Background

Natural language quantifiers are verbal expressions which are used to describe quantities. For example, the expression *many* in *many of the children laughed* describes a quantity of children. Such quantifiers vary with respect to the quantities which they convey, but also with respect to polarity. That is, while *a few* and *few* convey similarly small quantities, *a few* is positive and *few* is negative. Arguably, this second function of quantifiers has a bigger impact on our understanding of a situation than does the quantity conveyed. Compare (1) and (2) for example:

(1) Sadly, a few of the passengers died. They will be mourned by relatives.
(2) Thankfully, few of the passengers died. They thanked the pilot for his immense skill.

Although approximately the same numbers of passengers die in each case, (2) nevertheless constitutes good news (*thankfully*) because readers are focussed on the people who did not die. We have called this set the complement set, which is then available for pronominal reference using *they* in the example. *They* in (1) refers to what we have called the reference set (of dead passengers).

Since pronouns normally refer to entities which have been explicitly mentioned in the text, the pronominal reference in (2) is puzzling, and Presupposition-denial theory has been proposed as a possible explanation. Briefly, this theory suggests that negative quantifiers such as *few* simultaneously describe a quantity while denying a larger (presupposed) quantity. That is, *few* in (2) describes a small number, but implies that a larger number might have been the case, but is denied. The difference between what *is* and what *might have been* creates a shortfall set, for example, of passengers who might have died but did not. Readers tend to focus on this shortfall set, which leads to complement set reference.

Previous research has provided some evidence in support of this explanation (Moxey, 2006). Normally, positive quantifiers such as *a few* would not lead to complement set reference. However if this quantifier is used in a context where readers are focussed on the expectation of a large quantity (such as *all*), the shortfall between the high expectation and the small quantity conveyed by *a few* will be highly salient.

According to Presupposition-denial theory, some readers may focus on the complement set when *a few* is used in such a context, because focus is on a shortfall. Moxey (2006) found that when positive quantifiers such as *a few* are used to describe a small quantity in a context where a character expects a large quantity (*all*) this does indeed lead to some complement set references (as in (3)). If there is a shortfall, complement set reference is thus possible after a positive quantifier.

(3) Mr. Smith expected that all of his guests would finish the meal. A few of them ate it all. They____ had eaten too much earlier on.
(4) Mr. Smith expected that none of his guests would finish the meal. Few of them ate it all. They____ were proud of their empty plates.

Further, when negative quantifiers such as *few* were used in the context of an explicitly mentioned character expecting *none* participants were more likely than otherwise to use a plural pronoun to refer to the reference set, (as in (4)). Although *few* implies that a higher
quantity is denied (there is a shortfall), the quantity conveyed by few is higher than the none expected by the character, creating a surplus. Readers who focus on this surplus (of people who were not expected to eat, but did) will refer to the reference set.

This evidence for Presupposition-denial theory is limited because it is based on a constrained sentence continuation task in which participants were asked to complete sentences such as (3) and (4) after they. As participants read (3) they may have various sets represented in their model of the sentence. On encountering the plural pronoun, they may search for a particularly salient set and then try to think of something to say about it. In normal reading readers do not necessarily resolve the plural pronoun before they have processed what follows. That is, readers do not necessarily stop reading at they in order to work out who they is before continuing with the sentence. While the continuation task allows us to assess preferences with respect to the referent of they, eye-tracking experiments allow us to assess relative difficulty in interpretation during normal reading. By presenting text where the plural pronoun refers either to the reference set or the complement set, and observing eye movements and eye fixation durations we can determine how accessible each of these sets are in various contexts. Our first series of experiments uses eye movement monitoring techniques to examine the reading of quantifiers in the context of high versus low character expectations such as those manipulated in the Moxey (2006) studies.

According to Presupposition-denial theory, negative quantifiers imply that a larger amount is denied. However the amount denied by the quantifier need not be someone’s expectation, but may be unspecified, simply implying that the quantity is less than some possible quantity. If this theory is correct, an explicitly stated character desire may interact with the implication of the quantifier in the same way as character expectation has in previous studies. That is, replacing expected that with hoped that or wanted in (3) and (4) should yield similar results. Our second series of experiments examined both preferred continuations and on-line comprehension of quantified statements in the context of high versus low character desires.

All of the studies mentioned so far have examined the effects of expectation or desire on the normal focus patterns associated with a quantifier. However in every case the expectation or desire is attached to a mentioned character (Mr. Smith in examples (3) and (4)). In such a case the relationship between expectation/desire and quantity is hard to ignore. However according to Presupposition-denial theory a negative quantifier implies that a larger presupposed quantity is not the case whether or not there is a salient character with expectations/desires. It might therefore be supposed that the reader’s own expectations/desires regarding a quantity will also interact with the quantifier in determining focus. For example, there may be a difference in focus patterns following (5) and (6):

(5) Few of the parents hated their children.
(6) Few of the parents loved their children.

Existing evidence suggests that few will be interpreted as a greater quantity in (6) than in (5), because we expect more parents to love their children than to hate them (Moxey & Sanford, 1993). However, we now hypothesise that readers of (5) will be less likely to place the complement set (parents who don’t hate their children) in focus, compared to
readers of (6) where the complement set is parents who don’t love their children. According to Presupposition-denial theory, the reader’s high expectation in (6) together with the low quantity conveyed by few creates a shortfall, as does the implication from the negative quantifier few that a larger quantity is denied. We therefore expect complement set references after (6). However the reader’s low expectation in (5) together with the quantity conveyed by few may lead to a surplus (few may be more than expected). The existence of such a surplus clashes with the implication of few that a larger quantity is denied, and this may reduce focus on the shortfall, and the complement set. Our final series of experiments aimed to examine the effects of such implicit expectations on the focus patterns associated with quantifiers.

**Objectives**
The following objectives from our original proposal have been met by the experiments indicated:

1. To test specific predictions made by Presupposition-denial theory (Experiments 1-12).
2. To demonstrate that the focusing patterns associated with certain natural language quantifiers can be influenced by introducing explicit expectations about quantity (Experiments 1-4).
3. To examine whether these focusing patterns can be affected by participants’ own expectations about quantity given their implicit knowledge of the world (Experiments 8-10).
4. To investigate whether manipulating the desire for a certain quantity can influence focusing patterns (Experiments 5-7).
5. To demonstrate that it is focus on the shortfall between expectation/desire for a certain quantity and reality that leads to the observed focusing pattern (Experiments 1-10).
6. To use eye movement monitoring techniques to assess how readers react to and recover from violations of the focusing preferences created by these expectations and desires (Experiments 1-4, 6, 7, & 10).

**Methods**
We used two basic methods: a sentence continuation task and analysis of eye movements while reading.

Experiments 5, 8, 9, 11, and 12 used a sentence continuation paradigm. Participants were presented with one material to complete. In all cases participants read a quantified statement (sometimes preceded by a previous sentence), followed by a plural pronoun. Their task was to complete the sentence after they. At least two independent judges read and categorized each continuation according to the referent of the plural pronoun and in some cases also according to the content of the continuation. Disagreements between judges were extremely rare, but in all cases such continuations were placed in the ‘other’ category. Hierarchical log linear models were used to analyse the data as these can determine the significance of the differences between factors without relying on parametric assumptions or linear independence of the factor levels.

Experiments 1-4, 6, 7, and 10 were eye-tracking studies either using a Dual Purkinje Image eye-tracker or an SR Research Eyelink 2000 eye-tracker. Both of these trackers have high spatial and temporal resolution. Participants were set up on the eye-
trackers, and adequate calibration checks were carried out. Materials were divided into appropriate analysis regions and we computed several standard measurements for each region:

First-pass times (the time spent within a region before exiting the region to left or right),

Regressions in (the frequency of eye movements returning to the region from a subsequent region),

Regressions out (the frequency of eye movements exiting the region to the left to return to an earlier region),

Regression path times (the time from first visiting this region until the first exit to the right),

and total times for each region (total time spent within a particular region).

Data from the eye-tracking studies has been lodged with UKDA. Statistical analyses of eye movement data were based on ANOVA.

Results

Series 1: Four on-line studies of explicit expectation/quantifier.
Participants’ eye movements were recorded as they read passages describing the expectations of a character regarding a quantity, followed by a quantified statement, and ending with a plural pronominal reference to the reference set or the complement set (see (7)). All experiments had two expectation conditions (the character expecting all versus none). The quantifiers varied between experiments: Experiment 1 (a small number versus a large number); Experiment 2 (a few versus few); Experiment 3 (not quite all).

(7) /The teacher expected {all none} of the students to hand in good essays./1 A {small large} number of them produced well-written results. /2 Their {clarity confusion}/3 demonstrated how well they understood the topic/4

* / indicates regions of text used for analysis

The results suggested that when a positive quantifier is used and the character expects all (in other words when there is a shortfall) readers experience some difficulty. This was apparent from the total times for reading the quantifier region in Experiment 1, and the regressions into the expectation region when a few followed expected all in Experiment 2. Continuations with pronominal reference to the complement set are also less awkward when the character has expected all (when there is a shortfall). For example, Figure 1 shows the regression path times for the plural pronoun region in Experiment 3. These findings are consistent with the Presupposition-denial account, suggesting that differences between quantities described and quantities expected can lead to a shortfall, which is then more salient in subsequent text. Furthermore, the eye movement evidence suggests that inferences about the shortfall are made as we read about the characters’ expectations and process the quantified statements.

Figure 1 - Regression path times for the plural pronoun region in Experiment 3.
Experiment 4 was not included in our original proposal but was carried out in order to
discover whether it was necessary to include an explicit character to create a shortfall. We manipulated expectation by contrasting few with unexpectedly, few. The expectation was therefore just as salient as in Experiments 1-3, but was not attached to a character. First, we performed a pilot study to establish that unexpectedly, few was indeed interpreted as meaning that the quantity was unexpectedly small. In the main experiment participants read materials such as (8).

(8) Local MPs were invited to take part in a public inquiry about proposals to build a nuclear power station. /1 {Unexpectedly,} few of the MPs attended the meeting. /2 Their {presence absence} /3 helped the meeting run smoothly./4

Results suggested that initial processing of reference set continuations was difficult following unexpectedly, few. That is, when the quantifier and the expectation information point to a shortfall, it is more difficult to refer pronominally to the reference set. Thus, explicitly mentioned expectations influence the inferences readers make even when those expectations are not attached to a character.

**Series 2 – 3: Experiments on explicit desire.**

In Experiment 5 each participant was presented with a short text to read and asked to continue a sentence beginning with they (see (9) below). Rather than carry out separate studies for different quantifier pairs, we used a between participants design and incorporated four quantifiers (a few, few, nearly all, not quite all) in a single larger study. There were two levels of desire, (all versus none), yielding eight experimental conditions.
(9) John hoped that all /none of the guests would finish the meal. [Nearly all/Not quite all/A few/Few] of them ate it all. They…

Continuations were placed in the following categories:
1. Pronoun refers to the reference set (those who finished their meal in the example).
2. Pronoun refers to the complement set (those who did not finish their meal).
3. Pronoun refers to the set generally (of guests).
4. Other – pronoun refers to something else.

Each continuation was also categorised for content type, for example, the continuation may provide a reason for the predicate (a reason for finishing the meal) or a ‘reason-why-not’ (a reason for not finishing).

Each continuation was placed in one category from 1-4 and one content category. This second set of categories was included in the study as previous studies of complement set focus have noted a strong correlation between complement set focus and the ‘reason-why-not’ category, since reasons-why-not are essentially reasons for the shortfall.

The results suggest that the effects of a character’s desire are similar to those of a character’s expectations. Specifically the desire for all can create a shortfall when the quantity described is small, leading to more complement set continuations and correspondingly fewer reference set continuations (see a few/hoped all in Figure 2); on the contrary the desire for none can create a surplus, leading to more reference set continuations and fewer complement set continuations (compare hoped all with hoped none for the negative quantifiers in the figure). As with previous studies positive quantifiers nearly all and a few led to many more reference set continuations (although this bias was reduced after a few when the character hoped for all). Negative quantifiers not quite all and few led to mainly complement set focus although in both cases this bias was reduced when the character hoped for none. The analysis of the content of continuations also produced results consistent with our expectations.

Figure 2 – Frequency of reference set and complement set continuations in Experiment 5
Results from Experiments 6 and 7 show that the inference patterns associated with character desire and quantifier happen during the course of normal reading. In Experiment 6 we compared on-line comprehension of plural pronouns following *a few* and *few* in the context of high versus low character desire; in Experiment 7 we compared high versus low character desire with *not quite all*. The following is an example material from Experiment 6:

(10) John hoped that *{all none}* of the guests would finish their meal.1 *{A few Few}* of them ate it all.2 Their *{greediness restraint}* /3 was reflected in their waistlines.4

We did not include *nearly all* in these eye-tracking experiments as this quantifier always led to reference set continuations in the production study. The results are again consistent with Presupposition-denial theory. There is evidence of relative difficulty in processing when the character has a desire for *none* and this is followed by a negative quantifier (when the quantifier suggests a shortfall). Also, initial processing for the final region (after the pronoun) takes longer for *a few* when the character has wanted *all*, (when the character’s desire suggests a shortfall (see Figure 3)).

Figure 3 – First-pass reading times for the final region in Experiment 6.
Series 3: Implicit expectation/desire.

This series of experiments was designed to show the impact of a reader/writer’s own expectations on quantifier based inferences. We will report two sets of studies. The first consisted of two sentence continuation experiments, and one eye-tracking study manipulating expectations based on world knowledge. The second consisted of two further continuation studies using a slightly different manipulation of expectations.

Series 3A. In Experiment 8 participants were presented with low versus high expectation materials (such as (11) and (12)). Materials were matched for desirability (participants would want half of the quantities to be high and half to be low in each expectation condition):

(11) A few/few of the sweets are good for your health. They__
(12) A few/few of the cakes are fattening. They___

Continuations were placed in categories similar to those used for Experiment 5. It was found that focus after a few was unaffected by expectation. However, while few led to the normal bias towards complement set references (61%), this amount was significantly reduced (to 52%) when the reader expects a low amount. These results only partially support our hypothesis that implicit expectations will influence focus patterns.

One possible explanation was that the contextual manipulation of expectation on its own was too weak. Remember that in each expectation condition we had high and low desirable amounts. We therefore decided to use a stronger manipulation in Experiment 9 manipulating both desire and expectation such that high expectation materials were always high desire, while low expectation materials were always low desire (see (13) and (14)). In Experiment 9 we also included three sets of quantifiers (a
few, few, nearly all, not quite all, many, not many) in one large study so that we could generalize beyond a few and few.

Participants in Experiment 9 were presented with one sentence such as (13) or (14):

(13) Many parents physically abuse their children. They___
(14) Many drivers put their lights on when it gets dark. They___

Continuations were placed in similar categories to those used in previous studies. As Figure 4 shows, positive quantifiers led to reference set continuations regardless of the context, just as in Experiment 8. All of the negative quantifiers show a bias towards complement set continuations regardless of expectations, but notice that for few there are significantly fewer complement set continuations when readers both expect and desire a low quantity. As in Experiment 8, low implicit expectations detract from the implication of few that more was expected and this reduces focus on the shortfall.

Figure 4 – Frequency of complement and reference sets in Experiment 9.

While it is clear that the implicit expectations/desires manipulated in Experiment 9 have no influence on focus patterns after most quantifiers, it is important to assess whether their influence on the processing of statements containing few occurs as we read the text. In Experiment 10 we compared participants’ eye movements while reading materials containing few with those containing not many. Not many serves as a control negative quantifier since (based on Experiment 9) we do not predict any differences in the processing of this expression depending on the expectation or desire. In Experiment 10 participants read high versus low expectation/desire materials such as (14). The plural pronominal reference was always to the complement set.
Global AIDs figures are regularly reported in the news. The children in Britain are born with HIV. Their fortune is due to public awareness.

Education is a priority for the government. A few of the British children aged over 5 go to school. Their non-attendance will lead to policy changes.

The results of Experiment 10 suggest that few statements are generally harder to integrate with subsequent verb phrase information than not many statements. Readers look back at few more often and take longer to read the verb phrase overall compared to not many. This is consistent with the idea that readers are integrating expectation/desire information with their understanding of few. However there is also some support for the view that low implicit expectation is inconsistent with both negative quantifiers since the pronoun region (4) took longer to read following low expectation materials (see Figure 5).

Figure 5 – Total time taken to read the pronoun region in Experiment 10.

On one hand it seems that the function of few may be more context dependent than that of other quantifiers. On the other hand, Figure 5 shows that not many is also more awkward in the context of a low expected amount. Our manipulation of expectation in Experiment 10 may simply not be strong enough to influence the normal patterns of focus for strongly biased quantifiers. For example, while readers may expect and want the quantities to be low (or high) they may not consider that the writer’s expectations/desires are the same, or that they are relevant to the message. For this reason we designed series 3B experiments using materials which make low versus high expectations more salient, by including an initial sentence which makes the quantity relevant and which leads to the expectation before the quantifier is introduced.

Series 3B. In Experiment 11 participants read one item and wrote a continuation as with previous continuation experiments. There were 12 different versions of each basic material: half of them contained an initial sentence setting up a high expectation (e.g. 15); the other half contained a low expectation (e.g. 16). The second sentence began with one
of six quantifiers (nearly all, not quite all, many, not many, a few, few). Participants completed a third sentence after they:

(15) The students had put a lot of work into their essays. {Nearly all Not quite all A few Few} of them produced well-written results. They…
(16) The students hadn’t put much work into their coursework. {Nearly all Not quite all A few Few} of them produced well-written results. They…

The results show an effect of quantifier. Consistent with previous findings the positive quantifiers nearly all, a few and many led to a vast majority of reference set completions (247 compared to 15 complement sets). The negative quantifiers led to a majority of complement set completions (216 compared to 42 reference sets).

There was also a significant effect of expectation with the frequency of reference set completions far higher than that of complement sets in the high expectation category (161 versus 103 respectively), while the frequencies are identical when a low number is expected. This result is the opposite of that predicted.

On inspection of our materials, we noted that most of our initial context sentences in fact contained explanations, for example, in (15) the hard work is a reason for the well-written results; in (16) the lack of work is a reason for failure. Our intention was to set up an expectation of a high quantity in (15), and a low quantity in (16), but in fact these initial sentences may have a direct effect on focus. In previous studies (see Moxey & Sanford, 1993) the correlation between complement set reference and the provision of a ‘reason-why-not’ has often been noted. Perhaps giving a ‘reason-why-not’ in the initial sentence therefore places focus on the complement set directly rather than creating the expectation of a low amount.

Experiment 12 used initial context sentences to set up high versus low expectations without the provision of explanations. In this study we used materials such as (17) and (18) but with the quantifier few only (since we were interested in checking whether the replacement of an initial reason-why-not sentence with a non reason context sentence would reverse the effect for few observed in Experiment 11). Participants completed one sentence as before:

(17) The teacher was delighted with student performance. Few of them had produced well-written results. They
(18) The teacher was disappointed with student performance. Few of them had produced well-written results. They

Experiment 12 again found more complement set reference when the context suggests that a low number was expected. This is counter to our hypothesis, and appears inconsistent with results of studies where expectation is explicitly associated with a character, or indeed when the expectation is implicit in the reader’s background knowledge of the situation.

The results of Experiments 11 and 12 remain a puzzle, and a current topic of research for the PI.

Additional studies supported by this grant
In addition to the studies above there have been a number of related experiments carried out with the support of ESRC. We have run, and are currently analysing data from an
ERP study comparing brain activity for reference versus complement set continuations following positive and negative quantifiers. In addition Ruth Filik was awarded a small grant by the Experimental Psychology Society which examined the processing of positive and negative quantified statements in ironic and non-ironic contexts.

Activities

Presentations


**Outputs directly based on grant experiments:**


**Outputs supported by grant but not directly related to grant experiments:**


**Impacts**

From the papers and presentations noted above comments from researchers at national and international conferences have been very positive, and great interest has been shown in this work.

The idea that a shortfall can be created which can manipulate focus without the use of a quantifier has been the inspiration behind a PhD thesis (by Joanne Ingram). Her thesis also explores polarity in other areas, for example interpretations given to *half empty* versus *half full*. 
Ruth Filik has used the focusing properties of quantifiers as a means of investigating irony (supported by EPS).

**Future Research priorities**

This research has shown that the explicit expectations and desires of a salient character can weaken the normal focus patterns associated with quantifiers. The reader’s own desires and expectations regarding a quantity only weaken the complement set bias for the expression *few*. This suggests that in normal usage, when character expectations are not mentioned, negative quantifiers provide an important means of focusing readers on the complement (shortfall) set. This is important, because the manipulation is subtle, and because essentially this leads to the kinds of framing effects evident in the decision making literature. For example, the Asian disease problem, where preferences alter depending on whether the outcome is conveyed in terms of number of lives *saved* versus *lost*. Linda Moxey has submitted a proposal to ESRC aimed at discovering the extent to which framing effects can be explained by normal focus patterns which occur as we read. This research would contrast with the existing literature on framing effects which focuses on the different strategies adopted by participants faced with positive versus negative information (e.g. Prospect Theory, Kahneman & Tversky, 1979).

A second priority is the difference between *few* and *not many*. Previous research suggests that *few* implies that the writer expected more beforehand while *not many* implies that the writer assumes that the reader expected more beforehand (Moxey & Sanford, 1993). Here we found that the explicit expectations of a character can weaken the focusing function of both quantifiers. But *implicitly low expectations* only affect the focusing function of *few*. So the implication (from *few*) that the writer expected more is weakened when the quantity is generally expected to be low. The implication (from *not many*) that the reader is assumed to expect more however, is not weakened when the quantity is generally expected to be low. These differences between *few* and *not many* in terms of their implications regarding writer/reader/character expectations are interesting in their own right, and deserving of further investigation. We are currently working on possible theoretical underpinnings of these findings in our paper on the implicit expectation/desire results.

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i Experiment 8 was carried out as part of an MSc project conducted by Joanne Ingram under the supervision of Linda Moxey.

**References**
