On the Constraints Imposed by *Respectively*

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The *respectively* construction in English is exemplified by sentence (1):

(1) English and Dutch are used in Guyana and Suriname, *respectively*. [Gr]

Example (1) establishes two relations: one between English and Guyana, and one between Dutch and Suriname. Such examples have often been taken to show that *respectively* induces an intrasentential syntactic dependency among corresponding members of two coordinate structures.

Some authors have attempted to use this presumed dependency as evidence for other syntactic claims. For instance, Bar-Hillel and Shamir (1960) and Langendoen (1977) appeal to it as the basis for arguments that English is not a context-free language. Moltmann (1992), in her treatment of the syntax of coordination, proposes that *respectively* establishes a particular syntactic relation among elements of two coordinate constituents.

However, it has long been recognized that *respectively* need not relate members of two coordinate structures in the same sentence. For instance, Stockwell, Schachter, and Partee (1973, page 399) discuss the following example:

(2) They live in New York and Chicago respectively.

which is acceptable, for instance, in response to the question *Where do John and Bill live?* They state that such examples

> can only be used in a context in which it is known to what two people (or groups of people) **they** refers, and in what order those two people (or groups) are being referred to.

McCawley (1988, page 536–540) also discusses example (2), suggesting that in such cases *respectively* may serve as an "anaphoric device", with a coordinate structure as antecedent in a preceding sentence.

Pullum and Gazdar (1982, pages 481-485) discuss a strikingly similar example, although in a context that shows that McCawley's suggestion is insufficient. Their example, given in (3), is to be understood in a context where someone is attempting to pick out New York residents in a mass photo of the LSA membership:

(3) The people you have indicated are all New York residents except for the last two. They live in Chicago and Columbus respectively.

They state:

> In this case, the nonlinguistic context picks out a unique ordered set of people with whom Chicago and Columbus can be appropriately associated; but the sentence that contains *respectively* does not allow for a pairing between either *Chicago* or *Columbus* and any other noun phrase, so pairing of constituents certainly cannot be part of the correct characterization of *respectively* sentences.

In light of these arguments, we might characterize *respectively* as establishing a pairing not between members of two coordinate structures in the syntax, but between two ordered sets of semantic entities in the discourse.[1] Henceforth, we refer to these two sets as the *domain* and *range* of the relation expressed by the clause containing *respectively*.

To date, the robustness of this characterization and its consequences for syntactic arguments based on the *respectively* construction have not been convincingly shown, as past arguments have centered around a very limited set of examples.[2] We have collected a set of actually-occurring examples that not only reinforces this characterization, but reveals, to an extent not previously established, the degree to which resolution of the domain and range is dependent on discourse-level factors. Furthermore, we have found examples that suggest that the weaker assumptions required for Kac's (1987) more recent non-context-freeness argument for English are also flawed.

For our study, we collected all instances of sentences containing *respectively* in two large corpora, *The New York Times* (30,000 articles) and *Grolier's Encyclopedia* (27,000 articles). We found that out of a total of 548 examples, in 80 cases (15%) either the domain or range is not specified by a coordinate structure in the sentence containing *respectively*. These examples can further be classified into one of four categories: (1) cases where the domain or range is specified by a conjoined structure in a previous sentence (26 cases); (2) cases where the elements of the domain or range must be identified from distinct places in the discourse, the ordering being determined from order of presentation (23 cases); (3) cases where the domain or range and its ordering need to be accommodated, perhaps requiring world knowledge (11 cases); and (4) cases where the elements of the domain or range are not distinguished and their ordering is therefore not recoverable (20 cases); in these cases the ordering is inferred to be arbitrary or otherwise unimportant. The examples in our corpus can thus be seen as lying on a spectrum spanning from the use exemplified by sentence (1) to cases where greater amounts of information must be inferred both to identify and to order the domain or range.

In the following examples, the elements in the domain are specified by a coordinate structure in a previous sentence, with their ordering given by the ordering of the conjuncts:[3]

(4) Kevin Sweeney, 33, and Curtis Bristow, 32, are both former residents of San Diego. They received 20 and 14 years *respectively* for conspiracy to make methamphetamines. [NYT]

(5) Until Friday, government data showed the GNP to be growing at a healthy annual rate of 2.6 percent in last year's second quarter and 3 percent in the third period. The revised GNP numbers for these two quarters, however, were 1.6 percent and 1.7 percent, *respectively*. [NYT]

These cases are allowable within the constraint that McCawley (1988) suggests. However, the following sets of examples show that the situation is more complicated than this.

The elements in the domain in the following sentences are not specified by a coordinate structure, but instead are identified from several locations in the text with the ordering provided by order of presentation:

(6) How do you film buffaloes being shot and killed during a stampede without injuring a single beast? How do you get a buffalo to charge an actor without endangering either?

By using, *respectively*, fake and stunt buffaloes, says Jim Wilson, Kevin Costner's co-producer on "Dances With Wolves," a stunningly beautiful and, by all accounts, remarkably authentic portrait of American Plains Indian culture in the late 1860s. [NYT]

(7) The gain of an operational amplifier is given by the ratio of the feedback resistance to the input resistance. Thus if these two resistances are 100,000 and 1,000 ohms, *respectively*, the gain will be 100. [Gr]

(8) A springboard, with adjustable fulcrum, is 1 or 3 m (3 or 10 ft) above the water surface. The platform, inflexible, is set at 5-10 m (16-33 ft) above the surface. For Olympic and other major competition for both men and women, the 3-m and 10-m heights, *respectively*, are used. [Gr]

In the third class of examples, the domain and its ordering are not specified explicitly by a linguistic form alone, but must be accommodated. Examples (9) and (10), for instance, require inference that appeals to world knowledge:

(9) In most carbon compounds an adjacent atom will contribute one to three electrons, which are matched by an equal number from carbon to form a single, double, or triple bond, *respectively*. [Gr]

(10) A section cut downward from the surface through the various soil horizons forms the soil profile. From the surface downward, the major soil horizons are designated A, B, and C, *respectively*. [Gr]

Understanding sentence (11) requires that the hearer have domain-specific knowledge, namely that a championship basketball series is best-of-seven. The ordering of the games won is then accommodated using temporal order.

(11) Though the Trail Blazers won this series in six games from Phoenix, they were far from dominant. Their margins of victory were 2 points, 1 point, 6 points, and 3 points, *respectively*. [NYT]

In the final set of cases, no domain ordering is inferrable from context because its elements are not distinguished in the discourse. By treating the ordering as unknown or arbitrary, the meaning of *respectively* reduces to essentially that of 'each' or 'individually':

(12) In the long history of the Texas oil industry, there has rarely been a gusher as powerful as either of those that burst to the surface in the aging oil patch southwest of San Antonio last month. In an area regarded as well past its oil-producing prime, the wells surged with 20,000 and 12,000 barrels a day, *respectively*, in a field where most wells produce less than 500. [NYT]

(13) Eleven isotopes of copper are known, two of which are not radioactive and occur with a natural abundance of 69.09% and 30.91%, *respectively*. [Gr]

These four types of examples show that varying degrees of inference may be necessary to identify the domain, as well as to impose an ordering on it. Therefore, *respectively* cannot be seen as imposing an intrasentential syntactic relation between elements of two coordinate structures. It follows that proposals which depend on this, such as the one made by Moltmann (1992), cannot be maintained; furthermore, the Pullum and Gazdar argument against previous attempts to establish the non-context-freeness of English is upheld and reinforced.

More recently, Kac (1987) again appeals to a presumed syntactic dependency established by *respectively* in an attempt to establish the non-context-freeness of English. He acknowledges Pullum and Gazdar's example (3), but provides an argument which, he claims, is not susceptible to their criticisms. The argument rests crucially on the claim that sentence (14)

(14) I like, dislike, and like this and this respectively.

is ungrammatical because

> no NP in the second coordinate phrase can be construed as the Object of more than one V in the first. It then follows in turn that if the Vs are all surface-transitive, there must be at least as many NPs in the second coordinate phrase as there are Vs in the first. (Kac, 1987, pp. 446-447)

Kac's argument does not require that there be a *matching* number of conjuncts in the conjoined verb constituent and the object NP constituent, but instead depends on the weaker assumption that the number of conjuncts in the conjoined verb constituent is *less than or equal to* the number in the NP object constituent. However, this argument misses the point of the Pullum and Gazdar example: the analogous question for constructions like sentence (14) is whether *all three* objects for the verbs can be identified through intersentential reference from an NP with less than three conjuncts. Such is the case in example (15):

(15) John, Bill, and Pete were invited to the party. I like, dislike, and like these three men respectively.

We find such cases to be acceptable, and in so far as they are, the premise underlying Kac's argument is falsified and the argument collapses. While we found no cases exactly analogous to sentence (15) in our corpus (in fact, cases involving verb coordination appear to be somewhat rare in general), there are cases where the first constituent has a greater number of conjuncts than the second constituent (here, the *range* being resolved intersententially as in example (15)), suggesting that cases such as (15) should in theory be possible:

(16) In 1970, Japan and China became the fourth and fifth nations to possess independent launch capability. Osumi and China 1 were launched from within these two countries, *respectively*. [Gr]

(17) Glenn Davis, b. Claremont, Calif., Dec. 26, 1924, is a former football player who starred at the U.S. Military Academy as a freshman in 1943 and during West Point's undefeated seasons of 1944, 1945, and 1946. He scored 3, 20, 18, and 13 touchdowns, *respectively*, in those seasons. [Gr]

In conclusion, all analyses agree on one point: *respectively* establishes a pairing between elements of two sets having the same cardinality. However, the data presented here suggests that these elements are semantic entities in the discourse, not syntactic conjuncts of a coordinated constituent.

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Notes

[1]See Kay (1989) for such a proposal.

[2]For instance, Kac's (1987, pg. 444) non-committal comment "For the sake of argument, let us assume that they [Pullum and Gazdar] are correct on this point", suggests to us that some doubt remains about the adequacy of these examples.

[3]Examples from *The New York Times* are marked [NYT]; those from Grolier's are marked [Gr].