Singular Interpretations Linger During the Processing of Plural Noun Phrases

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Abstract

Plural nouns do not strictly refer to more than one object, which suggests that they are not semantically marked to mean "more than one" and that plurality inferences are made via a scalar implicature. Consistent with that hypothesis, recent evidence using a picture-matching paradigm supports founds that participants were equally fast to respond to a picture of a single object as a picture of multiple objects after reading a sentence containing a plural. This suggests that comprehenders activate both a semantic (i.e., singular) and a pragmatic interpretation (i.e., plural). The current study found that even after a 1500 ms delay, comprehenders still maintain activation of both meanings after reading a sentence containing a plural. This suggests that the activation of the singular meaning may not be due to the processing of a scalar implicature, but rather may be due to the nature of plural conceptual representations.

Keywords: plurals; semantics; pragmatics; scalar implicature; language comprehension; conceptual representations

Introduction

There is a well-known puzzle regarding the interpretation of plural noun phrases. Consider the following set of examples.

1a) Ben fed a shark.
1b) Ben fed sharks.
1c) Ben fed more than one shark.

2a) Ben didn't feed a shark.
2b) Ben didn't feed sharks.
2c) Ben didn't feed more than one shark.

For most people, 1b & 1c are essentially the same in meaning, and distinct from 1a. However, in the negated cases, 2a and 2b are usually judged as equivalent and distinct from 2c (Sauerland et al., 2005; Tieu et al., 2014). This suggests that "more than one" is not always the appropriate interpretation of a plural noun phrase. Because of this pattern of interpretations, linguists have argued that the plural is semantically unmarked, or weakly marked, for number, while the singular is strongly marked for number.

If the plural is semantically unmarked (or weakly marked) for number, then linguistic theory must account for the fact that, in many contexts, most people interpret plural nouns to mean "more than one". One hypothesis is that when comprehending a plural, comprehenders make a kind of pragmatic inference known as a scalar implicature (e.g., Spector, 2007; Tieu et al, 2014). A scalar implicature is a type of inference that arises when a weak expression is used instead of a stronger expression. For example, a sentence like *Zoe ate some of the cookies* is typically interpreted as meaning Zoe ate some but not all of the cookies. However, logically that does not have to be the case. If Zoe ate all of the cookies, it is also true that she ate some of the cookies. Thus, the statement that Zoe ate some of the cookies does not logically rule out the possibility that Zoe in fact ate all of the cookies. Nevertheless, comprehenders seem to assume that speakers use the strongest labels that are compatible with their intended meaning and interpret the fact that a weaker expression was used to indicate that the stronger meaning was not appropriate (Grice, 1975). Thus, they assume that if a speaker intended to indicate that Zoe indeed ate all of the cookies, they would have used the quantifier *all* because that would be the strongest way to communicate that state of affairs. Applying this logic to plural noun phrases, a scalar implicature account assumes that the literal, semantically defined interpretation of the plural is something like "at least one" and an implicature must be made to arrive at the "more than one" interpretation. The logic of the implicature is as follows: a plural can refer to a single entity, but if the speaker intended to refer to only one entity they would have used a stronger form (i.e., the singular) to express that.

Using a truth-value judgment task (e.g., T/F: *Does a dog have tails?),* Tieu et al. (2014), provided evidence for a scalar implicature account of plurality. Tieu et al. found that both adults and children interpreted plural nouns as meaning "more than one" more often in positive contexts (or upward-entailing environments) than negative contexts (or downward-entailing environments). This is consistent with typical scalar implicature patterns (e.g., Chierchia, 2004; Levinson, 2000). Additionally, Tieu et al. found that children were less likely to compute plural inferences than adults, which is also consistent with previous work showing that children are typically less likely to compute scalar implicature inferences than adults (e.g., Noveck, 2001).

Recently, Patson (in press) provided experimental evidence that is consistent with the hypothesis that comprehenders compute a scalar implicature when comprehending a plural. Patson (in press) used a picture-matching paradigm designed to probe the conceptual representation of plural noun phrases (e.g., Patson, George, & Warren, 2014). Using this picture matching paradigm, Patson, George and Warren (2014) had participants read a sentence that contained either a singular noun (as in 3), a plural definite description (as in 4), or a two-quantified plural (as in 5).

3) The parent handed the child the *crayon*.
4) The parent handed the child the *crayons*.

5) The parent handed the child the *two crayons*.

After reading the sentence, participants pressed a button and then they saw a picture of exactly one object, exactly two objects, or multiple (3-6) objects. Participants were instructed to decide whether or not the picture was of an object(s) that was mentioned in the sentence. They were instructed and trained to ignore the number of objects and base their judgment on object identify alone. Patson et al. measured how quickly participants responded affirmatively to the picture. When number was explicit (e.g., singular NP, two-quantified NP), participants were faster to judge a picture when the number matched. For example, after reading a singular noun phrase participants were faster to accurately decide that the picture was of an object that was mentioned in the sentence when there was only one object pictured compared to when multiple objects were pictured. This finding is straightforward: When number information is made explicit comprehenders have a detailed conceptual representation that contains that number information. Interestingly, for the plural definite description conditions, there were no judgment time differences based on picture type. That is, participants did not show a preference for pictures that depicted more than one object compared to pictures that depicted a single object. Patson et al. interpreted this finding as consistent with the theory that plurality is semantically unmarked for number. That is, because number information is not semantically explicit in a plural noun phrase, comprehenders do not explicitly represent number information when building a conceptual representation of a plural noun phrase. Therefore, they showed no preference for pictures of multiple objects over pictures of a single object.

Patson (in press) followed up this work and suggested that the lack of preference for a picture depicting multiple objects compared to a picture depicting a single object is due to the computation of a scalar implicature. In Patson (in press) comprehenders read sentences that contained plural noun phrases. The sentences were written to evoke a particular spatial configuration for the plural set. For example, in the first experiment, the sentential context either described a spatial configuration where the individual items that comprised the plural were spread out (e.g., the wind scattered the leaves) or the items were gathered closely together (e.g., a pile of leaves). After reading the sentence, comprehenders were shown a picture that matched the spatial configuration, mismatched the configuration, or was a single object. Patson found that participants were faster to respond to a picture when it matched the spatial configuration implied in the sentence than when it did not (cf. Stanfield & Zwaan, 2001). Importantly, participants were also faster to respond to a picture of a single item than to a picture that mismatched the spatial configuration implied in the sentence. Patson interpreted the match finding as indicating that comprehenders do not leave number information conceptually unspecified for plural noun phrases. Instead, comprehenders interpret plural noun phrases as meaning "more than one" and create highly detailed conceptual representations that contain information about how the individual entities that make up the plural set are arranged. Furthermore, Patson argued that this interpretation came about via a scalar implicature. This argument was based on the finding that even though comprehenders created highly detailed conceptual representations, they had activated a singular representation as evidenced by the finding that participants were faster to respond to the picture of a single object than the picture that mismatched the sentential context. Patson argued that this pattern of findings could be explained by assuming that during comprehension both the literal, semantic meaning ("at least one") and the pragmatic scalar implicature ("more than one") are computed during the processing of a plural. At the end of the sentence, both the semantic meaning and the pragmatic meaning are still active in memory, so participants are equally fast to respond to a picture that is consistent with the semantic meaning (e.g., a picture of a single object) as well as a picture consistent with the pragmatic meaning (e.g., a picture that matches the sentential context). This interpretation was based on findings presented by Kaup, Lüdtke, and Zwaan (2006). Kaup et al. had comprehenders read negated sentences and then presented them with pictures that either matched the affirmative state of affairs or the negated (actual) state of affairs. For example, participants read sentences like: *The umbrella was not open*. Then they saw a picture of either an open umbrella (affirmative state of affairs) or a closed umbrella (negated, or actual, state of affairs). In their first experiment, Kaup et al. presented the pictures immediately after the sentence. In that experiment participants were equally fast to respond to the affirmative picture as the negated picture. In the second experiment, Kaup et al. inserted a 1500 ms delay between the sentence and the presentation of the picture. In that experiment, participants were faster to respond to the negated picture than to the affirmative picture. Kaup et al. argued that comprehenders create conceptual representations for intermediate stages (e.g., the affirmative state of affairs) of linguistic processing and that those intermediate stages are still active at the end of the sentence. Furthermore, those intermediate stages get suppressed or deactivated over time and the comprehender is left with a conceptual representation that adheres to the actual state of affairs described in the sentence. While Kaup et al. interpreted their findings with respect to mental simulations comprehenders were performing during comprehension, these findings might also hold for scalar implicature processing. Specifically, this account predicts that during the processing of a scalar implicature, comprehenders compute and conceptually represent both the literal, semantic meaning of the scalar term as well as the pragmatic, implicature –derived meaning. Thus, given a delay between the end of the sentence and the presentation of a picture, comprehenders should show a preference for the pragmatic, implicature-derived meaning and not preference for the literal, semantic meaning. The current study tests this prediction.

Whether or not the singular interpretation maintains activation over a delay is an important question for understanding how plural noun phrases are conceptually represented. Very little work has been done to investigate how plural nouns phrases are conceptually represented (e.g., Patson, 2014). Given that number is a fundamental aspect of language processing, it is important to understand how language comprehenders represent it conceptually.

Although little work has been done to explicitly probe the conceptual representation of plural noun phrases, some theorist have speculated about what those conceptual representations might look like. For example, Johnson-Laird (1983) argued that the conceptual representation for large quantities could contain a small set of objects or may be a single token. Under this hypothesis, it is possible that when comprehenders conceptually represent a plural they represent the plural at both the level of the set and also represent a single token of the individuals that make up the plural. Activating a representation of both the set and the individuals that make up the set would be logical given that, depending on the context, the set or the individuals may be more relevant.

The current study was designed to investigate whether the activation of the singular meaning during the comprehension of plural noun phrases (Patson, in press; Patson, George, & Warren, 2014) persists after a 1500 ms delay. If the activation of the singular interpretation is due to the computation of a scalar implicature, then comprehenders should not show a reduced reaction time for a singular picture compared to a plural picture that mismatches the context after a delay (e.g., Kaup et al., 2006). If a reduced reaction time for a singular picture persists after a delay, it suggests that the activation of the singular interpretation was not due to the computation of a scalar implicature, but rather may be due to the nature of plural conceptual representations.

Method

Participants

Fifty four native speakers of American English volunteered to participate. Participants were recruited from the Columbus Center of Science and Industry (COSI).

Design and Stimuli

The experiment had a 2x3 repeated measures design. The first factor was the implied distribution of entities in the plural set. The sentences either implied that the entities within the plural set were spatially gathered (as in 6) or spatially spread out (as in 7).

6) The gardener raked up the leaves.
7) The breeze scattered the leaves.

The sentences used in the current study were a subset of the sentences used in Patson (in press). The sentences were normed to ensure they evoked the correct spatial configuration.

The second factor was the picture type (see Figure 1 for examples). The picture was either spatially gathered (e.g., a pile of leaves), spatially distributed (e.g., spread out leaves), or a single object. The pictures used in the current study were a subset of the pictures used in Patson (in press). In order to verify that all three picture types were similarly easy to identify, Patson (in press) ran a norming study in which participants were shown a label (e.g., leaves) and asked to judge whether a picture was a good match for that label. There were no response time differences based on picture type indicating that any response time differences in the Experiment are not due to differences in how the pictures are visually processed.

Figure 1. Pictures (in greyscale) used in the Experiment.

Forty two experimental items were divided into six lists such that each list contained one condition from each experimental item. Each participant viewed one list. Each list also contained the same set of 42 filler sentences. Filler sentences were structured exactly like the experimental sentences; however, in all of the filler items, the picture that followed the sentence was not of an item mentioned in the sentence. The filler pictures contained a mixture of singular objects, spatially grouped objects, and spatially distributed objects. The correct answer for the sentence-picture matching judgment was "no" for all 42 filler items and "yes" for all 42 experimental items.

Apparatus

The trials were presented using E-Prime v.2 experimental software (Schneider, Eschman, & Zuccolotto, 2002). A Dell P2412H 24-inch monitor (1920 X 1080 pixels) displayed stimuli with a screen refresh rate of 60 Hz. Keyboard presses were used to log responses and record reaction time.

Procedure

Participants were tested individually or in pairs. After they provided informed consent, they were given a verbal introduction to the experiment. Then the computer guided them through example trials followed by four practice trials with feedback. As in Patson et al. (2014) and Patson (in press), the instructions and practice indicated that participants' judgments should be based on object identity. That is, participants were instructed to answer "yes" when they saw a singular picture even when the sentence

contained a plural noun phrase. A left-justified fixation cross signaled the beginning of each trial. When participants pressed the spacebar, the cross was replaced by a sentence. Participants read the sentence at their own pace and pressed the space bar. The sentence disappeared and a blank screen appeared for 1500 ms. After the 1500 ms delay, a picture appeared in the center of the screen. Participants decided whether or not the picture was of an object mentioned in the sentence by pressing 'Y' for yes and 'N' for no on the keyboard. The picture disappeared only when participants made their response. The participants' button presses and response times were recorded.

Results

Overall, accuracy on the task was high (M = 96%, SD = 4%). One participant was dropped from the analysis due to extremely long reaction times (over 3 SDs greater than mean RTs).

The mean reaction times for correct trials are presented in Figure 2.

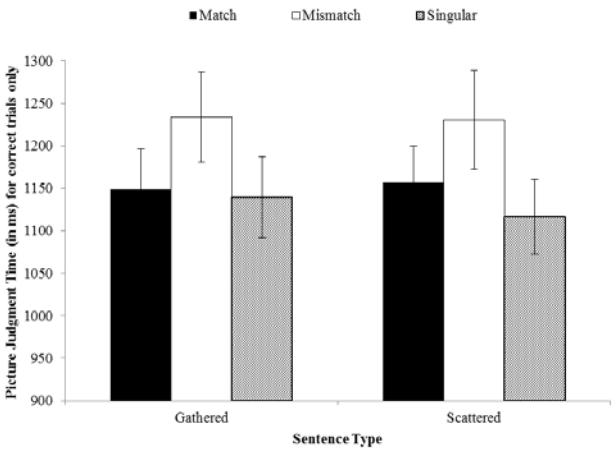

Figure 2. Mean (standard error) picture judgment time by sentence and picture type.

The main effect of picture type was significant, $F1(2, 104) = 13.09$, $MSe = 24556.73$, $p < .001$; $F2(2, 82) = 10.72$, $MSe = 40179.22$, $p < .001$. Neither the main effect of sentence type nor the interaction was significant, all ps > .10.

Planned comparisons indicated that participants were faster to respond accurately to the picture when the picture matched the sentential context than when it did not, $t_1(52) = 3.89$, $p < .001$; $t_2(41) = 3.60$, $p = .001$. Additionally, participants were faster to respond to the singular picture than to the picture that mismatched the sentential context, $t_1(52) = 4.53$, $p < .001$; $t_2(41) = 3.88$, $p < .001$.

Discussion

The results reported here replicate and extend the results reported by Patson (in press). When comprehenders read sentences containing plural noun phrases they are faster to respond accurately to a picture that matches the sentential context than to a picture that does not. Additionally, comprehenders are faster to respond to a picture of a single object than to a picture that does not match the sentential context. What is new in this experiment is that these effects occur even after a 1500 ms delay. This suggests that the singular interpretation that gets activated by the plural is not an intermediate stage of processing, but rather is part of the conceptual representation comprehenders build for plural noun phrases.

Importantly, these data do not undermine the scalar implicature account of plural noun phrases. Indeed, if the singular activation were due to the computation of a scalar implicature, it was predicted that participants in this experiment should not have shown a preference for the singular picture over the picture that mismatched the sentential context. However, the finding that participants did show a preference for the singular picture does not indicate that a scalar implicature was not computed. Instead, it suggests that the activation of the singular meaning was not due to the semantic content of the plural noun phrase, but rather may be due to the nature of how plural nouns are conceptually represented (as I will describe in more detail below). Furthermore, Patson (in press) argued that the semantic meaning of a plural noun phrase is something like "at least one". However, there are linguistic patterns that suggest this may not be the definition of the plural. For example, the sentence *I have zero dogs*, the meaning "at least one dog" would be incompatible with the intended meaning of the sentence. This issue is beyond the scope of this paper, but does suggest that the activation of the singular meaning may not have come from the semantic content of the plural noun phrase.

The data reported here suggest that during the comprehension of a plural noun phrase, comprehenders activate a representation of a single token of the objects that make up the plural and that activation persists over a 1500 ms delay. This suggests that the activation of the single token is an important part of the plural conceptual representation. This is reasonable given the fact that depending on the context the set or the individuals may be more relevant during the comprehension of plural noun phrases (e.g., Patson, 2014; Patson & Warren, 2010). For example, plural noun phrases can have either a collective (as in 8) or a distributed reading (as in 9).

8) Together the girls ate a cookie.

9) Each of the girls ate a cookie.

In the collective case (8), the predicate is applied to the set making the set is the most relevant referent for the plural noun phrase. In the distributed case (9), the predicate is applied to the individuals that make up the set, making the individuals the more relevant referent. Given that either the set or the individuals that make up the set can be more or less relevant (and that this relevance can shift throughout a discourse) it is reasonable that the conceptual representation would contain an explicit representation of both the set and the individuals that make up the set.

There is still an open question about why comprehenders represent a single token rather than multiple distinct entities when representing the individuals that make up the plural set. One possibility is that the single token representation is a way in which the conceptual representation is left indeterminate (e.g., Barsalou, 1999). For example, in discussing how a tiger's stripes may be simulated in a conceptual representation, Barsalou[1] argued that there are two ways in the conceptual image might be indeterminate. First, the stripes may be blurry, such that they cannot be counted. Second, they might be extracted from the representation of the tiger such that they appear in a patch. The data reported here are consistent with Barsalou's second suggestion for indeterminacy. With respect to the plural, the individuals that make up the plural set may be represented by extracting a single token from the plural set to represent each of the individuals. Future work will be necessary to fully investigate how plural noun phrases are conceptually represented.

Additionally, future work should be aimed at investigating how context influences the conceptual representation of plurals. Recently, Zwaan (2014) argued that different contexts may require different levels of conceptual representation. Given that context can influence the relevancy of the individuals that make up the plural set (e.g., Patson, 2014; Patson & Warren, 2010), the strength of the singular representation may be influenced by the context in which the plural appears.

Furthermore, scalar implicatures are more likely to be computed in some contexts compared to other contexts (Degen & Tanenhaus, 2015). Thus, given the linguistic evidence that plurals derive their number information via a scalar implicature (Tieu et al., 2014), future work aimed at investigating how context influences the conceptual representations of plural noun phrases must take into account how likely scalar implicatures are to be computed.

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[1] Barsalou (1999) and Zwaan (2014) argue for embodied representations. The arguments here are fully consistent with an embodied account of language processing. However, the arguments here do not rely on an assumption that language processing is embodied.