from one book.

C) Four girls went to the library. Three boys were reading a book.
3. A) Τρία γουρούνια έπαιζαν στη λάσπη. Δύο κότες έτρωγαν.

   B & C) Three pigs were playing in the mud. Two chickens were eating.
4. A) Τρεις γυναίκες κολυμπούσαν στη θάλασσα. Δυο άντρες έκαναν ηλιοθεραπεία.

   B & C) Three women were swimming at the sea. Two men were sun tanning.
5. A) Τέσσερα ελάφια ήταν στο δάσος. Δύο λιοντάρια ξεκουράζονταν.

B & C) Four deer were in the forest. Two lions were resting.
APPENDIX 6:

Experimental Discourses for Experiments 3, 5, 6, & 7

Note that the materials shown in (13) - (15) were not presented to participants of Experiment 6.

1. A) Τέσσερα άλογα ήταν στη φάρμα. Δύο (άλλα / από τα / Ø) άλογα έτρωγαν.

   B & C) Four horses were in the farm. Two (other / of the / Ø) horses were eating.

(a)  (b) Subet Picture New-Set Picture

(c) Non-Integrative Picture
2. A) Τέσσερις λαγοί πήγαν στο δάσος. Δύο (άλλοι λαγοί / από τους λαγούς / λαγοί) βρήκαν από ένα καρότο.

B) Four rabbits went to the forest. Two (other / of the / Ø) rabbits found from one carrot.

C) Four rabbits went to the forest. Two (other / of the / Ø) rabbits found a carrot.
3. A) Τέσσερις σκύλοι ήταν στον κήπο. Τρεις (άλλοι σκύλοι / από τους σκύλους / σκύλοι) βρήκαν από ένα κόκαλο.
B) Four dogs were in the garden. Three (other / of the / Ø) dogs found from one bone.
C) Four dogs were in the garden. Three (other / of the / Ø) dogs found a bone.
4. A) Τρία παιδιά ήταν στο σχολείο. Δύο (άλλα / από τα / Ø) παιδιά ήταν με τη σανίδα τους.

B) Three kids were at the school. Two (other / of the / Ø) kids were with the skateboard them.

C) Three kids were at school. Two (other / of the / Ø) kids were with their skateboard.
5. A) Τρεις άντρες ψάρευαν στο ποτάμι. Δύο (άλλοι / από τους / Ø) άντρες έπιασαν από ένα ψάρι.

B) Three men were fishing at the river. Two (other / of the / Ø) men caught from one fish.

C) Three men were fishing at the river. Two (other / of the / Ø) men caught a fish.
6. A) Τέσσερις πίθηκοι κρέμονταν από ένα δέντρο. Τρεις (άλλοι πίθηκοι / από τους πίθηκους / πίθηκοι) έτρωγαν από μια μπανάνα.

B) Four monkeys went hanging from one tree. Three (other / of the / Ø) monkeys were eating from one banana.

C) Four monkeys went hanging from a tree. Three (other / of the / Ø) monkeys were eating a banana.
7. A) Τρεις γάτοι ήταν σε ένα τοίχο. Δύο (άλλοι γάτοι / από τους γάτους / γάτοι) έπιασαν από ένα ποντίκι.

B) Three cats were on one wall. Two (other / of the / Ø) cats caught from one mouse.

C) Three cats were on a wall. Two (other / of the / Ø) cats caught a mouse.
8.  
A) Τέσσερα πουλιά κάθονταν πάνω σε ένα κλαδί. Δύο (άλλα / από τα / Ø) πουλιά έτρωγαν από ένα σκουλήκι.

B) Four birds were sitting on to one branch. Two (other / of the / Ø) birds were eating from one worm.

C) Four birds were sitting on a branch. Two (other / of the / Ø) birds were eating a worm.
9. A) Τρεις καμηλοπαρδάλεις ήταν στο ζωολογικό κήπο. Δυο (άλλες / από τις / Ø) καμηλοπαρδάλεις έτρωγαν από ένα δέντρο.

B) Three giraffes were in the zoo. Two (other / of the / Ø) giraffes were eating from one tree.

C) Three giraffes were in the zoo. Two (other / of the / Ø) giraffes were eating a tree.
10. A) Τέσσερις σκίουροι ήταν στο δάσος. Τρεις (άλλοι σκίουροι / από τους σκίουρους / σκίουροι) έτρωγαν.

B & C) Four squirrels were in the forest. Three (other / of the / Ø) squirrels were eating.
11. A) Τέσσερα καγκουρό έπαιζαν στο δάσος. Δύο (άλλα / από τα / Ø) καγκουρό κουβάλαγαν τα µωρά τους.

   B) Four kangaroo were playing in the forest. Two (other / of the / Ø) kangaroo were carrying the baby them.

   C) Four kangaroo were playing in the forest. Two (other / of the / Ø) kangaroo were carrying their babies.
Α) Τέσσερις πιγκουίνοι ήταν πάνω στα βράχια. Τρεις (άλλοι πιγκουίνοι / από τους πιγκουίνους / πιγκουίνοι) ξάπλωναν.

B & C) Four penguins were on the rocks. Three (other / of the / Ø) penguins were lying down.
13. A) Τρία παιδιά ήταν στη πισίνα. Δύο (άλλα / από τα / Ø) παιδιά έπαιζαν με μία μπάλα.

B) Three kids were in the swimming-pool. Two (other / of the / Ø) kids were playing with one ball.

C) Three kids were in the swimming-pool. Two (other / of the / Ø) kids were playing with a ball.
B) Four dolphins were in the pool. Two (other / of the / Ø) dolphins were playing with one starfish.
C) Four dolphins were in the pool. Two (other / of the / Ø) dolphins were playing with a starfish.
15.  A) Τέσσερις ελέφαντες ήταν στο δάσος. Τρεις (άλλοι / από τους / Ø) ελέφαντες κουβάλαγαν από ένα άντρα.

B) Four elephants were in the forest. Three (other / of the / Ø) elephants were carrying from one man.

C) Four elephants were in the forest. Three (other / of the / Ø) elephants were carrying a man.
1. A) Πολλά άλογα ήταν στη φάρμα. Δύο (άλλα / από τα / Ø) άλογα έτρωγαν.

   B & C) Many horses were in the farm. Two (other / of the / Ø) horses were eating.
2. A) Πολλοί λαγοί πήγαν στο δάσος. Δύο (άλλοι λαγοί / από τους λαγούς / λαγοί) βρήκαν από ένα καρότο.

B) Many rabbits went to the forest. Two (other / of the / Ø) rabbits found from one carrot.

C) Many rabbits went to the forest. Two (other / of the / Ø) rabbits found a carrot.
3. A) Πολλά παιδιά ήταν στο σχολείο. Δύο (άλλα / από τα / Ø) παιδιά ήταν με τη σανίδα τους.

B) Many kids were at the school. Two (other / of the / Ø) kids were with the skateboard them.

C) Many kids were at school. Two (other / of the / Ø) kids were with their skateboard.
4. A) Πολλοί σκίουροι ήταν στο δάσος. Τρεις (άλλοι σκίουροι / από τους σκίουρους / σκίουροι) έτρωγαν.

B & C) Many squirrels were in the forest. Three (other / of the / Ø) squirrels were eating.
5.  

A) Πολλά δελφίνια ήταν στην πισίνα. Δύο (άλλα / από τα / Ø) δελφίνια ἐπαιζαν με ένα αστερία.

B) Many dolphins were in the pool. Two (other / of the / Ø) dolphins were playing with one starfish.

C) Many dolphins were in the pool. Two (other / of the / Ø) dolphins were playing with a starfish.
6. A) Μία ομάδα από σκύλους ήταν στον κήπο. Τρεις (άλλοι σκύλοι / από τους σκύλους / σκύλοι) βρήκαν από ένα κόκαλο.

B) A group of dogs was in the garden. Three (other / of the / Ø) dogs found from one bone.

C) A group of dogs was in the garden. Three (other / of the / Ø) dogs found a bone.
7. A) Μία ομάδα από πουλιά κάθονταν πάνω σε ένα κλαδί. Δύο (άλλα / από τα / Ø) πουλιά έτρωγαν από ένα σκουλήκι.

B) A group of birds was sitting on to one branch. Two (other / of the / Ø) birds were eating from one worm.

C) A group of birds was sitting on a branch. Two (other / of the / Ø) birds were eating a worm.
8. A) Μία ομάδα από καμηλοπαρδάλεις ήταν στο ζωολογικό κήπο. Δυο (άλλες / από τις / Ø) καμηλοπαρδάλεις έτρωγαν από ένα δέντρο.

B) A group of giraffes was in the zoo. Two (other / of the / Ø) giraffes were eating from one tree.

C) A group of giraffes was in the zoo. Two (other / of the / Ø) giraffes were eating a tree.
9. A) Μία ομάδα από παιδιά ήταν στη πισίνα. Δύο (άλλα / από τα / Ø) παιδιά ἐπαιζαν με μία μπάλα.

B) A group of kids was in the swimming-pool. Two (other / of the / Ø) kids were playing with one ball.

C) A group of kids was in the swimming-pool. Two (other / of the / Ø) kids were playing with a ball.
10. A) Μία ομάδα από ελέφαντες ήταν στο δάσος. Τρεις (άλλοι / από τους / Ø) ελέφαντες κουβάλαγαν από ένα άντρα.

B) Some elephants were in the forest. Three (other / of the / Ø) elephants were carrying from one man.

C) Some elephants were in the forest. Three (other / of the / Ø) elephants were carrying a man.
A) Μερικοί άντρες ψάρευαν στο ποτάμι. Δύο (άλλοι / από τους / Ø) άντρες έπιασαν από ένα ψάρι.

B) Some men were fishing at the river. Two (other / of the / Ø) men caught from one fish.

C) Some men were fishing at the river. Two (other / of the / Ø) men caught a fish.
12. A) Μερικοί πίθηκοι κρέμονταν από ένα δέντρο. Τρεις (άλλοι πίθηκοι / από τους πίθηκους / πίθηκοι) έτρωγαν από μια μπανάνα.

B) Some monkeys went hanging from one tree. Three (other / of the / Ø) monkeys were eating from one banana.

C) Some monkeys went hanging from a tree. Three (other / of the / Ø) monkeys were eating a banana.

(a) Subset Picture
(b) New-Set Picture
(c) Non-Integrative Picture
13.  A) Μερικοί γάτοι ήταν σε ένα τοίχο. Δύο (άλλοι γάτοι / από τους γάτους / γάτοι) έπιασαν από ένα ποντίκι.

B) Some cats were on one wall. Two (other / of the / Ø) cats caught from one mouse.

C) Some cats were on a wall. Two (other / of the / Ø) cats caught a mouse.
14. A) Μερικά καγκουρό έπαιζαν στο δάσος. Δύο (άλλα / από τα / Ø) καγκουρό κουβάλαγαν τα µωρά τους.

B) Some kangaroo were playing in the forest. Two (other / of the / Ø) kangaroo were carrying the baby them.

C) Some kangaroo were playing in the forest. Two (other / of the / Ø) kangaroo were carrying their babies.
15. A) Μερικοί πιγκουίνοι ήταν πάνω στα βράχια. Τρεις (άλλοι πιγκουίνοι / από τους πιγκουίνους / πιγκουίνοι) ξάπλωναν.

B & C) Some penguins were on the rocks. Three (other / of the / Ø) penguins were lying down.
References


