THE CONTRIBUTIONS OF SINGULAR AND PLURAL NOUNS
TO SENTENCE PROCESSING COMPLEXITY:
EVIDENCE FROM READING TIME

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Abstract. The nature of semantic representations of plural nouns has been a subject of debates in the literature. The present research investigated the extent to which there are differences in the processing of plural versus single noun descriptions (e.g., the large chairs vs. the large chair). In two reading experiments, we tested whether plural (versus singular) nouns appearing in sentences were more difficult to process initially and/or led to increased processing difficulty when occurring in sentences that contain a temporary syntactic ambiguity. Reading time on syntactically ambiguous sentences containing plural or singular nouns were compared with reading time on unambiguous control sentences. The results of both experiments demonstrated significant effects of sentence ambiguity. No effects or interactions involving noun number were observed, indicating that the complexity of plural nouns does not result in processing difficulty during sentence comprehension.

Keywords: reading, semantic representations, syntactic ambiguity, comprehension, plural nouns, singular nouns.

Мессер Рейчел; Кеннісон Шіліа. Унесок іменників однини й множини у складність обробки речень: дані експериментів щодо швидкості читання.

Анотація. Природа семантичної репрезентації іменників в множині була предметом дискусії в літературі впродовж довгого часу. У нашому дослідженні проаналізовано, наскільки відмінними є обробка опису іменників в множині та обробка опису іменників в однині (наприклад, the large chairs vs. the large chair / *великі крісла та велике крісло*). У двох експериментах з читання було протестовано, чи іменники в множині (на противагу іменникам в однині), які траплялися в реченні, були одразу складнішими для обробки і/або призводили до підвищеної складності обробки, коли були в реченнях, що містили тимчасову синтаксичну неоднозначність. Швидкість читання синтаксично неоднозначних речень, що містили

іменники в множині чи однині, порівнювалась із швидкістю читання однозначних контрольних речень. Результати обох експериментів продемонстрували, що неоднозначність речень має суттєвий вплив. Жодних наслідків чи взаємодій, що могли б стосуватися числа іменника, не було виявлено. Це вказує на те, що складність іменників у множині не призводить до труднощів у обробці під час розуміння речень.

Ключові слова: *читання, семантичні репрезентації, синтаксична неоднозначність, сприйняття, іменники в множині, іменники в однині.*

1.1.   Introduction. Theoretical Background

Over the last fifty years, numerous studies have identified sources of processing difficulty in a variety of tasks involving reading comprehension (See Rayner, Pollatsek, Ashby, & Clifton, 2011 for review). Relatively few studies have focused on the conceptual representation of plural nouns has been debated (Barker, 1992; Barsalou, 1999; Johnson-Laird, 1983; Schwarzschild, 1996). One view is that their representations are inherently more complex than those of singular nouns due to the greater number of individuals included in the representation (Barker, 1992). This view is compatible with the notion that mental representations contain information about the perceptual features of the objects referred to by nouns (Barsalou, 1999; Zwaan, Stanfield, & Yaxley, 2002). In contrast, the representations of plural and singular nouns may be comparable in complexity if the representations are abstract in nature and information about individual entities are not specified (Schwartzchild, 1996).

There have been numerous studies comparing the processing of plural and singular nouns (See Patson, 2014, for review). Some of these studies have investigated the processing of single words using the lexical decision task during which participants were asked to judge whether a letter sequence was word or not. In these studies, plural nouns have not been shown to take longer to process than singular nouns (Baayen, Dijkstra, & Schreuder, 1997; Dominguez, Cuetos, & Segui, 1999; New, Brysbaert, Sequi, Ferrand, & Rastle, 2004; Schreuder & Baayen, 1997; Sereno & Jongman, 1997), despite the fact that in addition to the possible conceptual differences between plural and singular nouns, there can also be greater morphological complexity for plurals versus singulars.

Few studies have investigated the processing of plural and singular nouns within sentences. Ferreira and McClure (1997) showed that readers rapidly utilize information about the plural status of nouns during sentence processing. In the study, they compared reading time on sentences containing a temporary syntactic ambiguity. Example sentences are displayed in (1). Reciprocal verb conditions (i.e., 1a and b) were compared to conditions in which sentences contained an optionally transitive verb (i.e., 1c and 1d).

(1) a. After Jose and the bride kissed the party began in earnest. (Ambiguous)
   b. After Jose and the bride kissed, the party began in earnest. (Unambiguous)
   c. After Jose and the bride signaled the party began in earnest. (Ambiguous)
   d. After Jose and the bride signaled, the party began in earnest. Unambiguous)

For reciprocal verb conditions, there was no significant difference in reading time for ambiguous and unambiguous sentences, suggesting that information about the plural noun was used by readers to achieve the reciprocal interpretation of the verb. For optionally transitive verb conditions, readers took significantly longer to process ambiguous versus unambiguous sentences because *the party* was initially analyzed a direct object and later reanalyzed as the subject of the main clause. In subsequent work, Patson and Ferreira (2009) showed that readers' use of plural information differed for conjoined phrases (e.g., *Jose and the bride)* and for plural definite descriptions (e.g., *the lovers* or *the two lovers*), with readers avoiding the garden path (i.e., initial syntactic misanalysis) following a reciprocal verb for conjoined phrases but not for plural definite descriptions (see also Patson & Warren, 2011; 2014). In recent experiments involving a picture-matching task, Patson and colleagues (Patson, 2016; Patson, George, & Warren, 2014; Patson & Warren, 2015) have argued that the semantic representation for plural definite descriptions may not specify whether the noun is singular or plural.

Few studies have investigated differences in how plural and singular noun definite descriptions are semantically integrated during sentence processing. Kennison (2005) hypothesized that plural nouns may be semantically integrated with prior context more rapidly than singular nouns, because readers may use plural information to infer the presence of the head of the phrase (e.g., the eager house painter vs. the eager houses painter*). In two experiments, reading time was compared on sentences containing plural or singular definite noun descriptions preceded by an adjective that either formed a plausible or implausible combination with the noun. Example sentences are displayed in (2). The results supported the hypothesis. Reading time on plural nouns was longer for

(2) a. John said that the ancient castle(s) was/were…. Plausible

b. John said that the careful castle(s) was/were…. Implausible

implausible versus plausible conditions. Reading time on singular nouns did not differ for implausible and plausible conditions; rather, readers took longer to read the word following the noun in implausible versus plausible conditions. Further comparisons showed that while reading time on plural and singular nouns did not differ in plausible conditions, in implausible conditions, reading time on plural nouns was significantly longer than on singular nouns.

The purpose of the research described was to investigate further whether the representations of plural definite descriptions are more complex to process in sentences than singular definite descriptions, particularly when semantic integration is believed to occur. Patson (2014) asserted that for plural definite descriptions, plural is left fully underspecified; thus, no difference in the processing of plural and singular nouns is expected to occur. However, Kennison's (2005) results suggest that during sentence processing in which integrative semantic process occurs, plural definite descriptions

may take longer to process than singular definite descriptions, because integrative semantic processing is initiated earlier for plurals than for singulars.

We report two reading experiments in which we investigated how readers processed plural and singular definite descriptions that were syntactically ambiguous phrases and were syntactically reanalyzed at the point later in the sentence when the reader encountered disambiguating information. A traditional view of the process of syntactic reanalysis is that the processing difficulty during syntactic ambiguity resolution stems from the abandonment of an initial incorrect syntactic analysis and its interpretation, followed by the re-computation of an alternative syntactic analysis and its interpretation (Ferreira & Henderson, 1991). Although other researchers have argued that syntactic reanalysis may not involve the initial consideration of a single possible analysis of a sentence (See Sturt, Pickering, & Crocker, 2000, for discussion), sentences in which syntactic reanalysis is believed to occur typically take longer to process than sentences that are syntactically unambiguous. Our aim was to determine whether syntactically ambiguous sentences containing plural nouns take longer to process than similar sentences containing singular nouns.

2. Present Study: Experiment 1

We chose a syntactic ambiguity that has been found in prior studies to yield a large syntactic reanalysis effect with reading time on syntactically ambiguous sentences substantially longer than reading time on unambiguous control sentences (Adams, Clifton, & Mitchell, 1998; Mitchell, 1987). Sample sentences are displayed in (3). In 3a, the plural or singular noun is syntactically ambiguous, as readers typically misanalyse the noun as the direct object of the first verb and only realize the error when the second verb in the sentence is encountered. In 3a, the ambiguity is eliminated by the placement of a comma after the first verb.

(3) a. When Al called the lake(s) had been put on a no-fishing alert. (Ambiguous)

b. When Al called, the lake(s) had been put on a no-fishing alert. (Unambiguous)

If the representation of plural definite descriptions is more complex than those of singular nouns, the difference in reading time between ambiguous and unambiguous sentences should be larger for sentences containing plural nouns than sentences containing singular nouns.

2.1. Method

Participants. The participants were 60 undergraduates (23 men and 37 women) at a large public university in the Midwest region of the United States. The average age of participants was 19.25 years old (*SD* =2.19). All participants were native speakers of English, had normal or corrected-to-normal vision (i.e., either they wore eye glasses or reported that they had normal vision and did not need to wear eye glasses), and received course credit in exchange for their participation. Participants were not asked

about their knowledge of other languages, as bilingualism is uncommon in the undergraduate population at this institution.

Materials. 16 sets of experimental sentences were constructed for the experiment. Each set contained four versions in which two versions were syntactically ambiguous and two were unambiguous, containing a comma separating the sentences into two clauses. In half of the sentences in each set, the ambiguous noun was singular and in the other half, it was plural.

Procedure. Sentences were presented using E-Prime to control the stimuli presentation and recording of reaction times (Schneider, Eschman, & Zuccolotto, 2002). The experiment used a phrase by phrase self-paced reading window. Participants were instructed to press the "next" key to advance the presentation of the sentence; the "next" key corresponded to the "/" key on the keyboard. The key was labeled "next" with a sticker. The presentation of each sentence began with an array of asterisks; each asterisk corresponded to the position of a letter in the current sentence. After the participant pressed the "next" key, the first presentation region of the sentence appeared, replacing the corresponding asterisks. When the reader completed reading the first presentation region and pressed the key again, the second presentation region appeared, replacing the corresponding asterisks, and the first presentation region disappeared and was replaced with corresponding asterisks. This procedure was repeated until the last presentation region was read. Each sentence was followed by a yes/no comprehension question. The "z" key was used for "yes" responses. The "x" key was used for "no" responses. These keys were labeled "yes" and "no" with stickers. Participants used the index finger on the right hand for the "NEXT" key and the index and middle fingers on the left hand for "YES" and "NO." The 16 experimental sentences were intermixed with 88 filler sentences. Filler sentences contained a variety of sentence structures, which did not involve syntactic ambiguity, and were also followed by a yes/no comprehension question. Comprehension questions in the experimental sentences did not query the plural or singular noun. The same comprehension question was used for all versions of an item. Each participant viewed sentences in a unique random order. Participants were tested in a repeated measures design involving four counterbalancing lists, which were used to ensure that each item was viewed in each condition equally often across participants. Each participant was randomly assigned to a counterbalancing condition and tested individually in a private, well-lit cubicle. Each participant was given a practice session of 16 sentences, followed by the set of experimental items, which consisted of 104 sentences. The practice and filler items can be provided by the authors upon request. Each session lasted between 30–45 minutes.

Data Analysis. Data were analyzed using SPSS.

3. Results

Participants' accuracy for comprehension questions for Experiment 1 was 95%, indicating that they complied with the instructions of the reading task. Accuracy did not vary significantly across conditions in either experiment, Fs < 1. In both experiments, reading times for each presentation region were initially trimmed to

eliminate responses under 100 milliseconds or over three seconds. This trimming eliminated less than 1 percent of the observations in both experiments. Using the remaining observations, mean reading time per presentation region per condition per participant was calculated. For both experiments reported in this paper, the data were analyzed using analyses of variance (ANOVAs) in which both participants (F_1) and sentences (F_2) were treated as random effects as recommended by Clark (1973). Table 1 displays mean reading time by presentation region for Experiment 1.

The results failed to support the view that plural nouns increase processing difficulty during syntactic reanalysis as compared to singular nouns, as the noun type x ambiguity interaction was not significant at any region, Fs < 1. The presence of syntactic ambiguity affected reading time, as readers took longer to process sentences containing a temporary syntactic ambiguity than unambiguous sentences. Significant differences were observed at region 6 (ambiguous: 1088 ms vs. unambiguous: 949 ms), F_1 (1, 59) = 5.22, p = .026, η^2 = .08, F_2 (1, 15) = 5.17, p = .038, η^2 = .26, and at region 7 (ambiguous: 1017 ms vs. unambiguous: 938 ms), F_1 (1, 59) = 5.10, p =.028, η^2 = .08, F_2 (1, 15) = 2.96, p = .106, η^2 = .17. Reading time was not influenced by the type of noun (i.e., singular versus plural) at any region, Fs < 1.50.

4. Discussion

The results yielded no support for the view that plural nouns are more difficult to process during syntactic reanalysis than singular nouns. In order to be more certain of this conclusion, we conducted a second experiment to determine whether similar results could be obtained when a different type of syntactic ambiguity was tested with an additional group of participants.

5. Experiment 2

The purpose of the second experiment was to attempt to obtain results similar to those of Experiment 1 using different materials and different participants. Most notably, the materials involved a different type of syntactic ambiguity. Sentences contained the noun phrase (NP)/sentence (S) complement ambiguity, which has been the focus of numerous prior studies (Ferreira & Henderson, 1990; Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Kennison, 2001). Example sentences are displayed in 4. In 4a, the plural or singular noun is syntactically ambiguous, as readers typically misanalyse the noun as the direct object of the first verb and only realize the error when the second verb in the sentence is encountered. In 4b, the ambiguity is eliminated by the placement of the word *that* after the first verb.

4 a. Al knew the answer(s) would be in the back of the book. (Ambiguous)
    b. Al knew that the answer(s) would be in the back of the book. (Unambiguous)

If the representation of plural definite descriptions is more complex than those of singular nouns, then reading time should be determined by an interaction of noun type and ambiguity, as the difference in reading time between ambiguous and unambiguous sentences should be larger for sentences containing plural nouns than sentences containing singular nouns.

5.2. Method

Participants. There were 56 additional undergraduates (28 men and 28 women) at a large public university in the south central region of the United States. The average age of participants was 19.76 years old (*SD* =2.33). All participants were native speakers of English, had normal or correct-to-normal vision, and participated in exchange for course credit.

Materials. We constructed 16 sets of items for the experiment. For each set, there were four versions, two that contained the disambiguating word "that," and two that did not. Two versions contained a singular noun, one that was syntactically ambitious and one that was not. Two versions contained a plural noun, one that was syntactically ambitious and one that was not. A complete list of these materials is provided in the Appendix.

Procedure. The procedure was the same as in Experiment 1.

Data Analysis. Data were analyzed using SPSS.

6. Results

Participants' accuracy to comprehension questions for Experiment 2 was 96%. Accuracy did not vary significantly across conditions, as in Experiment 1,, Fs < 1. Mean reading time by presentation region for Experiment 2 is displayed in Table 2. As in Experiment 1, the noun type x ambiguity interaction was not significant, Fs < 1. Readers took longer to process sentences containing a temporary syntactic ambiguity than unambiguous sentences at region 4 (ambiguous: 634 ms vs unambiguous: 586 ms), by participants only, F_1 (1, 55) = 4.42, p =.04, η^2= .07, F_2 <1, and at region 5 (ambiguous: 589 ms vs. unambiguous: 532 ms), F_1 (1, 55) = 7.49, p = .008, η^2= .12, F_2(1, 15) = 58.18, p = .000, η^2= .80. Reading time was not significantly influenced by the type of noun (i.e., singular versus plural); main effects of noun type were not significant for any region (regions 4 to 8, Fs < 1.50 and for region 3, F_1(1, 55) = 3.41, p = .07, F_2 < 1).

7. Discussion

The results of Experiment 2 were similar to those of Experiment 1. There was no support for the view that plural nouns were more difficult to process during sentence comprehension than singular nouns. The presence of a plural noun in a sentence

containing a temporary syntactic ambiguity did not result in increased processing difficulty as compared to the same sentence containing a singular noun. Overall, readers did take longer to process sentences containing a syntactic ambiguity than similar sentences that were syntactically unambiguous.

8. General Discussion

The present research investigated whether sentences containing plural nouns were more difficult to process than sentences containing singular nouns. Prior research conducted using lexical decision tasks, in which plural and singular nouns were processed individually, demonstrated that plural nouns took longer to process than singular nouns. The present paper reported two reading comprehension experiments, in which participants read sentences containing either a plural or singular noun that was part of a syntactically ambiguous or unambiguous phrase. The results of two sentence processing experiments showed that there were no processing costs associated with processing of plural versus singular nouns in sentences containing a temporary syntactic ambiguity. Overall, readers did take longer to process sentences containing a syntactic ambiguity than similar sentences that were syntactically ambiguous. The results add to the growing number of language processing studies failing to observe evidence suggesting that the semantic representations of plural definite descriptions are underspecified for number (Patson, 2016; Patson, George, & Warren, 2014; Patson & Warren, 2011; 2014; 2015).

We acknowledge that a limitation of the present research relates to the fact that we measured reading time using a self-paced moving window. This method requires readers to process text more slowly than they would in a naturalistic reading situation. Other methods of measuring reading time, such an eye movement recording (Rayner, 1988), enable readers to process text in a more naturalistic fashion at rates that are more similar to reading in daily life. Eye movement recording, unlike self-paced methodologies, has the potential to detect relatively small differences in processing, which may provide evidence for the existence of distinct stages of processing. Such differences in processing may not always result in the reader consciously experiencing difficulty during processing. Despite the potential for eye movement recording and the self-paced moving window methodology to produce different patterns of results, prior research in which reading times have been recorded on the same sentences using both methods have found similar, rather than different, overall patterns of processing (Kennison, 2002; 2009).

We anticipate that the present research may serve as an impetus for future studies investigating whether factors that have been found to influence the processing of single words also influence the processing of words when the words are processed in the context of a sentence. We believe that such future studies will be useful for educators involved in the teaching of reading and for practitioners involved in the diagnosis and treatment of reading disorders.

9. Conclusions

The results of the two reading experiments showed that there were no significant differences in reading time for sentences containing plural versus singular nouns in sentences either containing a temporary syntactic ambiguity or sentences in which no ambiguity occurred. The results are consistent with the view that the semantic representations of plural and singular nouns are similar with regards to the specification of grammatical number.

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Appendix

The following list contains the items that were tested in Experiments 1 and 2, respectively. The elements within parentheses occurred in a subset of conditions.

Experiment 1

1. Last summer after Russell visited(,) the (seven, local) orchards ended up producing the best crop in decades.

2. Last summer after Alexander teased(,) the (four, small) ponds in the north field dried up.

3. Last spring before William wrote(,) the (three, nearby) rivers flooded all of the farm land west of the state line.

4. Last weekend when Nathaniel grilled(,) the (five, deep) caves overflowed with a steady stream of rats.

5. On Saturday after Richard paid,(,) the (six, big) clouds turned dark and it began to rain really hard.

6. Recently when Bruce called(,) the (three, large) lakes had been put on a no-fishing alert.

7. Suddenly after Lorraine kicked(,) the (two, high) mountains rumbled loudly as though an earthquake were happening.

8. Yesterday when Jacqueline called(,) the (eight, small) balconies filled with people who were wondering what was happening.

9. Frequently when Zachary pushed(,) the (five, nearby) villages would band together to make the negotiations even more difficult.

10. Occasionally when Samantha cooked(,) the (four, bored) kids would make a lot of noise in the street.

11. Today after Professor Lewis taught(,) the (three, remote) forests began burning because of a spreading wildfire.

12. On Saturday after Patrick cleaned(,) the (seven, public) fountains began to malfunction and stopped working.

13. Typically after Meredith baked(,) the (four, green) pastures become darker and darker because of the setting sun.

14. Today when Bradley threw(,) the (four, far) hills seemed to be close enough for the ball to reach them.

15. Last night when Allison(,) strummed the (ten, long) docks started to be topped with water from the storm surge.

16. This morning when Jonathan hammered(,) the (three, quiet) meadows filled up with birds that had been startled by the sound.

     Experiment 2

1. William knew (that) the answer(s) to the problem was (were) in the back of the algebra book.

2. Catherine forgot (that) the bag(s) near the closet was (were) full of apples and oranges from the farmer's market.

3. Stephen observed (that) the vulture(s) near the carcass was (were) moving around oddly and flappy its large wings.

4. Peter confirmed (that) the date(s) of the visit was (were) a time that he could be there.

5. Raymond accepted (that) the award(s) for the contest was (were) given to someone else.

6. Gregory learned (that) the formulas(s) for the problems was (were) different from the ones discussed in class.

7. Joseph explained (that) the example(s) about the trains was (were) also described in the textbook.

8. Martin announced (that) the event(s) for the athletes was (were) to be held on campus during next year's Homecoming week.

9. Marilyn remembered (that) the mansion(s) was (were) featured in a recent Hollywood movie.

10. Valerie saw (that) the acre(s) of woods was (were) stripped of most of the trees by the logging company.

11. Yvonne resented (that) the accusation(s) about the phone calls was (were) repeated by one of her closest friends.

12. Travis revealed (that) the winner(s) of the prizes was (were) going to receive season tickets for the Oklahoma City Thunder Basketball team.

13. Melissa overheard (that) the rumor(s) about the cheerleaders was (were) spread by some boys on the football team.

14. Victor concealed (that) the reason(s) for the absence was (were) related to his lack of money.

15. Jonathon wrote (that) the story(stories) about the cow was (were) similar to one that he read as a child in Iowa.

16. Meredith   found (that) the book(s) of poetry was left behind on the school bus after the field trip.

Table 1
Mean Reading Time in Milliseconds (Standard Errors) by Presentation Region and by Condition from Experiment 1.

Presentation Region		R4*	R5	R6	R7	R8
Type of Sentence	Type of Noun	*the lake(s)*	*had*	*been*	*put on*	*a no fishing alert*
Ambiguous	Plural	562 (25)	741 (53)	1077 (80)	1004 (52)	1117 (59)
Unambiguous	Plural	625 (35)	774 (43)	981 (76)	911 (44)	1074 (53)
	Difference	-63	-33	+96	+93	+43
Ambiguous	Singular	565 (30)	683 (43)	1098 (67)	1030 (61)	1136 (59)
Unambiguous	Singular	591 (32)	768 (39)	917 (56)	964 (66)	1093 (59)
	Difference	-26	-85	+181	+66	+43

Note: * indicates region containing singular or plural noun.

Table 2
Mean Reading Time in Milliseconds (Standard Errors) by Presentation Region and by Condition from Experiment 2.

Presentation Region		R3*	R4	R5	R6	R7	R8
Type of Sentence	Type of Noun	*the answer(s)*	*would*	*be*	*in the back*	*of*	*the book.*
Ambiguous	Plural	638 (30)	636 (32)	608 (26)	598 (31)	537 (16)	672 (37)
Unambiguous	Plural	712 (49)	580 (21)	551 (20)	581 (26)	546 (22)	680 (33)
	Difference	-74	+56	+57	+17	-9	-8
Ambiguous	Singular	593 (29)	631 (29)	570 (25)	573 (29)	526 (21)	688 (35)
Unambiguous	Singular	642 (38)	591 (24)	553 (2)	589 (25)	571 (25)	710 (33)
	Difference	-49	+40	+17	-16	-45	-22

Note: * indicates region containing singular or plural noun.