Under what Conditions is a Plural Represented as More than One? Two Methods for Testing

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Abstract

The current paper reviews the findings from a series of psycholinguistic experiments using two different methods designed to probe the conceptual representation of plural expressions. Experiments using a novel number interference paradigm suggested that singular indefinite NPs within distributed predicates are mentally represented as multiple entities (Patson & Warren 2010), but that distributed predicates are conceptually represented as multiple events only in the presence of strong cues to plurality (Patson & Warren 2015). These findings show that the number interference paradigm can be used to probe when comprehenders mentally represent multiple events and entities. A second set of experiments used a picture-judgment task to begin to understand the nature of the plural representations created by comprehenders. These studies suggest that the conceptual representations of plural definite descriptions are no more similar to pictures of small sets of items than they are to pictures of singletons (Patson et al. 2014). These findings and others contribute to a more nuanced view of how language comprehenders compute and represent number. Importantly, these findings introduce two experimental paradigms useful for probing plural representations.

1 Processing and Representing Plurals: Methods for Testing

Despite the fact that plural expressions present a number of interesting puzzles for language processing, very little work has explored the impact they have on comprehenders' processing. One reason for this may be that traditional experimental methods in psycholinguistics (e.g., self-paced reading, eye tracking, the visual world paradigm) do not lend themselves to probing the nature of comprehenders' representations of plurals. Consider the sentence: *There are books on the table*. There are a number of questions we might ask about comprehenders' representation of *books*. For example, do comprehenders build a representation that contains multiple books or do they simply represent a single token (Johnson-Laird 1983)? Neither hypothesis leads to predictions about reading times, so self-paced reading and eye tracking during reading do not naturally address this question. In order to study the nature of plural representations, we need methods that are better suited to probe these ques-

tions. The goal of this paper is to describe two methods that we have begun to use to investigate the nature of the plural representations that comprehenders generate during sentence processing. The first method is a modified self-paced reading method that includes a secondary task that is sensitive to whether multiple entities or events are present (section 1). The second method is a picture verification task. It has been used to probe the details of the conceptual representations that comprehenders build for plurals (section 2).

2 Do Comprehenders Represent Multiple Events and Entities when Processing Plurals?

The first, most basic question we might ask about any expression is whether comprehenders represent it as single or multiple entities or events. This question is deceptively complicated because there are multiple kinds of representations that might be generated for plurals. For example, some options for representing *books* in *There are books on the table* include: a single entity encompassing two or more books, a situationally appropriate number of individual books, a representation that incorporates both a set of books and the individual books within it, or even a single entity encompassing an unknown number of books. This last possibility is supported by evidence that the "more than one" interpretation assigned to plural expressions does not come from the semantic meaning of the phrase (Sauerland et al. 2005: 414). Consider the sentence in (1).

(1) *You are welcome to bring your children.*

(Sauerland et al. 2005: 417)

Sauerland et al. argue that (1) would not be paraphrased as *You are welcome to bring your two or more children.* In a context where the speaker is unaware of how many children the addressee has, *children* is felicitous even if the addressee only has a single child. Additionally, the question of how comprehenders conceptually represent plural entities gets even more complicated when those plural sets interact with event representations. For example, for a sentence like *The cats played in the sun*, a comprehender must first build a representation for *cats* and then to it apply some representation of playing, which might be a single playing event jointly accomplished by all the cats, some kind of single playing event that incorporates possibly separate playing by some cats, separate playing events for each cat, or even some other representation.

Adding an additional layer of complexity to this issue of representation is the fact that a growing body of work suggests that comprehenders often leave aspects of the linguistic content underspecified in their mental representations (e.g., Ferreira & Patson 2007). Underspecification is particularly relevant to the processing of plural definite descriptions because these referents are usually underspecified for numerosity. The example from Sauerland et al. (2005) above is an extreme example of this, but in English this underspecification is ubiquitous, as exemplified by the fact that *books* in the example sentence above could be referring to two books or 15 books or 50 books, etc. This raises important questions, such as: are some of these proposed representations less specified and more default than others? Can any

aspect of any representation be well- versus under-specified? What would a representation that is unspecified for number be like?

An important first step towards addressing some of these questions above would be the ability to determine under what conditions comprehenders represent multiple events and entities. To this end, we (Patson & Warren 2010) extended a number-of-words judgment task introduced by Berent et al. (2005). This method takes advantage of the fact that a plural introduces conceptual number information. In the original Berent et al. study, participants were shown either a single word or two words on a computer screen and asked to judge how many words appeared on the screen. Berent et al. found that participants were slower to make correct judgments to a single word when it was plural than when it was singular. Berent et al. argued that this was due to interference between the number judgment task and the abstract number information inherent to plural NPs.[1] We extended this method to sentences (Patson & Warren 2010). In our first experiment, participants read sentences that ended with either a singular or plural definite description such as: *The bartender served the beer to the man/men* (Patson & Warren 2010: 784). The sentences were presented in one- and two-word chunks displayed in the center of the computer screen. At the critical word (*man/men* in the example above) the font color changed from black to blue. Participants were trained that when the font changed to blue, they were to decide whether one or two words appeared on the computer screen and press the "1" or "2" key to indicate their decision (see Fig. 1). The time it took to make that decision was measured. In all of our experiments, the critical word is always a single word (i.e., requires a "one word" judgment). We found that participants were significantly faster to make the single word judgment when the word was singular compared to when it was plural. This confirmed that the paradigm could be extended to plural-marked words in sentences. However, this method would be even more useful if it were sensitive not only to the morphosyntactic marking of plurality, but also to number information driven by the sentential context. To test this, we conducted a second experiment in which morphosyntactically singular noun phrases were embedded in distributed predicates, as in *Each of the men carried a box* (Patson & Warren 2010: 785). If comprehenders assign wide scope to the distributing quantifier, it would result in an interpretation that can be paraphrased as "for each man there is a box that he carried". The most natural reading of this would involve multiple boxes. If comprehenders assign wide scope to the existential quantifier, it would result in an interpretation that can be paraphrased as "there is a single box and each man carried it".

[1] Berent et al. (2005) found that participants did not consistently take longer to make a "two word" judgment when two singular words were on the screen compared to when two plural words were on the screen.

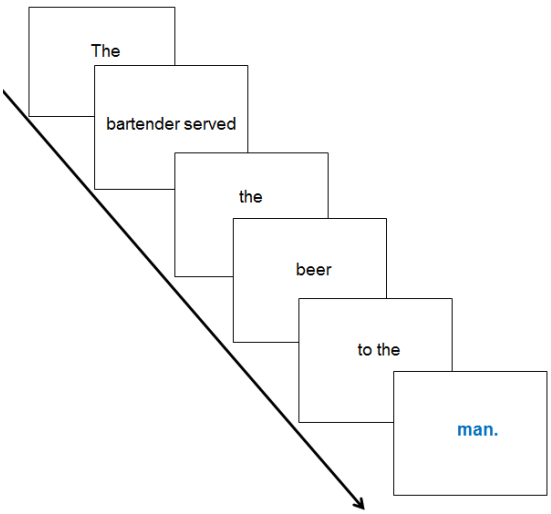

Fig. 1: Example experimental trial

In our second experiment, we compared sentences with distributed quantifiers ((2a) & (3a)) to sentences with collective quantifiers ((2b) & (3b)). We also varied whether the grammatical number on the critical word was morphosyntactically singular (as in (2a-b)) or morphosyntactically plural (as in (3a-b)). The morphosyntactically plural conditions provided a baseline to control for any potential differences in how difficult the two quantifiers might be to process.

(2) a. *Each of the men carried a* box.
b. *Together the men carried a* box.

(Patson & Warren 2010: 785)

(3) a. *Each of the men carried* boxes.
b. *Together the men carried* boxes.

The critical word was the NP in the predicate; *box* in the examples above. As in the previous experiment, we found that participants were faster to make a single word judgment when the word was morphosyntactically singular compared to when it was morphosyntactically plural. Critically, this was qualified by an interaction between quantifier and number marking; participants were slower to make the single word judgment when the word was singular and embedded in a distributed predicate (2a) compared to when it was embedded in a collective predicate (2b). This suggests that participants conceptually represented singular-marked NPs in distributed predicates as plural, meaning that wide scope had been assigned to the distributing quantifier. This experiment provides evidence that the number-of-words judgment paradigm is sensitive to plurality driven by the sentential context, not simply the morphosyntactic marking on the noun phrase. But importantly, the only way to represent the singular-marked NPs as plural in these sentences is to represent the referents of those NPs as distributed across multiple events. This hints that the current paradigm may be able to index whether a comprehender has represented a single event or multiple events.

We therefore directly investigated whether the number-of-words judgment paradigm could be used to index event plurality (Patson & Warren 2015). In our first ex-

periment, participants read sentences that contained either an iterative (as in (4)) or a punctual event (as in (5)). Note that the iterative event happens multiple times, instantiating multiple events, whereas the punctual event occurs once, instantiating only a single event.

(4) *Throughout the day, the student* sneezed *in the back of the classroom.*

(5) *After twenty minutes, the student* sneezed *in the back of the classroom.*

(Patson & Warren 2015: 1253)

On the critical verb region (*sneezed* in (4)-(5)), participants were slower to make the single word judgment when the sentence evoked an iterative event (4) compared to a punctual event (5). This suggests that the paradigm is sensitive to the representation of multiple events as well as multiple entities. Given this, we used the paradigm to begin to investigate when multiple events are instated during processing and under what conditions inherently distributed verbs instantiate multiple event representations (Patson & Warren 2015).

There is reason to think that predicate interpretation may sometimes be delayed until the full semantics of an event are available (e.g., Pickering & Frisson 2001). One reason for this is that post-verbal arguments can be critical to event interpretation. For example, the direct object of a verb can influence whether a plural event is interpreted as distributed or collective. Consider the sentence *The men carried…* If the sentence were continued with "a piano", most people would assign a collective reading to the predicate because world knowledge would make a distributed reading implausible. However, if the sentence were continued with "a briefcase", world knowledge might make a distributed reading more likely. Given this, a delaying strategy might make sense.

To investigate this issue, we compared collective (6) and distributed (7) events with transitive (*pitched*) and intransitive verbs (*slept*):

(6) *Together the hikers calmly* pitched/slept in *a small tent.*

(7) *Each of the hikers calmly* pitched/slept in *a small tent.*

(Patson & Warren 2015: 1257)

The rationale is that at the verb, the comprehender has access to the full event semantics for intransitive verbs, but not transitive verbs, which are awaiting a direct object. If comprehenders wait for the full event semantics before interpreting distributed quantifiers, then interference on the number-of-words judgment task should only occur for distributed events with intransitive verbs. Alternatively, if they do not wait for the full event semantics in the presence of a distributive quantifier, the interference on the number-of-words judgment task should be present for sentences with distributed quantifiers regardless of the verb type. Our results showed that participants were slower to make the single word judgment on the verb in a distributed context than in a collective context. There was no interaction with verb transitivity. This suggests that comprehenders do not necessarily wait for the full event semantics before instantiating multiple events.

The second question we asked was whether the inherent distributivity of a verb is enough to spur comprehenders to represent multiple events. From some of the experiments already discussed, it is clear that collective and distributive quantifiers can spur comprehenders to represent single or multiple entities and events. But

what if the cue to distributivity is less explicit, and comes from the semantics of the verb? Inherently distributed verbs are verbs that, if applied to a set, must be true of each member of the set. For example, contrast the sentences: *The cats awoke* and *The cats played*. *The cats played* can be interpreted to mean that every cat in the relevant set played by itself, or that the cats all played together as a group, or something intermediate with some cats playing singly and some together. This is not true of *The cats awoke*. That sentence can only be interpreted to mean that every cat in the relevant set woke up. *Awoke* is therefore inherently distributed.

We designed an experiment to test whether comprehenders build representations with multiple events for inherently distributed verbs with plural subjects. This experiment compared number-of-words judgment times on the verb for sentences like (8)-(10).

(8) *The boy in the house unexpectedly* awoke *before dawn.*

(9) *The boys in the house unexpectedly* awoke *before dawn.*

(10) *The boy and the girl in the house unexpectedly* awoke *before dawn.*

In (8), the subject of the verb is singular, so there is only one event. In (10), the conjoined subject (*the boy and the girl*) provides two individuated referents (Patson & Warren 2011), so the inherently distributed verb should apply to both and generate a representation with two events. Therefore, number-of-words judgment times should be faster on the verb in (8) than in (10). Indeed, participants were faster to judge the verb as a single word when the subject was singular (8) compared to when it was conjoined (10). What is not clear is whether comprehenders will create multiple events when the subject is a plural definite description, as in (9). Previous work indicates that plural definite descriptions are represented as undifferentiated sets and thus only introduce a single referent (Patson & Ferreira 2009; Patson & Warren 2011). If the predicate applies to that single plural referent and fails to distribute across the entities within the set, then number-of-words judgment times on (9) might pattern with (8). If the inherent distributivity of the verb combines with the plural subject to create a distributed representation of multiple events, then number-of-words judgment times on (9) should pattern with (10). The results were that the judgment times for (9) patterned with (8). This suggests that comprehenders did not create a representation that contained multiple events for inherently distributed verbs with plural definite descriptions as subjects. This may be because the distributivity inherent to a verb's semantics is not enough to force comprehenders to represent distributed events. Instead, in order to instantiate multiple events, comprehenders need stronger cues to plurality such as the presence of multiple referents to which to apply a predicate. Without multiple referents, the inherently distributed event is left undifferentiated and underspecified.

The work reviewed so far suggests that the number-of-words judgment task can be used to index whether a conceptual representation contains multiple events or entities. This task is therefore an important tool in efforts to understand the conditions under which comprehenders generate conceptual representations containing single versus multiple entities and events. Results from this task also go a small way towards characterizing plural representations. The findings reviewed so far suggest that comprehenders do specify plurality in their mental representations of plural entities, because if they left number completely unspecified (e.g., Sauerland et al. 2005), there should have been no interference for plurals in the number-of-words

judgment task. Still, this represents only a small step towards characterizing plural representations. Additional methods that more directly query other properties of these representations are needed.

3 How Detailed are the Conceptual Representations for Plurals During Sentence Comprehension?

Several studies have used a picture-matching paradigm to probe the conceptual representations of plurals created by comprehenders during the processing of sentences. This method is grounded in research on situated cognition (e.g., Barsalou 1999). Situated cognition argues that comprehenders' conceptual representations contain many experientially-derived properties of the entities and events they encounter. Consistent with this, evidence suggests that language comprehenders represent information such as shape, size, color, and the emotional content of linguistic content. The picture-matching paradigm has been widely used to test hypotheses derived from theories of situated cognition (e.g., Stanfield & Zwaan 2001; Zwaan et al. 2002). In this paradigm, participants read or listen to a sentence and then see a picture. Their task is to judge whether or not the picture is of an object that was in the sentence. For example, Stanfield & Zwaan (2001) used this paradigm to provide evidence that comprehenders represent information about the shape of an object during language comprehension. In their experiment, participants read sentences like:

(11) *The ranger saw an eagle in the tree.*

(12) *The ranger saw an eagle in the sky.*

In their study, participants were faster to identify a picture of an eagle that matched the context of the sentence. So in sentence (11) participants were faster when an eagle was depicted with its wings folded compared to with its wings spread out in flight. The reverse was true for sentence (12). Stanfield & Zwaan (2001) interpreted this as evidence that comprehenders conceptually simulate the action described in the sentence. If comprehenders simulate properties of the objects and actions they read or hear about, and we can query those simulations, doing so should provide another source of information regarding comprehenders' mental representations of number. We therefore used this picture-matching paradigm to investigate comprehenders' conceptual representations of plural noun phrases.

In Patson et al. (2014), participants read a sentence that contained either a singular noun (as in (13)), a plural definite description (as in (14)), or a two-quantified plural (as in (15)).

(13) *The parent handed the child the* crayon.

(14) *The parent handed the child the* crayons.

(15) *The parent handed the child the* two crayons.

(Patson et al. 2014: 1352)

After reading the sentence, participants pressed a button and then saw a picture of exactly one of the critical objects (i.e. a crayon for the example above), exactly two critical objects, or multiple (between 3 and 6) critical objects (see Fig. 2).

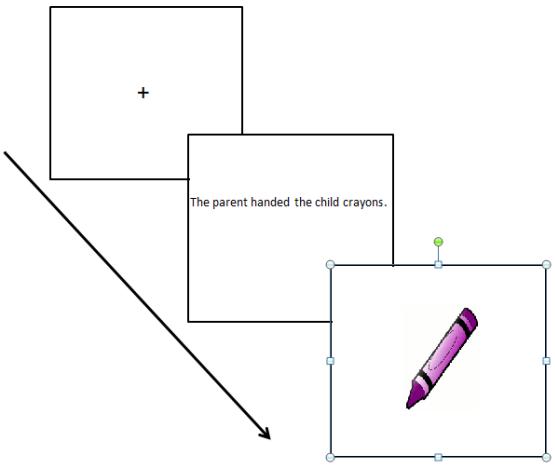

Fig. 2: Example trial containing plural definite description and one pictured object

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 identity alone. Patson et al. (2014) measured how quickly participants responded affirmatively to the picture. The results indicated that for conditions in which numerosity was explicitly specified in the sentence (e.g., singular NP, two-quantified NP), participants were faster to respond to a picture with an exactly matching number of objects than a picture with a non-matching number of objects. 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 if there was only one object pictured rather than multiple objects. This finding is straightforward: when number information is made explicit, comprehenders have a detailed conceptual representation that contains explicit number information. However, for the plural definite description conditions, participants did not show a preference for pictures that depicted more than one object compared to pictures that depicted a single object. In a second experiment, we confirmed that this effect occurs even when plurality is introduced conceptually and not via a plural definite description by having participants read sentences that had either a distributive (16) or a collective (17) quantifier.

(16) *Each of the men carried a box.*

(17) *Together the men carried a box.*

After reading a sentence with a collective quantifier, participants were faster to identify a picture of a single box compared to a picture of multiple boxes. After reading a sentence with a distributive quantifier, participants showed no preference for either picture type.

One interpretation of these findings is that they are consistent with the theory that plurality is semantically unmarked for number (e.g., Sauerland et al. 2005) and therefore indicate that comprehenders do not explicitly represent number information when building a conceptual representation for a plural noun phrase. If number is unspecified in a representation, then there is no reason that pictures of multiple objects should match it better than pictures of a single object. However, this interpretation is inconsistent with the findings of interference for plural definite descrip-

tions in the number-of-words judgment task. That interference suggests that representations for plural definite descriptions really are plural and contain multiple entities. An alternative explanation of the findings in Patson et al. (2014) is that comprehenders' final representations of plural definite descriptions are specified as plural, but that during intermediate stages of processing, comprehenders might also construct representations that include a singular representation. If picture matching is sensitive to these intermediate representations, that could explain Patson et al. (2014)'s findings, yet not necessarily be inconsistent with the evidence from the number-of-words judgment task. This explanation is consistent with a scalar implicature account of the plural (Patson 2016a) as we will describe below.

The scalar implicature theory of the plural was introduced to attempt to solve a well-known puzzle regarding the interpretation of plural definite descriptions. Consider the following set of examples.

(18) a. *Ben fed a shark.*
b. *Ben fed sharks.*
c. *Ben fed more than one shark.*

(19) a. *Ben didn't feed a shark.*
b. *Ben didn't feed sharks.*
c. *Ben didn't feed more than one shark.*

(Patson 2016a: 1140-1041)

For most people, (18b) and (18c) are essentially the same in meaning, and distinct from (18a). However, in the negated cases, (19a) and (19b) are usually judged as equivalent and distinct from (19c) (Sauerland et al. 2005; Tieu et al. 2014). As mentioned previously, this suggests that in some contexts (such as negation), "more than one" is not always the appropriate interpretation of a plural definite description. This pattern of interpretations suggests that the plural is semantically unmarked, or weakly marked, for number, whereas the singular is strongly marked for number. If the plural is semantically unmarked (or weakly marked) for number, then the "more than one" interpretation derived in most contexts must come from a pragmatic inference. One hypothesis is that when comprehending a plural, comprehenders generate 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. Consider the sentence in (20).

(20) *Zoe ate some of the cookies.*

(Patson 2016b: 1188)

Although the statement in (20) does not logically rule out the possibility that Zoe in fact ate all of the cookies, it is typically interpreted as meaning that Zoe ate some but not all of the cookies. Comprehenders seem to assume that speakers use the strongest labels that are compatible with their intended meaning, so upon encountering a weaker expression comprehenders assume that the stronger meaning was not appropriate (Grice 1975). Thus, they assume that if a speaker intended to indicate that Zoe 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 definite descriptions, a scalar implicature account assumes that the literal, semantically defined interpretation of a plural definite description 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 definite description 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.

Tieu et al. (2014) provided evidence for a scalar implicature account of plurality using a truth-value judgment task. For example, they asked participants to decide whether the question *Does a dog have tails?* (Tieu et al. 2014: 125) is true or false. The question should be answered "false" because a dog only has one tail. Tieu et al. found that both adults and children interpreted plural nouns as meaning "more than one" when the nouns were in positive contexts (or upward-entailing environments). That is, they answered correctly ("false") when asked *Does a dog have tails?* indicating they interpreted "tails" as meaning more than one. However, participants were less likely to answer correct when nouns were in negative contexts (or downward-entailing environments), such as *A dog does not have tails*. With these sentences, the answer should be "true" because a dog only has a single tail, however, participants answered "false" suggesting they did not interpret "tails" to mean more than one in these contexts (i.e., instead they interpreted the sentence as asking whether a dog has a tail.) This is consistent with typical scalar implicature patterns showing that scalar implicatures are more likely to be made in upward-entailing rather than downward-entailing environments (e.g., Chierchia 2004; Levinson 2000).[2]

The scalar implicature account of the plural could be used to explain the lack of a preference for a picture of multiple objects after reading a plural definite description reported in Patson et al. (2014). Most accounts of scalar implicature processing assume that participants access both the logical (semantic) meaning and the pragmatic meaning of the scalar term (e.g., Huang & Snedeker 2011). If logical meaning of plural is "at least one", but it is pragmatically strengthened to "more than one", then both of these meanings may be accessed during processing. If both meanings are activated, both may be represented conceptually (e.g., Kaup et al. 2006). For example, Kaup et al. found that during the processing of negated predicates such as *The door is not open* (Kaup et al. 2006: 1033), immediately at the end of the sentence comprehenders are equally fast to respond to a picture of a door that is open and a door that is closed. They interpreted this as evidence that comprehenders simulate both the actual state of affairs and intermediate stages of linguistic processing, e.g., the predicate that was to be negated. If, during the processing of scalar terms, comprehenders simulate both the actual state of affairs (e.g., the pragmatically strengthened meaning) as well as intermediate stages of linguistic representation (e.g., the logical meaning), then participants should be equally fast to respond to the picture that was consistent with their semantic representation (e.g., for a plural definite description that would be the singular picture) as the picture that was consistent with their pragmatically derived representation (e.g., the plural picture).

The results reported by Patson et al. (2014) do not distinguish between the underspecification and the scalar implicature accounts of plural conceptual representation. The lack of preference for the plural picture over the singleton picture could have resulted because both were equally bad matches to participants' underspecified conceptual representations. Alternatively, the lack of preference could have resulted because the singular and the plural meanings of the plural expression were

[2] Additionally, Tieu et al. (2014) 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).

both equally active in the conceptual representation, as predicted by the scalar implicature account. To distinguish between these two accounts, it is necessary to test situations in which they make different predictions. The underspecification account predicts that comprehenders should always respond similarly to all picture types after reading a plural definite description. This is due to the underspecified nature of the representation. On the other hand, the scalar implicature account places no constraints on the specificity of the plural representation. It would be consistent with comprehenders responding differently to plural pictures with different properties.

Patson (2016a) used this logic to provide evidence for the scalar implicature account. In her first experiment, comprehenders read sentences that contained plural definite descriptions. 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 in which 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 (2016a) 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. This pattern of findings is consistent with a scalar implicature account of the plural, according to which comprehenders reading a plural definite description activate the semantic meaning of the plural (which may be something like “at least one”) on their way to generating a highly detailed plural conceptual representation with information about the arrangement of the individual entities that make up the plural set. The fact that participants were faster to respond to a picture that matched the spatial distribution of objects implied in the sentence suggests that comprehenders do not leave number information conceptually unspecified. This is because, in order to represent how the entities within the plural set are spatially related to one another, multiple entities must be represented.

The work reviewed here provides some insight into how plural expressions are represented during processing. Experiments using a novel number interference paradigm suggested that singular indefinite NPs within distributed predicates are conceptually represented as multiple entities (Patson & Warren 2010), but that distributed predicates are mentally represented as multiple events only in the presence of strong cues to plurality (e.g., distributed quantifiers or multiple referents in the subject, Patson & Warren 2015). A series of picture-judgment experiments suggest that the conceptual representations of plural definite descriptions are no more similar to pictures of small sets of items than they are to pictures of single objects (Patson et al. 2014), which may be consistent with a scalar implicature account of the plural. There is still much work to be done on the representation of plurals. For example, in a second experiment, Patson (2016a) used the picture-matching paradigm to provide evidence that suggests that comprehenders represent information about set size unless the set size becomes uncountable. At that point, comprehenders may underspecify the conceptual representation or represent a single token (Johnson-Laird 1983). Work is needed to gain a deeper understanding about how large set sizes are conceptually represented. Furthermore, recent work using the picture-matching paradigm shows that after reading a plural definite description, participants

maintain activation of the singular representation even after a 1500 ms delay (Patson 2016b). This suggests that the activation of the singular picture may not be due to the activation of the logical interpretation of the plural. If it were, the activation should decrease over time, such that adding a 1500 ms delay between the sentence and picture should cause participants to show a preference for a picture of multiple objects compared to a picture of a single object (Kaup et al. 2006). The finding that participants maintain activation of the singular representation over a 1500 ms delay suggests that its activation was not due to an intermediate stage of processing. Instead, the singular representation may be part of the conceptual representation of the plural. Much work is still needed to investigate the nature of the conceptual representations created during the processing of plural expressions.

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