CHAPTER 9

DISTRIBUTIVITY

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9.1 INTRODUCTION TO *DISTRIBUTIVITY*

DISTRIBUTIVITY refers to the ability of sentences with plural subjects to give rise to an interpretation in which the property expressed in the sentence is predicated of the individuals of which the group or *plurality* is comprised, as opposed to predicating the property of the plurality itself (a collective interpretation). To illustrate, the sentence in (1) could be interpreted *collectively* (where the two men worked together to eat one pizza) or *distributively* (where each man ate his own pizza).

(1) The two men ate a pizza.

While this sentence is ambiguous, there are other sentences that seem only to give rise to either collective or distributive readings. For example, (2) can only have a collective interpretation, where the group has the property of meeting, not a distributive one where each man has the property of meeting, while (3) gives rise to a distributive reading, rather than a collective one, where each man has the property of having dark hair.

(2) The two men met in the alley by the warehouse.

(3) The two men have dark hair.

The difference between the unambiguous (2) and (3) on the one hand, and the ambiguous (1) on the other, has been taken as evidence that certain predicates are specified to be *collective*, *distributive*, or *mixed* (allowing for the other interpretation) (Link, 1983, 1987; Dowty, 1986; Lasersohn, 1995). Other inherently collective predicates are *gather* and *scatter*, while *be a (wo)man*, *have brown eyes*, *be big*, *be round*, and so forth, are among the inherently distributive predicates.

One proposal for accounting for the distributive reading of (1) is that a covert distributivity operator *D* is inserted into the representation, resulting in the predicate being applied to the atomic individuals that make up the plurality *the two men* (see e.g. Link 1983, 1987; Lasersohn 1995, 1998; Schwarzschild 1996; Brisson 2003). The same would apply to a

conjoined subject, such as *Frank and Dean*. Gillon (1987), Schwarzschild (1996), and Verkuyl & Van der Does (1991), among others, have also proposed the existence of a *cover*, which partitions the plurality into subsets in a given discourse context (see discussion in Brisson, 2003). Lasersohn (1995) has also proposed that a * operator applies to the predicate *P* to generate all of the individual sums of members, and **P* is closed under sum formation.

9.2 Lexically-encoded *distributivity*

While some predicates in sentences can be interpreted distributively, some quantifiers are known to lexically-encode distributivity. For example, in English, *every* and *each* are inherently distributive—the latter more so than the former—while *all* is not (Vendler, 1962; Beghelli & Stowell, 1997; Tunstall, 1998; Brisson, 2003). For example, (4) is typically interpreted with a distributive interpretation, whereby each of the men in the plurality has the property of eating a calzone.

(4) {**Every**|**Each**} man ate a calzone.

This judgement may arise in part from a preference by the sentence processor to assign surface scope (*every* > *a*) to scopally ambiguous sentences (cf. Kurtzman & MacDonald, 1993), but scope is not the determining factor in a distributive interpretation. The difference between these inherently distributive quantifiers on the one hand, and plurals on the other, is also illustrated in (5). The sentence in (a) requires that each individual man went to the racetrack, while (b) is weaker, and allows for non-maximality (Landman, 1989a,b, 1996; Brisson, 2003). That is, not every man in the plurality needs to have gone. In sentences such as (4), the quantifier *every* or *each* can be referred to as the distributive *key*, and the predicate as the distributive *share*. (Some languages have distributive-share quantifiers, but English does not.)

(5) a. {**Every**|**Each**} man went to the racetrack.
b. The men went to the racetrack.

The difference between the inherently distributive quantifiers *every* and *each* and the universal quantifier *all* is illustrated in (6). Quantificational phrases involving *every* or *each* cannot compose with a collective predicate such as *gather* or *scatter*, while those with *all* can (as long as *all* has first composed with a definite plural phrase).

(6) a. *{**Every**|**Each**} man gathered in a dimly lit alleyway.
b. **All** the men gathered in a dimly lit alleyway.

The contrast between *every* and *each* on the one hand and *all* on the other is attested in numerous other languages, including Georgian, Tagalog, Turkish, and others (Gil, 1995).

That *each* is inherently more distributive than *every* can be illustrated with the set of examples from Brasoveanu & Dotlačil (2015b) that follows in (7), which highlights what Tunstall (1998) has proposed as the 'differentiation condition' of *each*: that sentences with

each require the event structures to be totally distributive—that is, each of the atomic individuals is associated with its own sub-event, and these sub-events can be properly differentiated. For example, in (a), it must be the case that each student participates in a separate, spatiotemporally distinct photographing event. The sub-events might also be differentiated with different event agents and/or resultant states (see Tunstall, 1998; Landman, 2000).

(7) a. Jake photographed **every** student in the class, but not separately.
b. #Jake photographed **each** student in the class, but not separately.

If there is a covert distributivity operator D, one would expect that some languages would lexicalize this operator overtly. Indeed, it has been proposed that *each* is in fact such an overt distributivity operator (Link, 1983; Schwarzschild, 1994). By way of illustration, (8) forces the distributive interpretation of (1). It must be the case that each of the men eats his own pizza; they cannot share one pizza. If the example were different, such that a pizza was not consumed, but was instead moved from one table to another, the pizza could be the same pizza, but there would have to be separate moving events, with each of the two men as an agent of his own event.

(8) The two men **each** ate a pizza.

By contrast, (9) brings out the collective interpretation of (1)—although it does not force it in the same way that (8) forces the distributive interpretation, since it is possible that each man could eat his own pizza while they sit together in a booth in an Italian restaurant.[1]

(9) The two men ate a pizza **together**.

Not only quantifiers lexically encode distributivity. Some predicates obligatorily apply to the atomic individuals composing a plurality. Schwarzschild (2011) has called such predicates 'stubbornly distributive'. Distributive predicates include those such as *be round/square*, *have brown/blue eyes*, *be tall/big*, and *be intelligent*. When composed with a plurality in subject position, these predicates must modify the individuals in the group, rather than the group itself (as collective predicates like *gather* or *scatter* would). Thus, distributive predicates cannot compose with mass nouns, such as *bread* or *water*, since there are no individuals to be predicated of, but they can compose with object mass nouns, such as *furniture* or *jewelry*. However, if the mass noun appears in a phrase like *drops of water* or *loaves of bread*, the distributive predicate can then apply. This pattern is illustrated in (10).

(10) a. The pillows are {**round/big**}.
b. #The water is {**round/big**}.
c. The drops of water are {**round/big**}.
d. The furniture is {**round/big**}.

[1] For discussion of *together*, see Parsons (1980); Hoeksema (1983); Dowty (1986); Lasersohn (1990, 1995); Schwarzschild (1994, 1996); Verkuyl (1998); Brisson (2003); among others.

Some individual lexical items, such as *heavy*, lend themselves easily to either distributive or collective interpretations. For example, (11) could mean that each of the individual boxes is heavy, or that all together, the boxes are heavy (but each of them is relatively light). In this case, the context would serve to disambiguate.

(11) Those boxes are **heavy**.

In the sections that follow, I present the findings from a number of experimental studies conducted over the last few decades demonstrating how children and adults interpret both ambiguous and unambiguously distributive sentences in off-line experimental tasks investigating preference and/or acceptability, and how adults respond to overt cues to distributivity in tasks designed to collect real-time behavioural data. The collective findings from these studies indicate that children as young as 3 and adults access multiple readings (collective, distributive, cumulative) of ambiguous sentences. However, while adults take *each* as an unambiguous cue to distributivity, children do not appear to be sensitive to this lexical property of this quantifier until well after 7–8 years of age. Moreover, when adults do take the presence of *each* as a signal to access a distributive interpretation, this has a detectable effect in reaction time. While the vast majority of studies have been conducted in English, the growing interest in experimental work on distributivity has led to recent cross-linguistic explorations, which will no doubt continue in subsequent years, resulting in a clearer picture of the theoretical and developmental landscape of distributivity.

9.3 Development of the understanding of the distributivity of *each*

In this section, I focus on the overt distributivity marker *each*, and what children and adults know about the meaning of this lexical item. While *each*, *every*, and *all* in English are all universal quantifiers, they differ in the degree to which they require exhaustivity and distributivity in the predication of the plurality to which they apply. However, though a contrast rooted in distributivity between *each* and *every* on the one hand, and *each* and *all* on the other may be clear for adults, children as old as 5 to 6 years of age fail to appreciate this distinction. Thus, it appears that the difference among these quantifiers is a lexically-encoded contrast that must be learned over the course of development, and this appears to take a fair amount of time. This observation follows from a number of studies over the years.[2]

[2] Since the focus of this chapter is on distributivity, I will not review other literature on children's other non-adult-like responses to questions with universal quantifiers, such as the so-called 'quantifier spreading' cases. For discussion of these findings and related references, see, for example, Brooks & Sekerina (2005/6 and Chapter 15 in this volume); Roeper et al. (2011); and Syrett (2015c). Although this phenomenon may ultimately be related in some way to the patterns of performance summarized there, the connection is not transparent enough to make a connection here, given the range of work reviewed in this chapter.

To begin, a contrast between adults and children with *each* was observed by Ferenz & Prasada (2001) in an act-out task in which they gave children and adults instructions to put *all/each* (*of the*) objects in a certain location. When presented with the instructions with *all*, adults placed all of the relevant objects in the location roughly at once, but when presented with the instructions with *each*, they typically placed the objects in the location one at a time (as Vendler, 1962, and Tunstall, 1998, might have predicted they would). Children, however, did not interpret *each* as a cue to a 'distributive' response, and did not place the objects in the location one by one.

One might argue that since Ferenz & Prasada's experiment used an act-out task that children's failure to provide a 'distributive' response with *each* in this task is not sufficient evidence to demonstrate they lack understanding—that is, the argument might be that their performance underestimates their competence. This would not be surprising. However, further evidence that children lack an understanding of the strong distributivity property of *each* comes from their answers to *wh-* questions involving the universal quantifiers *every* and *each*.

Achimova et al. (2017) presented child and adult participants with scenarios followed by a question involving the interaction between a *which* phrase and a universal quantifier (either *every* or *each*). The *wh-* phrase and the quantifier either occupied subject or object position, as shown in (12).

(12) a. **Which game** did {**every/each**} friend play?
b. **Which friend** received {**every/each**} toy?

When the quantifier was in subject position (as in (a)), the prediction arising from the theoretical literature was that either a single answer or a Pair-List Answer (PLA) would be possible, with either universal quantifier. When the quantifier was in object position (as in (b)), the prediction was that a PLA should be barred with *every* (for theoretical reasons discussed therein), but permitted with *each*, given *each*'s strong distributivity.

Interestingly, consistent with previous research findings, children produced more PLAs than adults with *every* in the subject position (although PLAs *were* licensed here), but also with *every* in object position (where PLAs *were not* licensed). Adults conservatively produced single answers, even when either answer type was licensed. Interestingly, though, children *under*-produced PLAs relative to adults both when *each* was in subject position and when it was in object position. That is, adults took the presence of *each* to indicate strong distributivity, producing PLAs to questions such as the above as a result (in contrast to their consistent single answers with *every*), while children seemed oblivious to this lexical property of this quantifier.

Brooks & Braine (1996), Brooks et al. (2001), and Brooks & Sekerina (2005/6) also found that children diverged from adults in their treatment of *each* but patterned along with adults in their treatment of *all*. The divergence with *each* appears to be rooted in both exhaustivity and distributivity. Brooks and her colleagues presented child and adult participants with sentences following the template in (13)–(14), accompanied by black and white drawings in which some combination of N1s (e.g. people, flowers) were performing an action or were in some configuration with respect to some number of N2s (e.g. cakes, boats, vases). In one version of the task, participants were given a forced choice between two different images and asked to choose the best sentence to match the context

presented in the image, while in the other version, they were asked whether the sentence could accurately describe the individual picture.

(13) {**All** of the N1s are/**Each** N1 is} Ving an N2.

(14) There is an N1 Ving {**all/each**} of the N2s.

Adults had no difficulty making correct decisions about sentences with *all* and *each*, given the various contexts. Children patterned with adults with the *all* sentences and scenarios. For example, when presented with (13), they preferred a scene where all of the N1s were engaged in a Ving event with an N2, and when presented with (14), they preferred a scene in which each N2 was being acted on by an N1. However, with the *each* sentences, children showed no such preference. In the complementary acceptability judgement task, while adults did not accept the *each* version of (13) applied to a scene where there were some N1s doing nothing, children accepted such sentences. Finally, given an image where three N1s are acting on one N2, and an image where each of three N1s is each acting on a separate N2, adults accepted (13) in the latter, but not the former, context, while children accepted (13) a significant amount of time in both contexts. Thus, these results show that children do not reliably appreciate the role of *each* as a strong distributivity marker until well after age 8–9—a surprisingly late age in language development.

In a similar vein as Brooks and colleagues, Musolino (2009) was interested in assessing children's and adults' judgements of sentences with *each*, but his findings were set against the backdrop of sentences with numerical phrases. Sentences with plurals or numerical phrases in both subject and object position, such as (15), are multi-ways ambiguous, taking into account the presence of the D operator, quantification over events, scopal interaction between the subject and object phrases, and the possibility of a *cumulative* reading (Scha, 1981; Aone, 1991; Link, 1991; Schwertel, 2005). For example, here, the five men could have each purchased three calzones, all five could have chipped in together to purchase the three, some combination of the subsets of the five could have purchased some combination of the subsets of the three, or all together, the five could have purchased the three with it still being possible that one man purchased one calzone in the group.

(15) Five men purchased three calzones.

Musolino wanted to determine whether children (and adult controls) could access multiple interpretations of ambiguous test sentences that had numerical phrases in both subject and object position, as in (16), probing the availability of distributive, collective, and cumulative readings.

(16) Three boys are holding two balloons.

In an acceptability judgement task, both age groups accepted sentences such as this one when there were three boys, each of whom was holding two balloons (a distributive reading), and when there were two balloons, the group of which was being held by three boys (a collective reading). Neither age group accepted the sentence when there were two balloons, each held by three boys (the inverse scope reading where the object takes wide

scope over the subject). Only adults accepted the sentence in a context favouring the cumulative reading, where there was a total of three boys and a total of two balloons, each of which was being held by at least one boy.

However, when (16) was changed to the minimally different sentence (17) with *each*, both age groups accepted the new version of the sentence in the object-wide-scope context, and where there were two balloons, the group of which was being held by three boys. Thus, the presence of this overt distributivity marker made available an inverse scope reading that was not accessible before.

(17) Three boys are holding **each** balloon.

This finding thus reveals that children allow *each* to take wide scope in a linguistic environment in which they do not permit the same for an object indefinite. However, children may be *too* permissive in this regard, since they—unlike adults—accepted (17) in the first context, where there were three boys, each of whom was holding two balloons. Thus, both children and adults can assign multiple readings to sentences that give rise to distributive, collective, and cumulative interpretations, and constrain these interpretations such that not just any interpretation is licensed. At the same time, children fail to constrain the range of interpretations allowed by sentences with *each* in the same way that adults do. However, because the range of predicates in this experiment was rather minimal, and since the control items in this experiment did not involve extraneous boys or balloons and non-holding events, this experiment was not able to fully probe children's understanding of the range of permissible readings for the target sentences, or the distributivity property of *each*.

Syrett & Musolino (2013) followed up on these results with a wider range of predicates, presenting child and adult participants with prerecorded videos of actors performing distributive and collective events, described by ambiguous sentences, such as those in (18), and their unambiguous counterparts, which were created by inserting one or the other of the lexical items in parentheses.

(18) a. Two boys (each) pushed a car (together).
b. Two boys (each) built a tower (together).
c. Two girls (each) pushed a car (together).
d. Two girls (each) drew a circle (together).

As was predicted, children and adults accepted the unambiguous sentences in both the distributive and collective contexts.

When participants were given these sentences and still images of the distributive and collective events in progress in a forced-choice preference task and asked to make a choice between the two scenes, adults vastly preferred the collective context, while children had a slight but non-significant preference for the distributive context. But while adults reliably took *together* as a cue to collectivity, and *each* as a cue to distributivity, children—as might have been predicted, based on previous findings—appeared to be oblivious to this fact, accepting these lexically modified sentences in both contexts. However, in the forced-choice preference task follow-up, children showed that they preferred the collective context over the distributive one for sentences with *together*, showing that they, like adults, appreciate the collectivizing function of this modifier. We will return to this finding momentarily.

The fact that children diverge notably from adults in their interpretations of sentences with *each*, failing to fully appreciate the strong distributivity of this universal quantifier and accessing interpretations that are not licensed by sentences in which *each* appears, led Pagliarini et al. (2012) to predict that, in sentences without *each*, children should also diverge from adults in accessing a distributive interpretation more often than a collective one, similar to the trend Syrett & Musolino (2013) noticed in their forced-choice preference task. Their reasoning was as follows. Take a sentence such as (19), which allows for a distributive reading (where each boy lifts his own two boxes), a 'dependent' distributive reading (where each boy independently lifts the same two boxes), and a collective reading (where the boys work together to lift the two boxes, either simultaneously or sequentially).

(19) The boys lifted two boxes.

When presented with such a sentence, adults resolve the ambiguity in favour of a collective interpretation, considering the quantificational alternative that the speaker *could* have uttered featuring *each* (*Each boy lifted two boxes*). Since children do not appreciate the role of this more informative, disambiguating quantificational alternative, they do not readily conclude that a speaker who utters (19) most likely favours the collective reading, and therefore access the distributive reading, in contrast to adults.

Pagliarini et al. (2012) therefore presented participants with sentences with *each* in subject position and sentences without *each* in subject position (and instead featuring a plural definite description), accompanied by a still image portraying either a distributive or collective context, as noted in (20)–(23). (Their experiment was conducted in Italian, not English.)

(20) Each girl is building a sandcastle. (accompanied by picture of distributive context)

(21) Each boy is building a snowman. (accompanied by picture of collective context)

(22) The girls are building a snowman. (accompanied by picture of distributive context)

(23) The boys are building a tower. (accompanied by picture of collective context)

As expected, adults accepted (20) and rejected (21) in the distributive context, and accepted (23) in the collective context. They were split on acceptance of (22) in the distributive context. By contrast, children beginning at age 4 accepted all sentences in the given contexts. That is, consistent with the findings reported above, children incorrectly accepted (21) in the collective context, dropping below chance level acceptance only after age 8. And consistent with the pragmatic 'alternatives' hypothesis, they accepted (22) in the distributive context.

Although we have focused on the fact that the accumulated findings across tasks indicate that children are insensitive to the distributive property of *each* until well into late childhood, there is something to be said about their interpretations of sentences with *together*. While they accept such sentences in both distributive and collective contexts, Syrett & Musolino (2013) showed that they prefer the collective contexts when given the choice. Syrett & Musolino (2016) took this result as a starting point to probe the reason for children's acceptance of sentences with *together* in distributive contexts.

In a task similar to Syrett & Musolino (2013), Syrett & Musolino (2016) presented participants with sentences such as those in (24) not only in collective contexts, but also in distributive contexts in which the two individual events occurred sequentially. Their hypothesis, inspired by Lasersohn (1995, 1998), was that children accepted the sentences with *together* in Syrett & Musolino (2013) because the events were spatiotemporally contiguous sub-events of a larger event, and therefore licensed a non-collective reading supported by *together*.

(24) a. Two boys pushed a car together.
b. Two girls read a book together.

Indeed, in contrast to the previous findings, children rejected the sentences with *together* when the events were no longer time-locked—and even more so when children engaged with a puppet.

While children do not appear to recognize early in development that *each* is an overt cue to an unambiguous distributive interpretation of sentences, they *do* appear to recognize that certain predicates are 'stubbornly distributive' and obligatorily apply to individuals. Syrett (2015d) presented children age 2 to 5, and adult controls, with a binary forced-choice task in which they were introduced to different kinds of objects that would be conceptually and linguistically familiar to very young children (e.g. buttons, cups, fruit, blocks, pillows), along with properties that were also familiar. The individual properties of these objects were highlighted, as were the properties of a group (such as shape or size). Participants were then given a choice between two images on the screen: one where the group had the target property (e.g. being round) but the individuals possessed another (e.g. being square-shaped), and another where the properties were reversed. A set of brief instructions as in (25) accompanied these images, asking participants to point to the side of the screen as indicated.

(25) a. Point to the round {furniture/buttons}.
b. Point to the big {fruit/cups}.

Syrett (2015d) found that every age group was significantly more likely than chance to select the individuals with the target property upon hearing this prompt. Even by age 3, children's selection percentage closely resembled that of adults. The one difference between children and adults came from the predicate *be tall*, where children in the youngest age group consistently selected the group with the property, and then this pattern dropped off to chance or a little over chance level at 3 years of age.[3] Importantly, in a follow-up condition, when the instructions included the collectivizer *group*, as in (26), participants were significantly less likely to choose the side of the screen where the *individuals* had the target property, and were pulled toward the side of the screen where the *group* or *plurality* had the target property instead.

(26) Point to the round **group of** {furniture/buttons}.

[3] A similar finding for *tall* was also reported by Scontras & Goodman (2017).

These findings thus demonstrate that young children are not completely oblivious to the feature of distributivity. While they may not be sensitive to it as it is encoded in *each*, they are sensitive to it in certain predicates, which obligatorily apply at the level of the individual, rather than to the plurality of which these individuals are members. Thus, children appreciate that pluralities have a decomposable structure with individuable parts, and that distributive predicates modify these parts, regardless of whether the group is referred to with a plural count noun.

9.4 Real-time behavioural measures of distributivity and *each*

Earlier, we reviewed a range of findings from off-line act-out, acceptability judgement, and preference tasks revealing how children and adults respond to ambiguous sentences with potentially distributive interpretations and unambiguously distributive sentences featuring *each*. To complement these findings, this section reviews the findings from on-line tasks revealing how adults interpret sentences with *each*, compared to key baseline sentences. Results from these experimental tasks with adults, which measure eye gaze, self-paced reading, and reaction times in response to certain prompts, provide behavioural evidence that *each* serves as a reliable cue to distributivity (and the presence of a D operator) in real time, that distributive interpretations prompted by *each* have an immediate effect on how subsequent singular indefinites are processed, and that in specifying distributivity, *each* requires that the relevant property apply to atomic individuals composing the plurality such that the relevant events are differentiated from each other.[4]

Frazier et al. (1999) monitored participants' eye gaze while reading sentences with mixed predicates in order to determine whether positing a D operator for distributive interpretations signaled by *each* slowed down the sentence processor. Target sentences in their experiment had the structure of those in (27). The slashes below, which were not presented to participants, represent regions of interest.

(27) a. Edna and Milton / mailed one care-package **each** / after hearing about / the severe droughts in Africa.
b. Edna and Milton / mailed one care-package **together** / after hearing about / the severe droughts in Africa.
c. Edna and Milton / **each** mailed one care-package / after hearing about / the severe droughts in Africa.
d. Edna and Milton / **together** mailed one care-package / after hearing about / the severe droughts in Africa.

The (a) and (c) versions resulted in distributive interpretations, whereas (b) and (d) favoured a collective interpretation. Crucially, the (a) and (b) versions were locally

[4] See section 11.3 of the chapter by Nouwen et al. (Chapter 11 in this volume) for evidence for 'variation effects' that arise when modified numerals are embedded under the distributive quantifier *each*.

ambiguous, as the lexical item *each* or *together* did not appear until after the predicate, while the (c) and (d) versions were locally unambiguous, since these lexical items appeared immediately after the conjoined subject and before the predicate.

Frazier et al. (1999) first normed their experimental sentences in advance in a naturalness rating task to ensure that none had an inherently collective or distributive bias. A separate group of participants participated in the eye-gaze experiment. Participants saw one version of these sentences, and sixteen test sentences in total, along with a number of fillers. Two values were measured: first-pass reading time (the sum of fixations in a given region between the time of first entering and first leaving the region), and total reading time (the sum of all fixations in a given region, including the first-pass time and subsequent rereading of the material in the region).

Frazier et al. (1999) found an interaction in both the first-pass reading time and in the total reading time, such that distributive predicates were read more slowly than collective predicates in ambiguous sentences ((a) vs (b)). There were also more regressions out of the third region (and into the second region) in the distributive versions than in the collective versions, when the predicates were locally ambiguous. Frazier et al. (1999) took their findings as support for their hypothesis that the processor is slowed down with the locally ambiguous sentences when postulating the presence of a distributivity operator triggered by the presence of *each*. These findings might also be seen as consistent with Pagliarini et al. (2012)'s proposal that the default for adults is a collective interpretation, for pragmatic reasons, and that this is the reading they access until explicitly cued to access a distributive one.

Patson & Warren (2010) gathered evidence from reaction times that there is a processing cost when a singular indefinite phrase (e.g. *a box*) is interpreted as conceptually plural, when participants are given a cue by *each* to interpret the sentence distributively. Following a methodology used by Berent et al. (2005), they presented participants with a self-paced reading task, and then had them make rapid judgements of whether they saw one or two words in a key region. They predicted that singular indefinite phrases in a distributively interpreted sentence would be interpreted as conceptually plural, and therefore, that when asked about the number of words they saw on the screen, participants would be slowed to render 'one-word' judgements for indefinites in these environments than with singular indefinites in collectively interpreted sentences.

Target sentences were of the form in (28), with either *each* or *together* in subject position, and a singular or plural direct object (the latter meant to control for differences in reading time in the spillover region).

(28) a. **Each** of the men carried a **box**.
b. **Together** the men carried a **box**.
c. **Each** of the men carried some **boxes**.
d. **Together** the men carried some **boxes**.

Participants saw thirty-six target sentences, in a self-paced reading paradigm. The first part of the sentence was in black, while the last word in the indefinite phrase (in bold above) was in blue. Participants pressed the space bar to click through chunks of the sentence, and were told that upon seeing the blue text, they should decide whether there were one or two words on the screen and press '1' or '2' on the keyboard accordingly. (Filler items had two words displayed, so there was an equal number of '1' and '2' answers.)

Patson & Warren (2010) found that decisions about the number of words in the blue region (the sentence-final indefinite phrase) took longer when the decision was '1' and the phrase was grammatically plural-marked, and importantly, that there was an interaction between noun marking and distributive/collective interpretation such that with singular-marked indefinites, a '1' decision took longer for distributive interpretations than collective interpretations. There was no reliable effect of distributivity or plural-marking otherwise.

The fundamental distinction between *each* and *every* proposed by theoreticians discussed earlier has been further probed experimentally in both off-line and on-line sentence processing tasks. (See extensive discussion in Brasoveanu & Dotlačil, Chapter 14 in this volume.) Following seminal work on the interpretation and processing of quantificational phrases by Tunstall (1998), Brasoveanu & Dotlačil (2015b) designed a binary forced-choice task and a related self-paced reading task to test the prediction from Tunstall's differentiation hypothesis that participants should prefer the inverse scope of the quantifier *each* over the indefinite subject in (29) more than with *every*, and further, that the presence of a resultative, as in (30), should neutralize this preference, since it indicates the resultant state of the event ('be blue'), which reflects a distributive property of an individual.[5] (See the earlier discussion of stubbornly distributive predicates.) Thus, of all four sentences, (29b) should show the highest rate of inverse scope readings. (The area in parentheses, which was identical among the sentences, only appeared in the self-paced reading task, as a spillover region for analysis.)

(29) a. A helper dyed **every** shirt (without thinking about it).
b. A helper dyed **each** shirt (without thinking about it).

(30) a. A helper dyed **every** shirt blue (without thinking about it).
b. A helper dyed **each** shirt blue (without thinking about it).

In the binary forced-choice task, participants were given a choice between two interpretations, as in (31). There were eighteen test items in both experiments, distributed into four lists that represented four different item conditions, with every experimental item appearing exactly once in each list. These test items were interspersed with a number of fillers.

(31) A helper dyed every shirt blue.
a. Each shirt was dyed by a possibly different helper (until it was the color blue).
b. All the shirts were dyed by the same helper (until they were the color blue).

Brasoveanu & Dotlačil (2015b) found that inverse scope readings were highest with *each*, and without a resultative present. In the self-paced reading task, Brasoveanu & Dotlačil (2015b) found a significant slowdown in reading times for the *each* sentences starting at the third word (*about* above), but they found a significant interaction of quantifier and presence/absence of a resultative, such that the presence of the resultative led to a decrease in reading time for *each*, but not for *every*. This finding was to be

[5] For extensive discussion of the encoding of event structure in lexical semantics and verb frames, see Chen and Husband (Chapter 5 in this volume).

expected: since the resultative satisfied the differentiation condition, *each* needed to do less work.[6] Complementary sentence-processing work by Brasoveanu & Dotlačil (2015a) also revealed a processing cost for *each* in sentences with *same*, arguing that the reason is that the event differentiation requirements of *each* are at odds with the semantics of sentence-internal *same*.

9.5 Conclusions

The purpose of this chapter was to review the findings from a range of experimental studies on the topic of distributivity. The findings reported in this chapter reveal the following. First, although children as young as 3 years of age recognize, along with adults, that some predicates apply distributively to atomic individuals in a plurality, they, unlike adults, fail to appreciate the lexically-encoded distributivity of the universal quantifier *each*. In task after task, children accept sentences with *each* in non-distributive contexts and fail to produce a distributive response when given the opportunity to do so. Second, the presence of *each* has real-time consequences for adults processing sentences with distributive interpretations.

Since the vast majority of these studies, with very few exceptions, have focused on English and the quantifiers *every*, *each*, and *all* (and the modifier *together*), it seems fitting that recent research, motivated by theoretically-grounded hypotheses, has begun to extend these methodologies to languages beyond English. These investigations include languages in which particles or other discourse markers, rather than (or in addition to) universal quantifiers, signal distributivity, although in different ways, and the variety of ways in which the conditions required for distributivity can be satisfied. For example, *po* in Serbian and Russian has been argued to be a strong distributive share (or pluractional) marker, distinct from the Serbian term for *every*, *svaki*, and the Russian term for *every*, *kazhdyi* (Knežević 2015). The particle *dou* in Mandarin Chinese has been claimed to be similar to English *each* in its status as a distributivity marker, although it also has a meaning similar to English *even*, and functions as a propositional operator, taking a proposition as its argument, which is unlike a universal quantifier (Lee, 1986; Lin, 1998; Liu, 2016). Probing these and other languages further will allow us to get a much more fine-grained understanding of how distributivity is captured at the lexical level, and identify the universal and language-specific aspects of how distributivity is acquired and processed.

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[6] Brasoveanu & Dotlačil (2015b) also reported interesting differences among participants in their preference for scopal relations—hence the title of their paper. However, as those findings are not directly connected to the goals of this chapter, I leave them aside here.