University of Massachusetts Occasional Papers in Linguistics

2007

Processing Plural DPs: Collective, Cumulative, and Distributive Interpretations

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Processing Plural DPs: Collective, Cumulative, and Distributive Interpretations[*]

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1.   Abstract and Summary of Findings

This paper investigates the interpretation of sentences containing plural DPs. I consider sentences with plural DPs in both subject and object position, as in (1), which could have collective, cumulative, or distributive interpretations.

(1)   Three architects designed four buildings.

In both the collective and cumulative interpretations, the total number of buildings designed is four. The difference is that with the collective interpretation, all three of the architects collaboratively design all four buildings, while with the cumulative interpretation, it is underspecified as to how many architects design each building. With the distributive interpretation, there are twelve buildings designed; each architect designs four buildings.
     I compare two semantic theories that attempt to account for how these three interpretations are derived. Building on previous theories of lexical cumulativity, Kratzer (2003, 2005) proposes that the collective and cumulative interpretations are derived from the same structure. Verbs enter the syntactic structure with inherently cumulative denotations, and this inherent cumulativity gives rise to these two interpretations. Distributive interpretations, on the other hand, come about via phrasal cumulativity. Kratzer proposes that plural agreement morphology on a DP that is sister to the verb phrase introduces a (*) operator that pluralizes the VP. On this account, the final structure for all three interpretations is the same. However, the distributive interpretation comes about only after the VP has been pluralized by the external (*) operator.
     In contrast, Sternefeld (1998) proposes that collective, cumulative, and distributive

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interpretations are all derived from distinct structures. For Sternefeld, collective interpretations involve no movement of the subject or the object; cumulative interpretations involve movement of either the subject or the object; and distributive interpretations involve movement of both the subject and the object.

Given evidence which suggests that economy principles influence how structures are interpreted (see Anderson 2004), both the Kratzer and the Sternefeld accounts make predictions about processing preferences for these interpretations. On Kratzer's account, the prediction is that there is a preference for collective and cumulative interpretations. These interpretations are available earlier in the derivation than the distributive interpretation. Since distributive interpretations are available only after additional structure has been built, they should be more difficult. As is well-known, Frazier (1979) showed that for garden path sentences, once the parser has committed to a structure, subsequent alterations incur a processing cost. On Kratzer's account we expect distributive interpretations to incur a cost since they involve additional structure. Collective and cumulative interpretations come about automatically via inherent lexical cumulativity, while distributive interpretations involve an additional operation.

On Sternefeld's account, collective interpretations are the most structurally simple, since they do not involve movement. Cumulative interpretations are more complex than collective ones because cumulative interpretations involve one instance of movement. Distributive interpretations are the most complex because they involve two instances of movement. The prediction, then, is that there is a preference for collective interpretations over cumulative and distributive ones and a preference for collective and cumulative interpretations over distributive ones. The crucial point is that structurally simpler interpretations should be preferred to more complex ones and interpretations available earlier in the derivation should be preferred to interpretations available later in the derivation.

The results presented in this paper are consistent with previous studies which have shown that collective interpretations are preferred to distributive ones (Frazier, Pacht and Rayner 1999; Frazier and Clifton 2001; Kaup, Kelter, and Habel 2002). I build on this work by demonstrating that collective and cumulative interpretations are preferred in a wide range of linguistic contexts. In particular, earlier studies examined only sentences with conjoined subjects, and the collective preference could have been due to the form of the subject DP. I show that these interpretations are preferred irrespective of the shape of the subject DP. While the results of a plausibility study find that the items tested displayed a bias toward collective and cumulative activities, I argue that this plausibility bias is not responsible for the preference in all cases. The dispreference for distributive interpretations is consistent with both Kratzer's and Sternefeld's accounts, since distributive interpretations are the most structurally complex on both accounts.

Previous psycholinguistic work has combined the collective and cumulative interpretations and compared them with distributive interpretations. However, to my knowledge no previous research has focused on comparing collective interpretations with cumulative ones. While both the Kratzer account and the Sternefeld account make similar predictions with respect to distributive interpretations being dispreferred, these two accounts differ crucially with respect to whether or not there is a preference for collective interpretations over cumulative ones.

On the Kratzer account, there should be no preference, since both interpretations are available at the same point in the structure. On the Sternefeld account, however, collective interpretations should be preferred, since they involve no movement and are, thus, structurally simpler than cumulative interpretations. I present findings in which there is no significant preference for either collective or cumulative interpretations. This suggests that cumulative

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interpretations are not more structurally complex than collective interpretations and does not provide support for Sternefeld's account.

This paper is organized as follows. Section 2 provides an overview of the type of sentences and interpretations investigated in this paper, as well as a discussion of both semantic theories. Section 3 presents research on economy principles and interpretation, from which the predictions of both semantic theories are derived. Section 4 reviews previous psycholinguistic research on the interpretation of plurals. Section 5 presents the experimental studies. Finally, Section 6 summarizes the main findings and presents questions for further research. The experimental findings are highlighted below.

- Experiments 1 and 2 find that the collective/cumulative interpretation is preferred to the distributive one and that this preference holds across subject types. These results build on the findings of previous researchers and support the accounts of both Kratzer and Sternefeld.

- Experiment 3 finds that there is a plausibility bias against distributive activities. It seems that it is difficult to tell whether the predictions made by Kratzer and Sternefeld are actually borne out or if the plausibility bias is masked as a linguistic bias. However, I show that the bias against distributive activities is not responsible for the preference for collective/cumulative interpretations in all cases. Thus, there remains tentative support for the Sternefeld and Kratzer accounts that distributive interpretations are more complex.

- Experiment 4 finds that there is no significant preference for either collective or cumulative interpretations. These results do not provide support for Sternefeld's proposal that cumulative structures are more complex.

2. Background and Semantic Literature Review

This paper investigates the processing preferences for two types of ambiguity. First, I consider sentences which are presented as ambiguous between a collective/cumulative interpretation and a distributive interpretation. For these studies, I refer to the former as the 'C' interpretation and to the latter as the 'D' interpretation. Second, I consider sentences that are presented as ambiguous between a collective interpretation and a cumulative interpretation. The sentence in (1), repeated below in (2), displays a three-way ambiguity.

(2)   Three architects designed four buildings.

Assuming surface scope, in the collective interpretation of (2) all three architects worked together to design all four buildings. In other words, a total of four buildings were designed and each of the buildings was designed by a team comprised of the three architects. In the cumulative interpretation, it is also the case that a total of four buildings were designed. However, it is not necessary that all three architects worked on each building. It could be that two of the architects designed two buildings and that one architect designed the other two buildings. It is possible, however, that all three architects worked collaboratively to design all four buildings. In this sense, the collective interpretation is subsumed under the cumulative interpretation. The key distinction between these two interpretations is that in the collective interpretation all three architects necessarily participate in designing each of the four buildings,

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while in the cumulative interpretation, the number of architects involved in designing each building is underspecified.

There is also a distributive interpretation for (2). Unlike in the collective and the cumulative interpretations, with the distributive interpretation, a total of twelve buildings were designed. Here, each architect independently designs four buildings.[1] It should be noted that I only consider subject distributive interpretations, as described above. There is also an object distributive interpretation in which there is a total of twelve architects in a sentence such as (2). This interpretation fits a scenario in which each of the four buildings is designed by distinct groups of three architects. The distinction between these two types of distributive interpretations is important because they have different structures on the Kratzer account (and presumably on the Sternefeld account as well). The subject distributive interpretation is derived from merging a subject DP with plural morphology, and inserting a (*) operator that pluralizes the VP. However, the object distributive interpretation requires an additional step. After the subject is merged, the object is moved over it. Kratzer (2003, 2005) predicts that this interpretation should be extremely difficult to access, since the object moves only for the purpose of making the object distributive interpretation possible.

Kratzer's prediction that the object distributive interpretation is strongly dispreferred was confirmed for sentences such as (2). Four people were given the sentence in (2), along with two other sentences with the same structure, shown in (3).

(3)   a. Two mechanics winterized five cars.
        b. Two lawyers negotiated seven settlements.

Participants were asked to give the paraphrase that first came to mind. Two participants gave responses corresponding to the collective interpretation for all three sentences, while the other two participants gave responses corresponding to the cumulative interpretation for all three sentences.[2] Participants were then given paraphrases for the subject distributive and the object distributive interpretations. Participants were asked to indicate whether each sentence could have those interpretations and to indicate how difficult each of those interpretations was. Three participants indicated that the subject distributive interpretation was possible and somewhat difficult to access, and that the object distributive interpretation was not possible. One participant gave the opposite set of responses, indicating that the subject distributive interpretation was not possible, while the object distributive interpretation was somewhat difficult.[3] Because it appears

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[1] What I have described as cumulativity is sometimes referred to as weak distributivity (e.g. Sternefeld 1998), because the activity described in the VP is somehow distributed among the agents denoted by the subject. What I have termed distributivity is sometimes referred to as strong distributivity (also Sternefeld 1998) because the activity described in the VP is necessarily distributed to each individual agent denoted by the subject.

[2] Of course, it is possible that there is a carry-over effect. Since this was such a short study, it is possible that subjects simply stayed with the interpretation that they picked for the first item. As discussed in Section 5.4, a similar carry-over effect might have influenced the responses of some subjects in Experiment 4. However, factoring these subjects out of Experiment 4 did not change the overall findings. Even if there was a carry-over effect in the current mini-study, it is not clear that this has an effect on the overall findings.

[3] That one participant found the object distributive interpretation possible and the subject distributive interpretation inaccessible is surprising. It is not clear why this is the case.

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that the object distributive interpretation is highly dispreferred – impossible for three of four participants – the studies presented in this paper focus only on the subject distributive interpretation. For clarity, when I refer to Kratzer's account of the distributive interpretation, I am referring only to the subject distributive interpretation. The Kratzer account is explained in more detail below.

2.1. Semantic Theories of Plurality - What Structures Determine What Meanings?

This section provides an overview of both the Kratzer and the Sternefeld accounts. After a discussion of the role that economy plays in interpretation, we will be able to derive processing predictions for these two theories.

2.1.1. The Interpret Early Account

As discussed above, Kratzer (2003, 2005) proposes that the C interpretations for sentences such as (2) follow from lexical cumulativity, in which it is argued that verb denotations are inherently plural (see Krifka 1992 and Landman 1996 for discussion). These two interpretations are derived from the same structure and are available at the same point in the derivation. Kratzer assumes that verb roots are merged with cumulative denotations. Therefore, verb roots inherently contain collective and cumulative interpretations. Distributive interpretations, on the other hand, come about via phrasal cumulativity. The D interpretation is available because plural morphology on a DP that is sister to the verb phrase introduces a (*) operator. This distinction is explained below.

In a sentence such as *Mary and John fell*, there are two falling events, one by Mary and one by John, represented in (4a). When the predicate [|fall|] is starred, the summing up of those two falling events is included in the extension, as shown in (4b).

(4) a. $[|fall|] = \{<John, fall_1 >, <Mary, fall_2>\}$

b. $[|*fall|] = \{<John, fall_1 >, <Mary, fall_2>, <John+Mary, fall_1,+ fall_2>\}$

(Kratzer 2005:1)

The crucial point here is that starring the predicate includes the two falling events in which Mary and John are agents, respectively, as well as the sum of those two falling events. Starring the verb's denotation always includes the extension of the unstarred denotation.

This analysis extends to sentences with quantifiers, such as the ones considered in the current studies. The sentence in (5) contains numeral quantifiers in both subject and object position.

(5) Two children lifted two boxes.   (Kratzer 2005:10)

In (5) the verb *lifted* automatically introduces a (*) operator and the collective and cumulative interpretations become available. The two children could have lifted the two boxes together or one child could have lifted one box while the other child lifted the other box. In order to get the distributive interpretation, the plural morphology on the subject DP introduces another (*) operator. This happens because Kratzer assumes

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(following Sauerland 2005) that in plural DPs, both the determiner and the noun come with distinct number projections, as shown in (6).

(6)

    [plural]

        D

          [plural]

             classifier   N
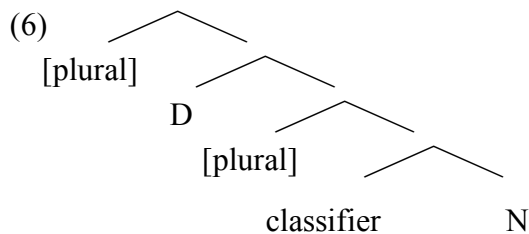
Kratzer proposes that the lower [plural] feature pluralizes the noun, but that the higher [plural] feature is uninterpretable within the DP. This feature moves out of the DP and creates a verbal inflectional head right below the DP. This movement results in a (*) being inserted, the function of which is to pluralize its sister VP, as shown in (7).

(7)

  DP   pluralized sister predicate

      [plural] = *   (Kratzer 2005:27)
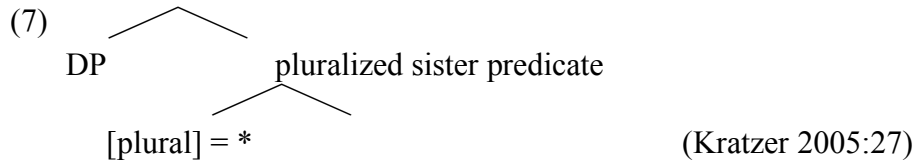
The result of this movement and (*) insertion is that the distributive interpretation becomes available. The structure in (7) allows us to obtain a meaning for (5) in which one child lifts two boxes and the other child also lifts two boxes.

      Kratzer uses data from German to motivate the proposal that plural agreement morphology on the sister DP is responsible for distributive interpretations. In sentences such as (8a), when the plural DP is low, the distributive interpretation is not available.

(8)   a. Ich hab' 10 Minuten lang zwei Hasen   gestreichelt
         I   have 10 minutes long two   rabbits petted
         'I petted a group of 2 rabbits for 10 minutes.'
       b. Ich hab' zwei Hasen 10 Minuten (lang) gestreichelt
         I   have two rabbits 10 minutes (long) petted
         'I petted 2 rabbits for 10 minutes each.'   (Kratzer 2003:117)

In (8a), the plural DP, 'two rabbits' remains low in the VP. However, in (8b), the object has shifted higher in the structure. The distributive interpretation is now available because the moved plural DP introduces a (*) operator that pluralizes the VP.

      Kratzer proposes the representation in (9) for the sentences such as (5). The (*) that is responsible for lexical cumulativity is not shown. In (9), the (*) that is external to the VP is introduced by the plural morphology on '2 children'.

(9)   (2 children) * [lifted 2 boxes]   (Kratzer 2005:16)

Crucially, the representation in (9) covers both the C and the D interpretations. The C interpretations are automatic, as verb roots are inherently cumulative. Since starring the VP

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always retains the original extension, the (*) operator in (9) pluralizes the VP and gives rise to distributive interpretations, while retaining the collective and cumulative interpretations. The crucial distinction between 'C' and 'D' interpretations is that 'C' interpretations are available as soon as the verb is merged and do not require movement of the morphologically plural DP.

Kratzer's proposal allows a single representation to cover a wide range of scenarios. We do not need to posit structures that are unique to collective, cumulative, and distributive interpretations. While (9) covers all three interpretations, the interpretations are available at different points in the derivation. On this theory, there is a maximally simple structure that removes from the semantics the burden of accounting for every scenario that satisfies a sentence's truth conditions.

It should be noted that a crucial element of Kratzer's proposal is that it is cast in the framework of an event semantics. The earlier account discussed in the next section does not employ an event semantics and proposes that distinct truth conditions are satisfied by distinct structures.

2.1.2. *The Distinct LFs Account*

According to Sternefeld's (1998) account, there is a near one-to-one match between LF representation and interpretation. Crucially, on Sternefeld's proposal, the collective interpretation is derived without LF movement of the subject or the object, whereas various cumulative interpretations are derived via one instance of lambda abstraction in which either the subject or the object is moved. The distributive interpretation, however, is derived via two instances of lambda abstraction. Sternefeld proposes six possible structures for sentences such as (10). The LF representations and syntactic structures in (11) - (16) correspond to Sternefeld's examples (20) and (22).

(10)   Five men lifted two pianos.   (Sternefeld's (19))

The structure in (11) represents the collective interpretation. In this interpretation, there is one event of five men together lifting two pianos at the same time (one piano is stacked on top of the other). Though this scenario is implausible, the reading exists, nonetheless.

(11)   Collective interpretation
        LF: $(\exists X)$(`five (X)` $\wedge$ `*man(X)` $\wedge$ $\exists Y$)(`two (Y)` $\wedge$ `*piano(Y)` $\wedge$ `lift (X,Y)`))
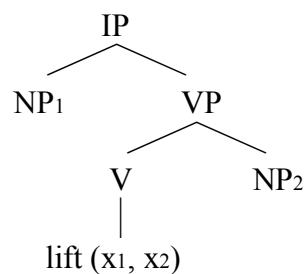
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In (11) there is no lambda abstraction, and therefore, no LF movement. There are (*) operators which pluralize [|man|] and [|piano|], but crucially, there is no (*) within the verbal projection, so we get the reading in which there is only one activity of lifting. The structure in (11) is in stark contrast to the proposed structure under the Kratzer account. As explained in the previous section, starring the verb is obligatory, but the possible interpretation in which there is only one event is retained. For Sternefeld, starring the verb is optional and the interpretation in which there is only one event is derived from a structure in which the verb is not starred. We can contrast the representation in (11) with the representations Sternefeld proposes for cumulative interpretations. In (12) – (15), the various cumulative interpretations are represented.

(12)   Cumulative 1
        LF: $(\exists X)$ (five(X) $\wedge$ *man(X) $\wedge$ X $\in$ *λx[$(\exists Y)$(two(Y) $\wedge$ *piano(Y)
              $\wedge$ lift(x,Y)))
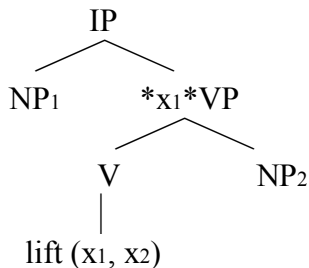
In this interpretation there are subsets of the five men and these subsets jointly lift two pianos. The crucial distinction between (11) and (12) is that in (12) there is lambda abstraction of [|men|]. These subsets are necessarily engaged in distinct activities of lifting two pianos. We necessarily have a set that contains two pianos, though these two pianos need not be the same. Unlike in (11), in which there is necessarily a set that contains five men, in (12) the number of men in each set is not specified. Crucially, in (12) there is more than one activity of lifting.

        In the representation in (13), the five men jointly lift two pianos and it is possible that each piano is lifted by five men at a time.

(13)   Cumulative 2
        LF: $(\exists X)$ (five(X) $\wedge$ *man(X) $\wedge$ $(\exists Y)$(two(Y) $\wedge$ *piano(Y) $\wedge$ Y $\in$
              *λy [lift(X,y)]))
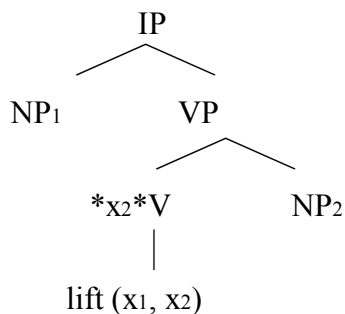
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The distinction between (12) and (13) is that the object is lambda abstracted over. Here, the objects are not necessarily lifted as a group, but the men necessarily act as a group. This LF covers readings in which there is necessarily a set of five men and these five men work together to lift two pianos. However, the pianos need not be lifted at the same time. We could have two activities of lifting which involve all five men, and in each activity one piano is lifted.

In the representation in (14), five men lift two pianos at a time, but the number of pianos lifted is independent of the number of men in the set.

(14)   Cumulative 3
LF: $(\exists X)(\text{five}(X) \wedge \text{*man}(X) \wedge (\exists Y)(\text{two}(Y) \wedge \text{*piano}(Y) \wedge X \in$
$\text{*}\lambda x[\text{lift}(x,Y)]))$

```
                IP
              /    \
          NP₁       VP
                  /    \
            *x₁*V       NP₂
               |
         lift (x₁, x₂)
```
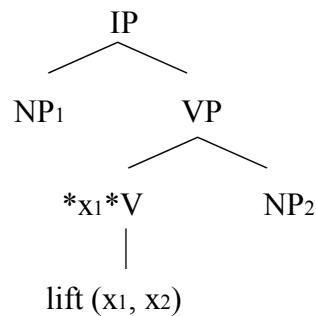
This LF is quite similar to the one in (12), but instead of having a (*) at the VP projection, here the (*) is at the level of the verb. There could be groups consisting of any number of men lifting two pianos.

The representation in (15) is what Sternefeld calls the "pure cumulative". The groups of men and the groups of pianos are completely underspecified.

(15)   Cumulative 4
LF: $(\exists X)(\text{five}(X) \wedge \text{*man}(X) \wedge (\exists Y)(\text{two}(Y) \wedge \text{*piano}(Y) \wedge$
$<X,Y> \in \text{**}\lambda xy[\text{lift}(x,y)]))$

```
                IP
              /    \
          NP₁       VP
                  /    \
        *x₁,*x₂*V       NP₂
               |
         lift (x₁, x₂)
```
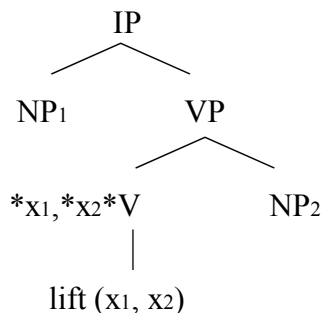
In this interpretation, each of the five men and each of the pianos is involved in an activity of lifting, but it is not specified how many men lift how many pianos. It could be that two men lift one piano and three men lift the other piano. It could also be that all five men lift the two pianos separately or at the same time.

The final structure that Sternefeld proposes represents the distributive interpretation

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(what Sternefeld calls the "pure distributive"). In this interpretation, represented in (16), there are subsets of men and subsets of pianos, with each subset of men lifting each subset of pianos.

(16)   Distributive
        LF: $(\exists X)$(five(X) $\wedge$ *man(X) $\wedge$ $(\exists Y)$(two(Y) $\wedge$ *piano(Y) $\wedge$ X $\in$
        *λx[[Y $\in$ *λy[lift(x,y)]]]))

```
            IP
          /    \
       NP₁      VP
              /    \
      *x₁**x₂*V     NP₂
              |
         lift (x₁, x₂)
```
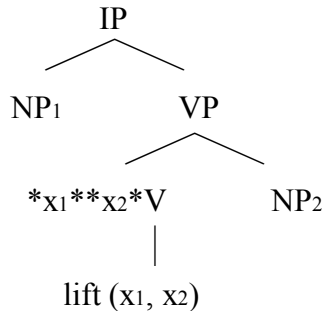
In (16) each man independently lifts two pianos, but it is not specified how the activity of lifting occurs. It is possible that one man lifts one piano at a time and another man lifts both pianos while they are stacked on top of each other. The point here is that it is necessarily the case that each man is the sole agent of at least one lifting event. What distinguishes the distributive representation from the various cumulative interpretations is that in (16) there are two instances of lambda abstraction. Interestingly, Sternefeld does not propose a structure for the object distributive interpretation. There is not a representation which necessarily means that there are ten men, with each of the two pianos lifted by a distinct group of five men.

The next section discusses psycholinguistic work processing quantifiers, the key finding being that structurally complex interpretations are costly. After a discussion of these findings, we will be able to outline the processing predictions made by both Kratzer's and Sternefeld's accounts.

3.   Economy and Interpretation

Economy principles guide interpretation. For example, Tunstall (1998) proposes the Principle of Scope Interpretation, which states that the default scope in multiply-quantified sentences is determined by the surface structure. Additionally, Tunstall argues that the default scope is preferred unless there is evidence to compute another scope. Anderson (2004) builds on this idea and proposes a principle of Processing Scope Economy which states that computing a more complex representation is more costly than computing a simpler representation.

(17)   Processing Scope Economy: The human sentence processing mechanism prefers to compute a scope configuration with the simplest syntactic representation (or derivation). Computing a more complex configuration is possible but incurs a processing cost.

<div align="right">(Anderson's (46))</div>

In particular, Anderson provides evidence that processing inverse scope is more difficult than processing surface scope for sentences such as (18).

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(18)   a. A climber scaled every cliff.   (Anderson's (18))
        b. Every climber scaled a cliff.

Assuming the system proposed in Heim and Kratzer (1998) for quantifier movement and lambda abstraction, in the surface scope interpretation, the subject raises out of its base VP-internal position and the object raises from its base position to a higher VP internal position, as shown in (19).

(19)   <t>   (Anderson's (19))

        DP <<e,t>,t>   <e,t>
        a climber   [λy. y scaled every cliff]

                              2   VP <t>

                        DP <<e,t>,t>   <e,t>
                        every cliff   [λx. t₂ scaled x]

                                   1   VP <t>

                                         <e>   V' <e,t>
                                         t₂

                                              V <e<e,t>>   <e>
                                                scaled   t₁
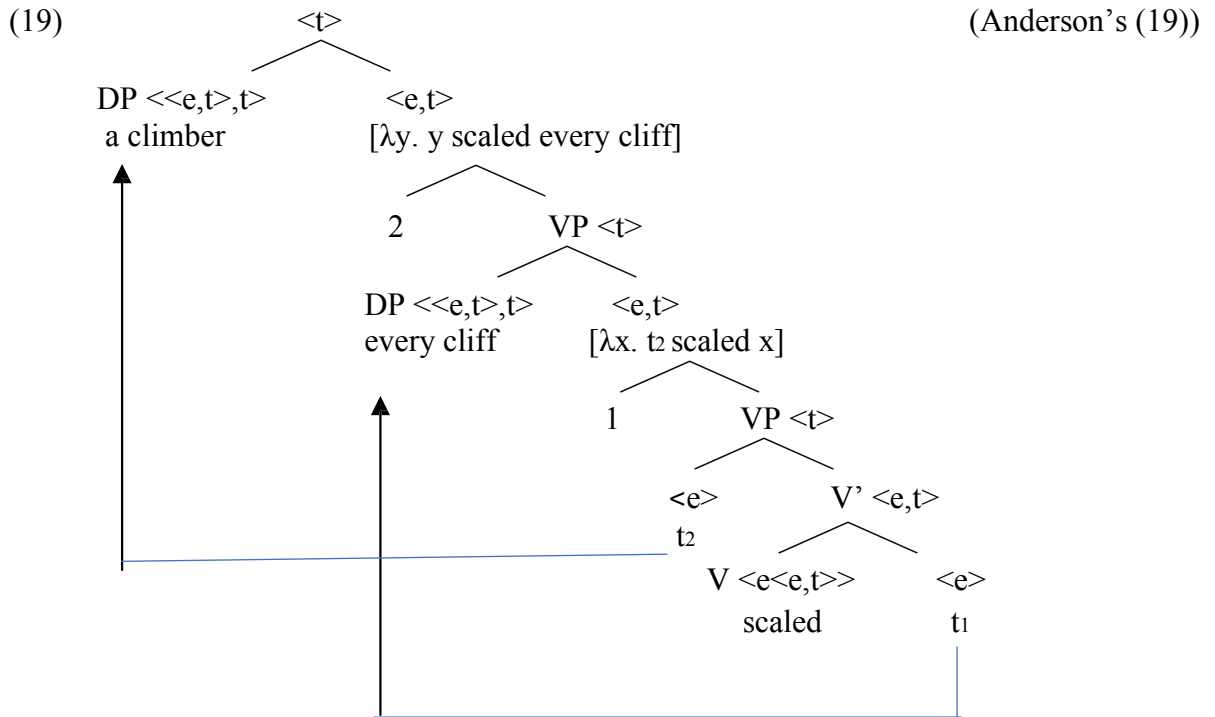
In order to get the inverse scope interpretation, the object moves twice, first to a higher VP-internal position and then to a position above the subject, as shown in (20).

(20) $\langle t \rangle$ (Anderson's (20))

DP $\langle\langle e,t\rangle,t\rangle$ $\langle e,t\rangle$
every cliff   [λx. a climber scaled x]

      1        $\langle t \rangle$

     DP $\langle\langle e,t\rangle,t\rangle$ $\langle e,t\rangle$
     a climber   [λy. y scaled t_1]

       2   VP $\langle t \rangle$

       DP $\langle e\rangle$ $\langle e,t\rangle$
       t_1 [λx. t_2 scaled x]

        1   VP $\langle t \rangle$

        $\langle e\rangle$ V' $\langle e,t\rangle$
        t_2

        V $\langle e\langle e,t\rangle\rangle$ $\langle e\rangle$
        scaled t_1
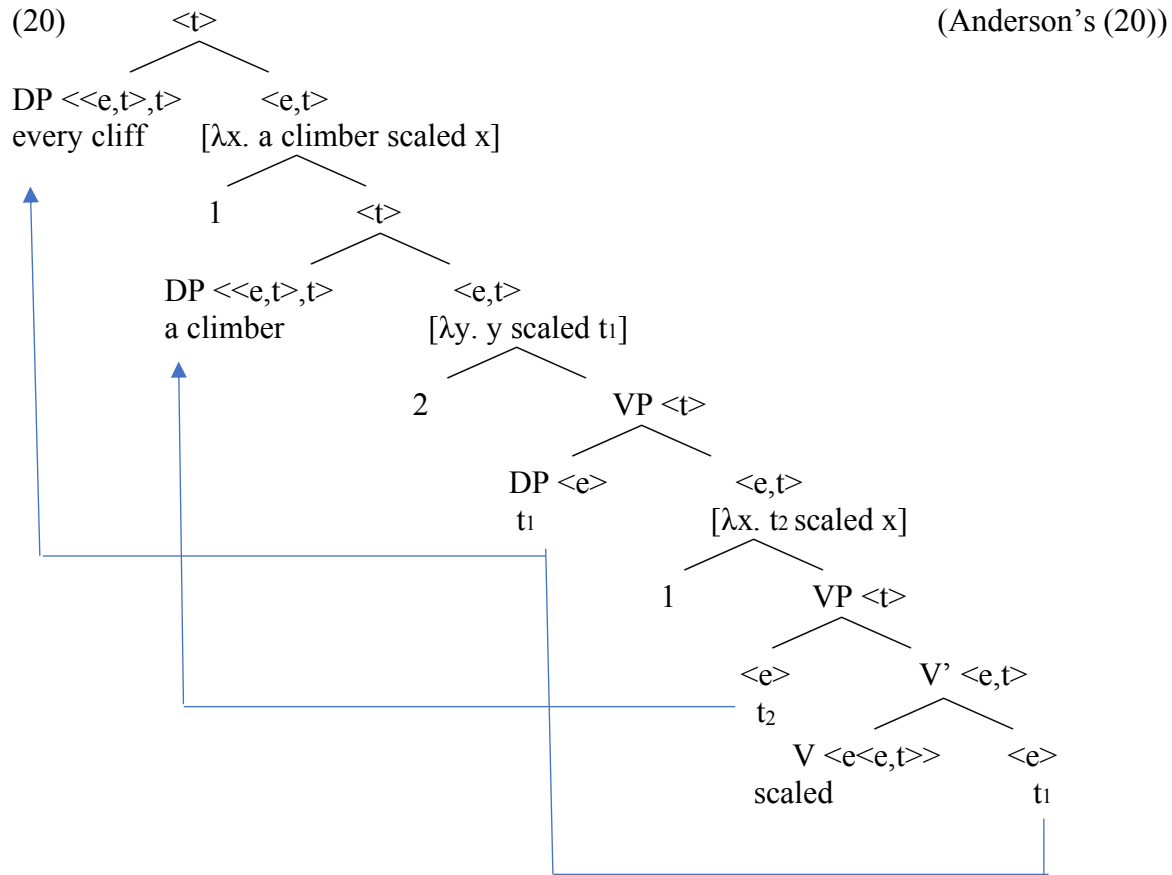
On this account inverse scope is more structurally complex than surface scope because inverse scope involves an additional movement of the object, and building additional structure for the final landing site.

It should be noted that while Anderson adopts the QR account of scope interpretation as her working theory, she is not committed to it. She discusses two other types of analyses. The first is a flexible types account, in which inverse scope interpretations are obtained from type- shifting a determiner. The other is a Combinatory Categorial Grammar approach in which scope is determined by the timing of an operation that specifies the indefinite. It should also be noted that within an event semantics system, such as that proposed by Kratzer (1996), the verb *scaled* would actually be of type $\langle e\langle st\rangle\rangle$ because it would only have one argument, the object. The agent is an external argument, which would be introduced via event modification. On this account, the object would not need to move in (19) in order to be interpreted, and it would move only once in (20) to obtain scope over the subject. The object moves for interpretive reasons, not because there is a type mismatch. Adopting this proposal does not change the larger point. The inverse scope is still more structurally complex because it requires that the object move higher than the subject, which means that additional structure needs to be built. The crucial point here is that the more structurally complex interpretation incurs a processing cost.

Anderson conducted a series of studies which confirmed that inverse scope is more

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difficult to process, both with and without contextual information. In an off-line questionnaire, Anderson found that without context, surface scope interpretations were preferred 81% of the time for sentences such as (18a). Another study found that when the context supported a surface scope interpretation, 81% of the responses were for surface scope interpretations, but when the context supported an inverse scope interpretation, only 53% of the responses were for inverse scope interpretation. These results established that surface scope is the default interpretation for doubly quantified sentences

In another experiment, doubly quantified sentences such as (21a) were embedded in contexts biased toward either surface or inverse scope and in which there was a disambiguating sentence that contained either a singular or a plural subject, as in (21b).

(21)   a. An experienced climber scaled every cliff./ Every experienced climber scaled a cliff.
         b. The climber was very skilled/The climbers were very skilled.
                                                          (Anderson's (65)-(66))

For the *a…every* sequence, the singular subject disambiguates to surface scope and the plural subject to inverse scope. For the *every…a* sequence, the plural subject disambiguates to surface scope and the singular subject to inverse scope. In both the *a…every* sequence, and the *every…a* sequence, the inverse scope disambiguating sentence was read more slowly than the surface scope disambiguating sentence. This was the case even when the context supported an inverse scope interpretation.

Finally, another study confirmed that inverse scope interpretations are processed more slowly than surface scope interpretations. When respondents assigned the inverse scope interpretations to sentences such as (22a) – as indicated by responses to a comprehension question (22b) – they took longer to read the sentence than when they assigned the surface scope interpretation.

(22)   a. A paratrooper jumped from every plane.
         b. How many paratroopers jumped from planes?
                    One (surface) Several (inverse)   (Anderson's (78))

While the interpretations for the sentences investigated in the current studies assume surface scope, Anderson's findings are relevant because of the more general claim that structurally complexity equals processing difficulty in constructions containing an ambiguity. We can use Anderson's work to make predictions about Kratzer's and Sternefeld's accounts. Sternefeld's proposal predicts that the collective interpretation should be preferred to the cumulative and the distributive and that both the collective and the cumulative should be preferred to the distributive. This is straightforward, since the collective interpretation is the structurally simplest and the distributive interpretation is the most structurally complex. The complexity is directly correlated with the amount of movement required to obtain each interpretation.

Kratzer's proposal, on the other hand, predicts that neither the collective nor the cumulative interpretation should be preferred to the other, but that both of these interpretations should be preferred to the distributive interpretation. On this account distributive interpretations are available later in the derivation. Collective and cumulative interpretations

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are available as soon as the verb root is merged. Kratzer proposes that the [plural] feature needs to move out of the DP in order to be interpreted. It is this movement which introduces the (*) operator that pluralizes the VP. Only after this (*) has been introduced is the distributive interpretation available. The predictions for both accounts are shown in (23).

(23)   Processing Predictions
        a. Sternefeld: collective > cumulative > distributive
        b. Kratzer: collective/cumulative > distributive

The findings of additional psycholinguist research suggest that collective interpretations are preferred to distributive ones, confirming the predictions of both accounts.

4.   Psycholinguistics Research

Work by Frazier, Pacht and Rayner (1999) was concerned with whether the representations for sentences with collective and distributive interpretations are vague or ambiguous. In particular, they assumed the Minimal Semantic Commitment (MSC), which states that "only necessary or invited semantic commitments are made" (Frazier, et al. 1999:88). The MSC predicts that if a representation is ambiguous, the processor commits to one interpretation. If a representation is vague, the processor waits to get disambiguating information before committing to an interpretation. The study involved an eye movement experiment which tested reading times for sentences where the collective or distributive interpretation was forced either before or after the verb. Example items are shown in (24).

(24)   a. Lynne and Patrick saved $1000 **each** to pay for their honeymoon.
            (late disambiguation, distributive)
        b. Lynne and Patrick saved $1000 **together** to pay for their honeymoon.
            (late disambiguation, collective)
        c. Lynne and Patrick **each** saved $1000 to pay for their
           honeymoon. (early disambiguation, distributive)
        d. Lynne and Patrick **together** saved $1000 to pay for their honeymoon.
            (early disambiguation, collective)   (Frazier et al.'s (7))

In (24a) *each* appears after the verb *saved* and encodes the distributive interpretation, while in (24b) *together* appears after the verb and encodes the collective interpretation. Conversely, in (24c) the distributive *each* appears before the verb and in (19d) the collective *together* appears before the verb. If sentences such as (24) are vague, then the difference in complexity between (24a) and (24b) should be the same as the difference in complexity between (24c) and (24d). The operator that is responsible for the distributive reading would have to be inserted in both (24a) and (24c), so whatever processing cost is associated with that operator should affect the relationship that each sentence has with its collective counterpart. However, if these sentences are ambiguous, then the processor would make a commitment to one interpretation. If the processor commits to a default collective interpretation, the difference between (24a) and (24b) should be greater than the difference between (24c) and (24d). This is because in (24a) and (24b) the disambiguating *each* or *together* comes after the verb. If the processor commits to the collective interpretation, then the structure would need to be changed

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– i.e., a distributive operator inserted – and this altering of the structure should result in longer reading times. While (24c) is also distributive, the structure does not have to be revised because *each* comes before the verb. According to the ambiguity hypothesis, processing the sentence in (24c) requires inserting a distributive operator, while processing the sentence in (24a) requires not only inserting a distributive operator, but doing so after the processor has committed to the collective interpretation.

Frazier, et al. found that, in the late disambiguation condition, the distributive sentences (24a) were read more slowly than the collective sentences (24b). Additionally, the number of regressive eye movements in the late disambiguation distributive sentences compared to the late disambiguation collective sentences was found to be significant. (Frazier et al. 1999:97-100) These findings suggest that the processor commits to the collective reading while processing the predicate unless there is a reason to postulate a distributive operator and provide evidence that inserting a distributive operator involves altering the representation and not simply specifying an underspecified representation. These findings also suggest that the collective interpretation is the default. If distributive readings are derived from some additional operator, either a distributive operator or from LF movement, then it seems plausible that such an operator would only be inserted when evidence for it is given.

Frazier and Clifton (2001) found that sentences which describe multiple events take longer to interpret than those which describe a single event, again suggesting that collective interpretations are preferred to distributive interpretations. For instance, the sentence in (25a) has a distributive bias since it is not plausible that there is one activity of putting on makeup with both Lucy and Susan serving as agents. However, in (25b) it could be the case that Betty and Ben played tennis with each other or that they each played tennis with other people.

(25)   a. Lucy and Susan put on make-up. (Distributive bias)
        b. Betty and Ben played tennis. (Distributive or collective) (Frazier and Clifton's (i))

The experiment consisted of a visual acceptability judgment task in which sentences appeared on a screen and subjects pulled one of two triggers to indicate if the sentence was acceptable or unacceptable. It was found that decisions were made more quickly about (25b) than (25a). This is consistent with the findings of the previous study. Since (25b) can plausibly be interpreted as either distributive or collective, it appears that the default collective interpretation is accessed immediately. However, in (25a) it seems that there is a cost associated with processing the distributive interpretation. Additionally, decisions were made more quickly about sentences such as (26a) than about sentences such as (26b) and (26c).

(26)   a. Jenny and David called.   (conjoined subject)
        b. Jenny called and David did too.   (conjoined sentences)
        c. Jenny called. David did too.   (separate sentences)

(Frazier and Clifton's (3))

Sentences such as (26a) are ambiguous between the collective and the distributive interpretation. However, sentences such as (26b) and (26c), which contain elided VPs, are biased toward a distributive interpretation. The sentential conjunction and the two separate sentences have a bias toward separate events. The slower decision times about the sentences

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in (26b) and (26c) suggest that the processor wants a collective interpretation and the distributive interpretation incurs a cost. If there was no preference for either interpretation, there should be no difference in the decision times.

These two studies provide evidence that there is a strong preference for collective interpretations. Taken together with the research that suggests structurally simpler interpretations are preferred, it seems that collective interpretations are preferred because they are less complex than distributive interpretations. What is not clear, however, is whether this preference is limited to conjoined subjects. It could be that the collective preference is an artifact of the examples and that DPs containing conjoined proper names have a bias for a collective interpretation.

Other research has found that the form of the subject DP can determine whether a collective or a distributive interpretation is accessed. In a study of the interpretation of plural DPs in German, Kaup, Kelter, and Habel (2002) found that *beide* 'both' has a distributive meaning and *sie* 'they' has a collective meaning. These researchers were attempting to resolve the issue of whether a plural DP is represented as discrete entities (tokens) or as a single whole (an assemblage) and whether a token or assemblage interpretation was a property of the DP or of the verb. They found that the form of the DP determines whether the sentence receives a collective or distributive interpretation.

In an off-line questionnaire, participants were presented with sentences such as those in (27) and asked a question such as in (28).

(27) a. They brought a gift.
      b. Both brought a gift.   (Kaup et al's (24))

(28) How many gifts were brought?   (Kaup et al's (25))

For the 'they' sentences, there was a statistically significant preference for the collective interpretation, represented by the response "one gift." For the 'both' sentences, there was a statistically significant preference for the distributive interpretation, represented by the response "two gifts." Participants also rated the acceptability of sentences such as in (27) and the pronoun was not found to have a significant effect on acceptability. However, participants also rated the acceptability of sentences in which either *they* or *both* was the subject but in which the predicate could only have a collective interpretation, as in (29).

(29) They/both met at the cinema. (Kaup et al 2002:24)

These sentences were rated significantly more acceptable when the subject was 'they' than when it was 'both'. These results of another study conducted by Kaup et al confirm that 'they' has a collective interpretation, while 'both' has a distributive interpretation. Here it was found that participants were more likely to use 'they' when the referents of the pronoun share common traits. Having common traits increased the likelihood that the referents of the pronoun would be represented as a group. However, participants were more likely to use 'both' when the referents of the pronoun did not share common traits. Having the referents differentiated increased the likelihood that they would be represented as tokens. The results of this study are discussed in more detail in Section 5.2.

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5.   Experiments

5.1.   Experiment One

Experiment One was a pilot study with two goals. The first goal was to explore whether the C preference was constant across different types of subjects. Given the psycholinguistic work discussed above, there remain questions about whether the form of the subject DP matters. While Frazier, Pacht and Rayner (1999) and Frazier and Clifton (2001) found that distributive interpretations are dispreferred, it is not clear whether these results were an effect of the form of the subject DP. All items contained subjects with conjoined proper names. Since Kaup, Kelter, and Habel (2002) explicitly showed that the collective and distributive interpretations are dependent on the form of the subject DP in German, there could be a similar effect in English. The second goal was to explore whether the distributive interpretation could be primed by creating a bias toward multiple events.

5.1.1.   Subjects, Materials, and Procedure

Participants were 24 University of Massachusetts undergraduates who were taking an undergraduate linguistics course. Subjects received course credit. The experiment consisted of an off-line questionnaire survey in which participants were given a scenario in which the object DP in the target sentence contained a numeral quantifier. Following the scenario and target sentence were two numbers: one that corresponded to the 'C' interpretation and one that corresponded to the distributive 'D' interpretation. This is exemplified in (30).

(30)   Three pregnant women ate six pieces of chocolate.
             How many pieces of chocolate were eaten?   6   18

In (30) the response '6' indicates the 'C' interpretation and a response '18' indicates a D interpretation. Subjects were instructed to circle the number that best corresponded to their interpretation of the sentence. There were 8 items and 4 conditions for each item. Surveys were counterbalanced so that each participant received one condition for each item. The survey also contained 21 filler items.
    There were two conditions for the predicates: those which intuitively seemed neutral with respect to the plausibility of the 'C' interpretation and the plausibility of the distributive interpretation and those which intuitively seemed to have a plausibility bias toward a distributive interpretation.[4] The list of predicates is shown in (31).

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[4] One flaw of this study is that the predicates were not classified as neutral or distributive-biased based on any independent tests. A better route would have been to use intrinsically distributive verbs (Lasersohn 1988). Schwarzschild (2007) also proposes that some predicates are "stubbornly distributive", but it is not clear that the predicates listed here as having a distributive bias are stubbornly distributive.

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(31)   Experiment One VPs[5]

Neutral Predicates	Distributive-biased Predicates
…ate six pieces of chocolate	…drank three glasses of soda
…winterized ten cars	…ironed four shirts
…designed four buildings	…knitted three scarves
…abducted three children	…called fifty homes

There were three conditions for the subject DP, with each target sentence preceded by at least one sentence that provided context. The subject conditions were: (1) plural subject with numeral quantifier; (2) plural subject with definite determiner; and (3) plural subject with conjoined proper names. Additionally, there was a fourth condition. The plural subject with conjoined proper names was preceded by a scenario that was biased toward separate events. An example item from each condition is listed in (32) – (35).

(32)   *Numeral Subject*
Patients were sitting in the waiting room at the doctor's office. <u>Three pregnant women ate six pieces of chocolate.</u>
        How many pieces of chocolate were eaten?   6   18

(33)   *Definite Determiner Subject*
Three pregnant women were sitting in the waiting room at the doctor's office. <u>The women ate six pieces of chocolate.</u>
        How many pieces of chocolate were eaten?   6   18

(34)   *Conjoined Proper Names*
Jane, Mary, and Susan are pregnant and were sitting in the waiting room at the doctor's office. <u>Jane, Mary, and Susan ate six pieces of chocolate</u>.
        How many pieces of chocolate were eaten?   6   18

(35)   *Conjoined Proper Names/Multiple-Event Bias*
Jane, Mary, and Susan are pregnant and they go to the same doctor. They often snack on candy while sitting in the waiting room. It turned out that they all had appointments last Thursday. Jane's appointment was at 9:00 a.m.; Mary's was at 10:00 a.m.; and Susan's was at 11:00 a.m. <u>Jane, Mary, and Susan ate six pieces of chocolate.</u>
        How many pieces of chocolate were eaten?   6   18

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[5] The survey also contained items in which the object DP contained an indefinite. The results for these items were largely consistent with the overall findings. For the three subject conditions, the C interpretation was preferred. However, for the condition with conjoined proper names embedded in a context supporting multiple events, there was a 50%-50% split between the C and D interpretations. The form of the object DP was not under investigation, but it does seem to have some effect.

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The items exemplified in (32) – (34) are designed to test whether the C preference holds across various subject types. The prediction is that these items will show a preference for C interpretation, since they should behave the same as sentences with conjoined proper names. The target sentence in the items exemplified in (34) and (35) is the same; both contain three conjoined proper names. (Some items contained two conjoined proper names, as shown below in (36).) The difference is that in (35), the scenario has a bias toward separate events. The prediction is that the distributive interpretation will be more accessible than in the condition without the biased scenario. The rationale is that it will be easier to access the distributive reading if multiple events have already been established. In (35), the scenario is intended to establish that Jane, Mary, and Susan were sitting in the waiting room at different times. Since distributive interpretations require multiple events, the scenario intended to have a priming effect. It should be noted that some of these items indirectly bias multiple events, as shown in (36).

(36)   Melissa was shocked when she heard the leading news stories about two kidnappers. The first story was about a kidnapper called Bruce and the other story was about a kidnapper called Tyson. Apparently, Bruce and Tyson abducted three children.
How many children were abducted?   3   6

In (36), there are two events of reporting about the abductions, the idea being that this will bias the subject to think that there are two events of abducting.

5.1.2. Results and Discussion

In all of the conditions, there was a strong preference for the C interpretation, confirming that this preference is not restricted to conjoined subjects. These results build on and go beyond the findings of Frazier, Pacht and Rayner (1999) and Frazier and Clifton (2001). The C responses for each of the subject conditions are as follows: Numeral – 80.5%; Definite Determiner – 89.6%; Conjoined Proper Names – 83.3%; and Conjoined Names with separate events priming – 76.4%. The raw percentages are listed in (37).

(37) Experiment One Results

	Predicate Type				
	Neutral		**Distributive bias**		
Subject	**C**	**D**	**C**	**D**	**Totals**
Numeral	88%	12%	75%	25%	**C:**80.5% **D:**19.5%
Determiner	100%	0%	79%	21%	**C:**89.6% **D:**10.4%
Proper Names	92%	8%	75%	25%	**C:**83.3% **D:** 16.7%

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Proper Names w/Multiple-Events	87%	13%	63%	37%	C:76.4% D: 23.6%
Totals	92%	8%	73%	27%	

These results suggest that the parser does indeed commit to a C interpretation unless given other evidence. These results provide further evidence that these structures are ambiguous and that the collective interpretation is a default. If the representation were underspecified, we would expect a fairly even split between C and D interpretations. Looking at the predicate types, those categorized as neutral received 92% overall C responses and those categorized as distributive-biased received 73% overall C responses. While there does seem to be an effect of predicate type, there is still an overall preference for the C interpretation with the "distributive" predicates. It could be that these predicates do not actually have a distributive bias, in which case we would expect that approximately 50% of the responses would be distributive if there was not a general preference for C interpretations. However, even if these predicates have a distributive bias, this bias is overcome. Comparing the two conditions that contain conjoined proper names, both show a preference for the C interpretation. There are 83.3% C responses in the regular scenario and 76.4% C responses in the separate event biased scenario. It seems that the scenario had some effect of priming separate events, but this effect was not substantial enough to warrant the D interpretation being preferred to the C interpretation. This study establishes that there is a general preference for C interpretations and confirms the predictions of both Kratzer's account and Sternefeld's account.

5.2. *Experiment Two*

This experiment was designed as a follow-up to Experiment One, with some of the same items used. There were some differences, however. In particular, there were two conditions for the subject DP. The subject consisted of either three conjoined proper names or two proper names and a definite description. The items in previous studies consisted of either two or three proper names, and this study removes that inconsistency. The rationale for the different subject conditions was inspired by Kaup, Kelter, and Habel (2002), who found that commonality affected the ability to form groups. Since German 'they' has a collective meaning, Kaup et al predicted that the difficulty of resolving the reference of 'they' would depend on how much the individuals had in common. For 'both', however, Kaup et al predicted that the degree of commonality would be irrelevant. Since 'both' has a distributive meaning, resolving the referents does not require grouping individuals. Therefore, whether or not the individuals share common traits should not matter. A self-paced reading study was conducted in which participants read narratives containing two main characters. The degree of commonality between the two characters was varied. The degree of commonality affected reading times for target sentences containing 'they' but not target sentences containing 'both'. Building on these findings, the two subject conditions in the current study are designed to see if commonality, as exhibited by the same referring device, affects the ability to form a group. If so, there should be

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an increase in distributive responses for the condition that contains two proper names and a definite description.

5.2.1   Subjects, Materials, and Procedure

The subjects consisted of seventy-two University of Massachusetts undergraduates who received course credit. Subjects logged in to the experimental website to complete the questionnaire. The items were fillers for a study on bare plurals and natural kinds.

There were three conditions for the predicate – neutral eventive, distributive eventive, and stative. Again, the neutral and the distributive predicates were classified based on intuition. The VPs classified as stative pass a standard test for stativity; these predicates do not allow the progressive form. The list of predicates is in (38).

(38) Experiment 2 VPs

Neutral	Distributive	Stative
…investigated four murderers.	…pinched five children.	…detested four murderers.
…designed four buildings.	…pushed five nerds.	…admired five quadriplegics.
…poisoned five patients.	…ironed five shirts.	…were pleased with eight settlements.
…decorated five rooms.	…drank four glasses of soda.	…ruled four lands.
…winterized seven sports cars.	…shot four intruders.	…liked five children.
…negotiated eight settlements	…smacked four trouble- makers.	…feared seven suspects.
…abducted five children.	…called fifty homes.	…approved of five magazine covers.
…followed four suspects.	…ate seven pieces of chocolate.	…owned four buildings.

Participants were instructed to read the target sentence and select the paraphrase which best matched their interpretation of the sentence. The target sentence was presented at the top of the screen and the two interpretation options were presented in boxes toward the bottom of the screen. As with Experiment One, this study did not tease apart the collective and cumulative interpretations. The C and D interpretations were disambiguated by replacing the subject of the

target sentence with "each of them", for the D interpretation, and "altogether they" for the C interpretation, as exemplified in (39).

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(39)   Bill, Fred, and Dan investigated four murderers.
        {1} Each of them investigated four murderers.   (D)
        {2} Altogether they investigated four murderers.   (C)

The adverb *altogether* was chosen because it seems ambiguous between a collective and a cumulative interpretation while *together* has a bias toward a collective interpretation (see Lasersohn 1995:182-217 for discussion of collectivizing adverbials). Having subjects select a paraphrase removes a complication that might have been present in the first study. Participants would have had to perform a multiplication problem in order to get the D interpretation and it may have simply been easier to select the C option, since it did not require this additional step.

5.2.2   Results and Discussion

Consistent with the results of Experiment One, there is a clear preference for the C interpretation, which holds across all conditions. Subjects received a score of 1 for choosing the D paraphrase and a score of 2 for choosing the C paraphrase. The overall average score was 1.89 and the average score for each condition is shown in (40).

(40)[6]   Experiment Two Results

Condition	*Sample Item*	*Average* 1= D interpretation 2= C interpretation
Neutral Eventive: **3 proper names**	Bill, Fred, and Dan investigated four murderers.	1.93
Neutral Eventive: 2 proper names and a definite description	Bill, Fred, and the other detective investigated four murderers.	1.93
Distributive Eventive: **3 proper names**	Beatrice, Esmerelda, and Desdemona pinched five children.	1.90
Distributive Eventive: 2 proper names and a definite description	Beatrice, Esmerelda, and the old hag pinched five children.	1.81
Stative with 2 proper names and a definite description	Bill, Fred, and the other detective detested four murderers.	1.88
Stative with 3 proper names	Bill, Fred, and Dan detested four murderers.	1.87

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[6] Because the experimental environment was not controlled, response times were not analyzed.

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The averages for each condition are substantially closer to 2 than to 1. If there were no preference, we would expect at least some of the conditions to have an average approximating 1.5. Additionally, there is no evidence of an effect for subject type within any of the VP conditions. T-tests were conducted comparing the two subject conditions within each VP type. The means for subject DPs containing three proper names were compared with the means for subjects DPs containing two proper names and a definite description. The difference is not significant for any of the VP categories, as shown in (41).

(41)   Comparison of subject DP conditions for each VP type

VP type	Significance of means for 3 proper names and 2 proper names plus a definite description
Neutral	p=.8923
Distributive	p=.7321
Stative	p=1

There is a high probability that we ended up with the same average within the neutral condition and almost the same average within the stative condition by chance. The evidence for an effect of subject type for these conditions is inconclusive. We can conclude, however, that for the distributive condition there is not an effect of type. While the average for the condition with two names and a definite description is closer to 1.5 than the condition with three names, the difference between these two averages is not significant.

The results of Experiment Two do not provide support for the idea that forming a group is easier when the members are introduced by the same referring device.[7] Taken with the results of Experiment 1, we have evidence that C interpretations are preferred with plural subjects of the following forms: definite determiner, numeral quantifier, conjunction of two proper names, conjunction of three proper names, conjunction of two proper names and a definite description.

At this point, it seems that both Kratzer's and Sternefeld's predictions are on the right track. The arguably more structurally complex distributive interpretation is consistently dispreferred. However, perhaps there are alternative explanations. Frazier, Pacht and Rayner (1999) suggest that distributive interpretations are more difficult because the parser does not automatically postulate a distributive operator, but also discuss the possibility that distributive interpretations might be dispreferred because they necessarily require postulating multiple events (Crain and Steedman 1985).

Another possibility might be found in Lasersohn (1988, 1990). Lasersohn observes that languages often represent events which encode group action and events which encode spatio- temporal proximity in the same way, as with English *together,* as shown in (42).

(42)   a. John and Mary lifted the piano together.
        b. John and Mary sat together.
        c. John and Mary stood up together.   (Lasersohn 1990:179)

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[7]Although, the Kaup et al study was much more comprehensive. If the current study had contained scenarios in which characters were introduced separately and in different ways, the commonality effect may have shown up.

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The sentence in (42a) illustrates the familiar collectivizing use of *together*. The sentence in (42b) illustrates what Lasersohn terms the "spatial proximity" use. This sentence is true only if John and Mary are sitting in close physical proximity. The sentence in (42c) illustrates what Lasersohn terms the "temporal proximity" use. This sentence is true only if John and Mary stand up at (nearly) the same time. Lasersohn also provides examples of Tamil and Korean encoding these three concepts with the same morpheme. Perhaps this close connection between collective activities and activities which occur in the same spatial or temporal location is playing a role in the preference for C interpretations. It could be that the VPs in the target sentences implicitly suggested that the activity occurred in one location. For instance, it might be more plausible to imagine the activity of investigating four murderers to occur in the same police station. If the activity encoded in the VP somehow primes subjects to conceptualize the activity occurring in the same place or during the same time, then this might prime C interpretations.

5.3 Experiment Three

While the results of Experiments One and Two suggest a clear preference for C interpretations, it is not yet clear that this preference is linguistic. The purpose of Experiment 3 was to gauge the plausibility of the scenarios presented in the items in Experiment 2. If the preference for C interpretations is linguistic, there should not be a plausibility preference for C activities. It was expected that there would be no significant difference between scenarios that described distributive activities and those that described C activities. However, the results suggest that C activities are generally preferred to distributive activities in real world contexts. Even so, this plausibility bias does not explain the C preference in all instances.

5.3.1. Subjects, Materials, and Procedure

This experiment was conducted as an off-line questionnaire. The subjects consisted of 48 University of Massachusetts undergraduates taking an introductory linguistics course. All subjects were native speakers of English and received course credit for their participation. The experimental items consisted of the target sentences used in Experiment 2, disambiguated to either the C or the D interpretation. The instructions were as follows: *Each item below describes a situation. Please read the item carefully and rate on a scale of 1-5 how likely the situation described is.* Because the goal of this experiment was to assess the plausibility of the events described, and not the linguistic interpretation of the sentences, participants were also orally instructed to visualize the events and think about how likely they are in the real world before rating the scenario. Examples of the items are below.

(43)   a. Diane, Charlene, and Trisha poisoned five patients. Altogether they poisoned five patients.
How likely is this situation?   1   2   3   4   5
                                          extremely unlikely   *extremely likely*

   b. Diane, Charlene, and Trisha poisoned five patients. Each of them poisoned five patients.
How likely is this situation?   1   2   3   4   5
                                          extremely unlikely   *extremely likely*

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There were 8 counter-balanced forms. For each target sentence, participants saw either the 'C' disambiguation or the distributive disambiguation. Additionally, there were 56 filler items. Participants took 20-30 minutes to complete the questionnaire.

5.3.2.   Results and Discussion

The findings suggest that distributive activities are less plausible than C activities. Participants consistently rated activities in which the agents acted separately as less plausible than activities in which the agents worked together. The results are shown in (44).

(44)   Experiment Two Plausibility Averages (1=extremely unlikely 5=extremely likely)

Condition	Exper-iment 2 Average	Average Plausibility 'C' Rating	Average Plausibility 'D' Rating	Significance (comparing 'C' and 'D' plausibility)
1. Neutral Eventive with 3 proper names	1.93	4.13	2.79	p=.052
2. Neutral Eventive with 2 proper names and a definite description	1.93	4.20	2.52	p=.000372
3. Distributive Eventive with 3 proper names	1.90	3.61	2.56	p=.00469
4. Distributive Eventive with 2 proper names and a definite description	1.81	3.57	2.83	p=.2121
5. Stative with 3 proper names	1.87	4	2.92	p=.0576
6. Stative with 2 proper names and a definite description	1.88	4.19	3.67	p=.0852

The chart above compares the average rating for Experiment 2 with the average plausibility ratings. As discussed above, all of the conditions in Experiment 2 show a preference for the C interpretation, and the plausibility data show that for all conditions the C scenario is more

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plausible. This difference, however, is not significant for all conditions and only approaches significance for other conditions. T-tests were conducted comparing the differences between the C and D interpretation for each condition. In conditions 2 and 3, the difference between the C plausibility and the D plausibility is significant. In conditions 1 and 5, the difference between the C and D plausibility approaches significance. Finally, in conditions 4 and 6, the difference between the C and D plausibility is not significant.

What can we conclude from these results? While there seems to be a general plausibility bias against distributive activities, since this bias is not significant for all conditions, the preference for C interpretations cannot be explained solely by plausibility. There remains support for both Kratzer's and Sternefeld's proposals that distributive interpretations are derived from more complex structures.

5.4. Experiment Four

Up to this point, I have collapsed the collective and cumulative interpretations. Experiment Four, however, teases them apart. While previous research has focused on comparing collective and distributive interpretations, there has not been work comparing collective and cumulative interpretations. While both Kratzer's and Sternefeld's accounts predict that distributive interpretations are dispreferred, these two accounts differ crucially with respect to collective and cumulative interpretations. As discussed in Section 2.1.2, on Sternefeld's   account, collective interpretations are represented by a simpler structure than cumulative interpretations. For the collective interpretation of *Five men lifted two pianos*, there is necessarily one group of five men and one activity of lifting. For Sternefeld, the representation for the collective reading does not involve any LF movement, because there is not quantifying over men or over acts of lifting pianos. The various cumulative interpretations involve movement of either the subject or the object, depending on the scenario represented. This account predicts that collectives will be preferred to cumulatives, since collectives do not involve any LF movement By contrast, Kratzer's account predicts that neither interpretation will be preferred to the other. Both of these interpretations are derived from lexical cumulativity and are available at the same point in the derivation. The quantification over events that Sternefeld derives by movement, comes automatically from starring the predicate. Therefore, lexical cumulativity gives us interpretations in which there is one group of men and one lifting event, as well as interpretations in which there are subsets of men and subsets of lifting events and, somehow, two pianos get lifted.

5.4.1. Subjects, Materials, and Procedures

The experiment consisted of an offline questionnaire. Participants were sixty-seven University of Massachusetts undergraduates. All subjects were native speakers of English who received course credit for their participation. There were 14 items. Since this experiment was intended to be a small pilot study (more subjects than anticipated participated), there were no filler items. Participants completed the questionnaire in 5-10 minutes.

Each item consisted of a target sentence, followed by both cumulative and collective paraphrases of the sentence. The paraphrase for the cumulative interpretation began with *altogether* and in the collective paraphrase, *together* followed the VP. Participants were instructed to read each sentence as they normally would and select the paraphrase which best

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described the interpretation of the sentence that came to mind first. Because the collective interpretation can be a subset of the cumulative, these two readings were distinguished by a scenario for each option. For the cumulative paraphrase, the scenario indicated that the agents in the subject DP acted independently, while for the collective paraphrase, the scenario indicated that the agents acted together. Examples of the items are below.

(45)   Two tailors made four suits.
    ____Altogether they made four suits. For example, the tailors work for different designers and each tailor made fewer than four suits. The total number of suits made added up to four.
    ____They made four suits together. For example, the tailors work for the same designer and they worked as a team to make each of the four suits.

(46)   Two girl scouts sold twenty boxes of cookies.
    ____Altogether they sold twenty boxes of cookies. For example, the girl scouts are members of different troupes and each girl scout sold fewer than twenty boxes of cookies. The total number of boxes of cookies sold added up to twenty.
    ____They sold twenty boxes of cookies together. For example, the girl scouts are members of the same troupe. They worked as a team to sell each of the twenty boxes of cookies.

The scenarios following each paraphrase were included to make the intended interpretations explicit. Examples of the paraphrases without the scenarios were presented to subjects who were not used in the final experiment. These examples are shown in (47).

(47)   a. Two tailors made four suits.
        ____Altogether they made four suits.
        ____They made four suits together.

        b. Two girl scouts sold twenty boxes of cookies.
        ____Altogether they sold twenty boxes of cookies.
        ____They sold twenty boxes of cookies together.

There was strong feedback that while the paraphrase with *together* clearly evoked a collective interpretation, the paraphrase with *altogether* did not necessarily evoke a cumulative interpretation. Some subjects got a collective interpretation for the *altogether* paraphrase.

While the paraphrases tease apart these two interpretations, the cumulative paraphrase does not represent the range of situations which would fit the cumulative interpretation. For instance it could be the case that each girl scout sells five boxes of cookies on her own and that as a team the two girl scouts sell ten boxes of cookies. Because cumulative interpretations can be captured by so many different situations, providing a scenario which captures all of these situations would be quite complicated.

There were always two participants in the subject DP in the target sentence and the numeral in the object DP alternated between a high number and a low number. The rationale for this alternation was that low numbers might have a bias toward collective interpretations, while high numbers might have a bias toward cumulative interpretations. There were two counter- balanced forms such that subjects only saw each target sentence with either a high or

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low numeral in the object position.

5.4.2. *Results and Discussion*

The data were tabulated with cumulative responses receiving a score of 1 and the collective responses receiving a score of 2. While the average combined score for all items was slightly closer to 2; this slight preference for the collective interpretation was found not to be significant (p=.17). The average score for all items was 1.59. This was compared to a null hypothesized average score of 1.5.

Of the 67 subjects, 12 chose the same option for all fourteen items; 7 consistently chose the collective interpretation and 5 consistently chose the cumulative interpretation. Since there were so few items and no fillers, it is not clear whether these subjects actually got the same interpretation for all items or whether there was a carry-over effect. However, factoring out these responses has almost no effect; the overall average remains 1.59. These results suggest that cumulative interpretations are not more difficult to process than collective interpretations. Thus, the prediction made by Sternefeld's account is not borne out.

Additionally, there was a secondary effect of interaction between low/high numerals in the object position. Both object conditions showed a preference for the collective interpretation; the average score for items with a low numeral was 1.63 and the average score for items with a high numeral was 1.55. A T-test showed that this difference was significant (p=.009). However, an item by item comparison found that with the exception of one item – *Two salesmen visited five homes/twelve homes* – there was no significant difference between the high numeral object condition and the low object numeral condition. The item by item comparison is summarized in (48).[8]

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[8] Of course, it is possible that this null result does not necessarily mean that the collective and cumulative interpretations are derived from the same structure, as Kratzer proposes. First, it could be that a theory of lexical cumulativity more accurately captures how collective and cumulative interpretations are derived. We do not see a preference for one interpretation because they are derived from the same structure. It could also be that these two interpretations are derived from different structures, but that the cumulative structure is not more complex than the collective structure. An experiment with a more sophisticated technique might be able to provide more concrete evidence. Results supporting such a claim would pose a challenge for both accounts. Kratzer's account would have to explain how the two interpretations could come about via different structures, if lexical cumulativity is inherent. Sternefeld's account would have to explain why more complex representations would be preferred to simpler ones.

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(48) Experiment 4 Item Results and Object Numeral Interaction

Item	**Low Object Average** 1=cumulative 2=collective	**High Object Average** 1=cumulative 2=collective	**Combined Average**	**Significance of difference between low and high averages**
(1) Two tailors made…	four suits. **1.70**	twelve suits. **1.73**	1.71	p=1
(2) Two girl scouts sold…	five boxes of candy. **1.64**	twenty boxes of candy. **1.45**	1.55	p=.23
(3) Two lawyers negotiated…	three settlements. **1.64**	ten settlements. **1.47**	1.55	p=.14
(4) Two rappers recorded…	three CDs. **1.49**	six CDs. **1.52**	1.5	p=1
(5) Two janitors cleaned…	four rooms. **1.52**	eight rooms. **1.27**	1.39	p=.11
(6) Two judges drafted…	three documents. **1.40**	seven documents. **1.58**	1.48	p=.16
(7) Two salesmen visited…	five homes. **1.70**	twelve homes. **1.41**	1.55	p=.03
(8) Two fire marshals inspected…	three buildings.	ten buildings.	1.65	p=.75

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Item	Low Object Average 1=cumulative 2=collective	High Object Average 1=cumulative 2=collective	Com-bined Aver-age	Significance of difference between low and high averages
	1.64	**1.67**		
(9) Two voters campaigned for…	four can-didates. **1.67**	eight candidates. **1.64**	1.65	p=.82
(10) Two repairmen fixed…	four windows. **1.70**	twelve windows. **1.52**	1.61	p=.16
(11) Two grandmothers sewed…	three quilts. **1.64**	six quilts. **1.58**	1.61	p=.60
(12) Two detectives interrogated …	four suspects. **1.79**	eight suspects. **1.79**	1.79	p=1
(13) Two TAs drafted…	three exams. **1.45**	six exams. **1.48**	1.47	p=1
(14) Two women visited…	five wounded soldiers. **1.79**	ten wounded soldiers. **1.60**	1.70	p=.09
	1.63	**1.55**	**1.59**	

While there might be an effect of the object numeral, it is not clear how substantial this effect is. While there was no plausibility study for this experiment, the ostensible effect of the object type suggests that plausibility factors are influencing the interpretations.

6. General Discussion and Questions for Further Research

To conclude, the first two studies showed that there is a preference for C interpretations irrespective of the form of the subject DP and the third study showed that this preference is not entirely due to plausibility. Thus, it seems that both Kratzer's and Sternefeld's proposals that distributive interpretations are derived from more complex structures is on the right track. Finally, the fourth study failed to find a significant preference for collective interpretations over cumulative interpretations. These results are more consistent with Kratzer's account that collective and cumulative interpretations are derived from the same structure than with Sternefeld's account that cumulative interpretations are more complex. Of course, it is possible that a larger study with a more sensitive technique might deliver other results. While the results do not support Sternefeld's account, it is difficult to say

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whether the results actually do support Kratzer's account. There is, of course, the null effect problem. A larger study employing different methodology might be able to distinguish between not supporting Sternefeld's account and actually supporting Kratzer's account.

Additionally, the present studies raise several interesting questions. First, while the shape of the subject DP was the focus of Experiments One and Two, the effect found in Experiment Four of the numeral in the object DP needs suggests that the shape of the object is relevant. As mentioned in Footnote 6, having an indefinite in object position increased distributive responses. Further research is needed in order to compare the impact of the object DP on all three interpretations.

Second, the source of the plausibility bias against distributive activities is unclear. Perhaps there is a preference for having events occur in the same spatio-temporal location, and the fact that some languages encode collectivity and spatio-temporal proximity in very similar ways reflects this conceptual preference. Perhaps it is more difficult to conceptualize multiple events than it is to conceptualize a single event. If this is the case, then the source of the preference for C interpretations might not be a simpler structure. Rather, there is something about our conceptualization of events that prefers a single activity to multiple ones. (However, the results of Experiment Four, in which there is not found to be a significant preference for collective interpretations, argues against this idea.) It could also be that there is a conceptual reality to the idea that plural DPs denote groups. While the theory argues that a group is comprised of all individuals and all sub-groups that can be formed from those individuals, perhaps it is easier to conceptualize the individuals acting as some sort of unit and not as individuals.

Third, Sternefeld's proposal assigns different structures to different cumulative interpretations. Since each structure involves one instance of lambda abstraction, we would expect that these various interpretations would be of equal complexity. If plausibility could be controlled for, we would expect not to see preferences for any of these interpretations.

Finally, the relative inaccessibility of the object distributive interpretation should be explored. On Kratzer's account, the object distributive should be strongly dispreferred to the subject distributive, because this interpretation requires movement motivated solely for the purpose of accessing the right interpretation. The intuitions discussed in Section 2 seem to confirm this prediction.

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