Respectively interpretation and Binding Conditions A and B

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Abstract

The theory of *respectively* interpretation proposed in Yatabe & Tam (2021) entails that Binding Conditions A and B need to be formulated as constraints on the form of semantic representations. It is possible to formulate the two binding conditions as such constraints if anaphoric relations are encoded in semantic representations in a way analogous to the way they are encoded in Discourse Representation Theory.

1 Introduction

In this paper, I am going to examine the interaction between *respectively* interpretation and binding conditions. I will first describe the theory of *respectively* interpretation that is presented in Yatabe & Tam (2021), and argue that it is the best theory of *respectively* interpretation currently available. Then I am going to show what consequences that theory has about binding theory.

2 Yatabe and Tam (2021)

In Appendix D of Yatabe & Tam (2021), we present a theory of *respectively* interpretation that is capable of assigning appropriate truth conditions not only to a sentence like (1) but also to sentences that involve non-constituent coordination, such as (2) and (3).

(1)   Chris and Pat read Austen and Beckett respectively.

(2)   John loves and Mary hates oysters and clams respectively. (from Postal (1998, p. 134))

(3)   Chris bought, and Pat sold, a car on Thursday and a bike on Friday, respectively.

According to the theory, each such sentence is initially associated with a semantic representation that expresses a reading different from the *respectively* reading, and that semantic representation is later rewritten to become a representation expressing the *respectively* reading. For instance, in the case of the sentence in (1), the proposed grammar initially creates a semantic representation that expresses the proposition that both Chris and Pat read both Austen and Beckett, and that representation is subsequently rewritten to become a representation that expresses the proposition that Chris read Austen and Pat read Beckett. The presence of the word *respectively* in a sentence is taken to merely signify the need to invoke this rewriting mechanism, and is disregarded in associating an initial semantic representation to the sentence.

Let me introduce a useful term, *single-conjunct extract*, and then use that term to describe the way the rewriting mechanism works. What I will call a *single-conjunct extract* of a semantic representation is what is obtained by retaining only one conjunct[1] of each coordinate structure in the semantic representation. For instance, the single-conjunct extracts of the initial semantic representation of sentence (1) are four semantic representations that respectively express "Chris read Austen", "Chris read Beckett", "Pat read Austen", and "Pat read Beckett". Now, suppose you consistently choose the first conjunct in obtaining a single-conjunct extract of the initial semantic representation of sentence (1). You get a representation expressing the proposition that Chris read Austen. Likewise, if you consistently choose the second conjunct in obtaining a single-conjunct extract of that semantic representation, you get a representation expressing the proposition that Pat read Beckett. It is by conjoining these two single-conjunct extracts that the rewriting mechanism produces the final semantic representation that expresses the *respectively* reading.

This theory is designed to be able to deal with examples like (4) in which disjunction gives rise to *respectively* interpretation.

(4)   Sentence A and sentence B will be true just in case the set of sneezers contains every man or most babies, respectively.

The fact that not all instances of conjunction and disjunction can give rise to *respectively* interpretation is captured by the following constraint.

(5)   When the rewriting mechanism transforms a formula X into another formula Y that represents a *respectively* reading, there must exist a paraphrase of X that satisfies the following three conditions.
  * The paraphrase is truth-conditionally equivalent to X, given an appropriate context.
  * The paraphrase can be obtained by combining the single-conjunct extracts of X using conjunction and disjunction.
  * Deletion of some of the single-conjunct extracts in the paraphrase yields Y.

I will illustrate the workings of this constraint using concrete examples. The first example is sentence (1). As I already noted, this sentence is initially associated with a semantic representation expressing the proposition that both Chris and Pat read both Austen and Beckett. This proposition can be paraphrased as "Chris read Austen, Chris read Beckett, Pat read Austen, and Pat read Beckett". And if you delete two of the four single-conjunct extracts in this paraphrase, you obtain the *respectively* reading, "Chris read Austen and Pat read Beckett". Therefore this *respectively* reading is licensed by the constraint in question.

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[1]Things that are coordinated with each other in a syntactic or semantic coordinate structure will all be referred to as conjuncts in this paper, irrespective of whether the coordinator involved expresses conjunction or disjunction.

The second example we consider is sentence (4).[2] Suppose that the coordinate DP *sentence A and sentence B* and the disjunction in *every man or most babies* are both interpreted outside the scope of the biconditional.[3] Then the proposition expressed by the initial semantic representation for the sentence will be something like (6).

(6) For each x in the group consisting of sentence A and sentence B, either x is true iff the set of sneezers contains every man or x is true iff the set of sneezers contains most babies.

This can be paraphrased using single-conjunct extracts as in (7), where P stands for "the set of sneezers contains every man" and Q stands for "the set of sneezers contains most babies".

(7) [[For each x in the group consisting of sentence A, x is true iff P] or [for each x in the group consisting of sentence A, x is true iff Q]] and [[for each x in the group consisting of sentence B, x is true iff P] or [for each x in the group consisting of sentence B, x is true iff Q]].

By deleting the second and the third single-conjunct extract in this paraphrase, we get the *respectively* reading, "Sentence A is true iff P, and sentence B is true iff Q". Therefore this *respectively* reading is also licensed.

The third example, given in (8), is a case where *respectively* interpretation fails to materialize.

(8) *Sue or Karen jogs or drives respectively. (from Eggert (2000))

The semantic representation initially associated with the sentence can be paraphrased as "Sue jogs or Sue drives or Karen jogs or Karen drives", using the four single-conjunct extracts of that initial representation. However, no matter which single-conjunct extracts you delete in that paraphrase, you cannot arrive at the *respectively* reading of the sentence, "Sue jogs *and* Karen drives", which is constructed by *conjoining* a single-conjunct extract that is obtained by consistently choosing the first conjunct and a single-conjunct extract that is obtained by consistently choosing the second conjunct. Therefore this *respectively* reading fails to be licensed.

3 Two other theories of *respectively* interpretation

Now, there are two other theories of *respectively* interpretation that can deal with cases involving non-constituent coordination. I will compare our theory with those

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[2]I thank Hans Kamp for pointing out the potential problem that an example like this containing a biconditional could pose for our account.

[3]One way to give the disjunction wide scope over the biconditional is to analyze the sentence as involving left-node raising of the string *will be true just in case the set of sneezers contains* out of a VP of the form *will be true just in case the set of sneezers contains every man or will be true just in case the set of sneezers contains most babies.*

two theories in this section.

The first theory to review is what is proposed in Goodall (1987). According to this theory, the syntactic representation of a sentence that receives *respectively* interpretation consists of multiple clauses that are conjoined with each other. In this theory, coordination in general is represented as a union of phrase markers, that is, a "pasting together," one on top of the other, of two or more trees, with any identical nodes merging together. Thus, the sentence *John and Mary saw himself and herself (respectively)* is assumed to involve union of the phrase marker for *John saw himself* and the phrase marker for *Mary saw herself*.

There are two good reasons to be skeptical of this theory. First, as discussed in detail in Dalrymple & Kehler (1995), a theory like Goodall's cannot be applied to an example like (9), which is acceptable as a response to a query such as *Where do John and Bill live?*.

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

Now, Bošković (to appear) argues that *respectively* interpretation induced by a plural DP should be regarded as an entirely different phenomenon from *respectively* interpretation induced by coordinate structures, citing the contrast between sentence (10) and the second sentence in (11).

(10) Bill and Sue hired himself and nominated herself respectively.

(11) I finally met Lyn and Bill yesterday. *These two students hired herself and nominated himself respectively.

If this view is on the right track, then a sentence like (9) becomes irrelevant in evaluating the validity of Goodall's theory. However, the contrast that Bošković notes does not necessarily show what he says it does. The second sentence in (11) may be degraded not because it has syntactic structure fundamentally different from that of sentence (10) but rather merely because the anaphors in the sentence lack antecedents that agree with them in gender, number, and person. I will come back to this issue in Section 7.

The second problem with Goodall's theory is that it is incapable of dealing with cases involving disjunction. There is nothing in Goodall's theory that accounts for the fact that both conjunction and disjunction can yield *respectively* interpretation under some circumstances but not under other circumstances.

The second theory that I would like to compare our theory to is the one proposed in Kubota & Levine (2016). This theory is an extension of the theory presented in Gawron & Kehler (2004) using Categorial Grammar mechanisms. Unlike Goodall's theory, it has no problem dealing with sentences in which a plural DP like *they* gives rise to *respectively* interpretation. However, just like Goodall's theory, their theory cannot deal with cases where disjunction is responsible for *respectively* interpretation. Kubota & Levine (2018) and Kubota & Levine (2020) discuss the possibility of adding a special mechanism to their theory that deals specifically with *respectively* readings induced by disjunction, but do not present a concrete theory.

Incidentally, in Yatabe & Tam (2021), we note the existence of examples like (9), but do not go on to present a concrete analysis of such examples. This shortcoming, however, is easy to fix. As shown in detail in the Appendix of the present paper, all that needs to be done is to add to the theory the assumption that the INDEX value of a plural DP can be of the form $x_1 + \cdots + x_n$.

4   Binding facts and *respectively* interpretation

Our theory of *respectively* interpretation has some immediate consequences for binding theory. Consider first the following two sentences, both discussed in Goodall (1987).

(12)   John and Mary saw him and a cow respectively.

(13)   John and Mary love his pet goldfish and him respectively.

Coreference between *John* and *him* is disallowed in sentence (12) but possible in sentence (13). Assuming that our almost purely semantic account of *respectively* interpretation is on the right track, there is arguably no reasonable way to account for these observations in syntactic terms, and we are led to conclude that Binding Condition B is a constraint on the form of semantic representations.

Next, consider the following examples.

(14)   Which man and which woman did respectively the doctor talk to about himself, and the lawyer talk to about herself? (from Postal (1998, p. 161))

(15)   John and Mary hired himself and nominated herself respectively. (from Bošković (2022))

Assuming, again, that Yatabe and Tam's theory is on the right track, it seems difficult to escape the conclusion that Binding Condition A is also a constraint on the form of semantic representations.

5   Reformulating Binding Condition A

In what follows, I will show that it is actually possible to reformulate Binding Conditions A and B as constraints on the form of semantic representations if we make certain assumptions about the way anaphoric relations are encoded in semantic representations. First, I assume that a pronominal like *her* contributes to the semantic representation an elementary predication like (16) and that a reflexive pronoun like *yourself* contributes an elementary predication like (17). These elementary predications indicate which variable in the semantic representation is to serve as the antecedent of each pronoun.

(16) $\begin{bmatrix} \text{RELATION} & \text{anaphora} \\ \text{PRONOMINAL} & i \\ \text{ANTECEDENT} & j \end{bmatrix}$

$$
\begin{bmatrix}
\text{SYNSEM} & \begin{bmatrix}
\text{CAT} & \boxed{1} & \begin{bmatrix}
\text{HEAD} & \begin{bmatrix}
det \\
\text{AGR} & \begin{bmatrix}
\text{PER} & \text{3rd} \\
\text{NUM} & \text{sg} \\
\text{GENDER} & \text{f}
\end{bmatrix}
\end{bmatrix} \\
\text{VAL} & \begin{bmatrix}
\text{SUBJ} & \langle\rangle \\
\text{COMPS} & \langle\rangle \\
\text{MOD} & \langle\rangle
\end{bmatrix}
\end{bmatrix} \\
\text{CONT} & \begin{bmatrix}
\text{SEMHEAD} & \boxed{2} \\
\text{INDEX} & \boxed{3}
\end{bmatrix}
\end{bmatrix} \\[4ex]
\text{DOM} & \left\langle
\begin{bmatrix}
\text{PHON} & her \\
\text{SYNSEM} & \begin{bmatrix}
\text{CAT} & \boxed{1} \\
\text{CONT} & \begin{bmatrix}
\text{EP} & \left\langle
\begin{bmatrix}
\text{HNDL} & \boxed{2} \\
\text{RELN} & \text{some} \\
\text{VARIABLE} & \boxed{3} \\
\text{RESTRICTOR} & \boxed{4} \\
\text{SCOPE} & \boxed{5}
\end{bmatrix}
,
\begin{bmatrix}
\text{HNDL} & \boxed{4} \\
\text{RELN} & \text{anaphora} \\
\text{PRONOMINAL} & \boxed{3} \\
\text{ANTECEDENT} & \boxed{6}
\end{bmatrix}
\right\rangle
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
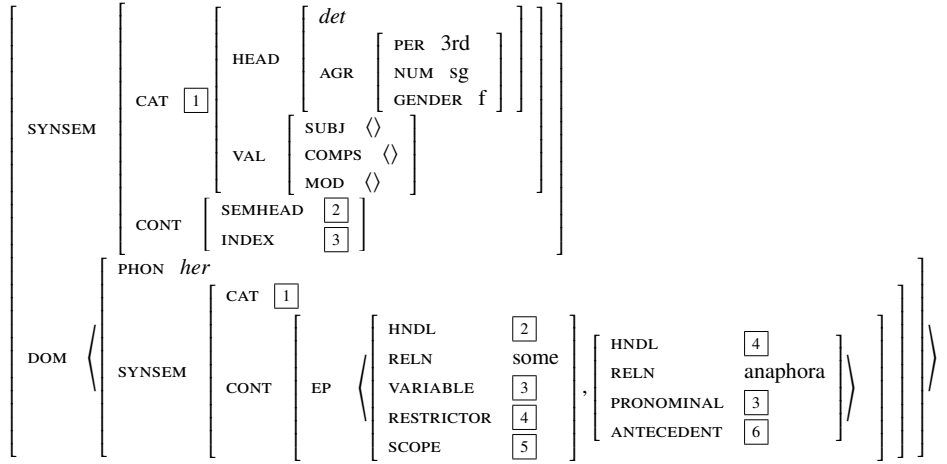\right\rangle
\end{bmatrix}
$$

Figure 1: Part of the lexical entry for *her*

$$
(17) \quad \begin{bmatrix}
\text{RELATION} & \text{anaphora} \\
\text{REFLEXIVE} & i \\
\text{ANTECEDENT} & j
\end{bmatrix}
$$

I also assume that no two DPs in the same sentence are allowed to have the same index, and that what is captured by coindexing in most other theories is instead captured by elementary predications like (16) and (17).

To be more concrete, I propose that a pronominal like *her* and a reflexive pronoun like *yourself* be associated with lexical entries like those shown in Fig. 1 and Fig. 2 respectively. Notice that, in each of these lexical entries, the EP value inside the DOM value[4] contains an elementary predication expressing an existential quantifier in addition to an elementary predication stating which variable is to be the antecedent of the variable contributed by the pronoun. The existential quantifier provides existential closure for the variable provided by the pronoun, creating semantic representations that bear some similarity to the semantic representations postulated in Discourse Representation Theory (see Kamp & Reyle (1993)).

I will further assume that elementary predications contributed by predicates indicate which variable has come from which grammatical function. For instance, an elementary predication contributed by an active verb *see* and an elementary predication contributed by a passive verb *seen* will be like the ones shown in (18) and (19) respectively.

$$
(18) \quad \begin{bmatrix}
\text{RELATION} & \text{see} \\
\text{SUBJECT} & i \\
\text{OBJECT} & j
\end{bmatrix}
$$

---

[4]See Yatabe & Tam (2021) for an explanation as to why elementary predications expressing the meaning of expressions need to be placed inside DOM values.
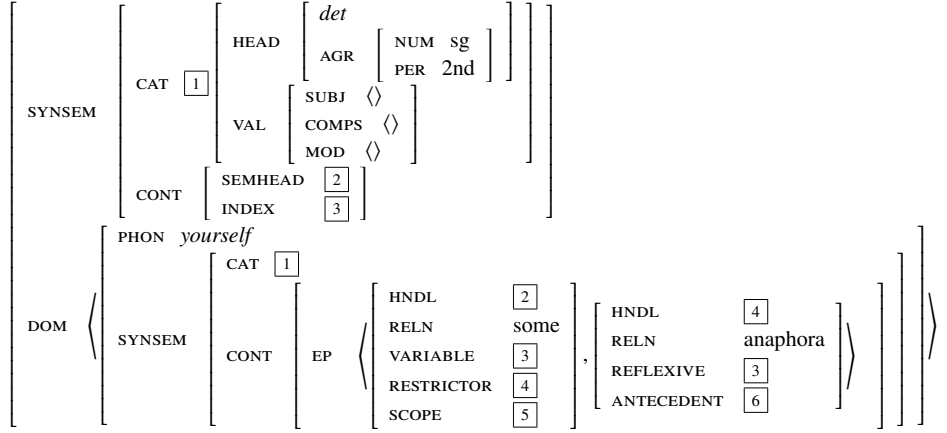
$$
\begin{bmatrix}
\text{SYNSEM} & \begin{bmatrix}
\text{CAT} \;\boxed{1}\; & \begin{bmatrix}
\text{HEAD} & \begin{bmatrix}
\textit{det} \\
\text{AGR} & \begin{bmatrix} \text{NUM} & \text{sg} \\ \text{PER} & \text{2nd} \end{bmatrix}
\end{bmatrix} \\
\text{VAL} & \begin{bmatrix} \text{SUBJ} & \langle\rangle \\ \text{COMPS} & \langle\rangle \\ \text{MOD} & \langle\rangle \end{bmatrix}
\end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{SEMHEAD} & \boxed{2} \\ \text{INDEX} & \boxed{3} \end{bmatrix}
\end{bmatrix} \\
\text{DOM} & \left\langle \begin{bmatrix}
\text{PHON} & \textit{yourself} \\
\text{SYNSEM} & \begin{bmatrix}
\text{CAT} \; \boxed{1} \\
\text{CONT} & \begin{bmatrix} \text{EP} & \left\langle \begin{bmatrix} \text{HNDL} & \boxed{2} \\ \text{RELN} & \text{some} \\ \text{VARIABLE} & \boxed{3} \\ \text{RESTRICTOR} & \boxed{4} \\ \text{SCOPE} & \boxed{5} \end{bmatrix} , \begin{bmatrix} \text{HNDL} & \boxed{4} \\ \text{RELN} & \text{anaphora} \\ \text{REFLEXIVE} & \boxed{3} \\ \text{ANTECEDENT} & \boxed{6} \end{bmatrix} \right\rangle \end{bmatrix}
\end{bmatrix}
\end{bmatrix} \right\rangle
\end{bmatrix}
$$

Figure 2: Part of the lexical entry for *yourself*

(19)
$$
\begin{bmatrix}
\text{RELATION} & \text{be\_seen} \\
\text{SUBJECT} & i \\
\text{OBLIQUE} & j
\end{bmatrix}
$$

Given these assumptions, Binding Condition A can now be stated as in (22). The term *outrank*, used in (22), is defined in (20). The term *exempt anaphor*, also used in (22), is defined in (21). What is called the *initial semantic representation* of a sentence here is the MRS representation that the grammar initially associates with the sentence. What is called the *final semantic representation*, on the other hand, is the semantic representation which is produced by the rewriting mechanism responsible for *respectively* interpretation and which expresses the correct truth conditions of the sentence.

(20) Let E be an elementary predication and let X and Y be variables contained in E. We say that X *outranks* Y in E if and only if (i) X is the SUBJECT value of E and Y is not, or (ii) X is the OBJECT value of E and Y is neither the SUBJECT value nor the OBJECT value of E, or (iii) X is the SECONDARY-OBJECT value of E and Y is not the SUBJECT value, the OBJECT value, or the SECONDARY-OBJECT value of E.

(21) An elementary predication E of the form shown in (17) is an *exempt anaphor* in a semantic representation M if M does not contain an elementary predication in which the REFLEXIVE value of E is outranked by some other variable.

(22) Binding Condition A:
Let M' be a final semantic representation that has been derived by applying (possibly vacuously) to an initial semantic representation M the rewriting mechanism responsible for *respectively* interpretation. Let E' be an elementary predication of the form shown in (17) that is contained in M', and E be the source of E' contained in M, which means that E is either

identical to E' or an alphabetic variant of E'. Suppose that E is not an exempt anaphor in M. Then M' must contain an elementary predication in which the REFLEXIVE value of E' is outranked by the ANTECEDENT value of E'.

Let me illustrate how this condition applies to some concrete examples, starting with the simple sentence in (23).

(23)   Chris likes herself.

The EP value associated with the sentence as a whole is shown in (24). Note that the meaning of a quantifier such as *some* is assumed to be a three-place predicate whose arguments are (i) the variable it binds, (ii) the restrictor, and (iii) the (nuclear) scope. Note also that it is assumed that the handle of an elementary predication contributed by a proper noun is obligatorily equated with *gtop*, the global top handle (see Yatabe & Tam (2021, p. 31)).

(24) $\left\langle \begin{bmatrix} \text{HNDL} & gtop \\ \text{RELN} & \text{identical} \\ \text{ARG1} & i \\ \text{ARG2} & \text{Chris} \end{bmatrix}, \begin{bmatrix} \text{HNDL} & h2 \\ \text{RELN} & \text{like} \\ \text{SUBJECT} & i \\ \text{OBJECT} & j \end{bmatrix}, \begin{bmatrix} \text{HNDL} & gtop \\ \text{RELN} & \text{some} \\ \text{VARIABLE} & j \\ \text{RESTRICTOR} & h1 \\ \text{SCOPE} & h2 \end{bmatrix}, \right.$
$\left. \begin{bmatrix} \text{HNDL} & h1 \\ \text{RELATION} & \text{anaphora} \\ \text{REFLEXIVE} & j \\ \text{ANTECEDENT} & i \end{bmatrix} \right\rangle$

The list of elementary predications given in (24) is equivalent to the following formula, where "$j \rightarrow i$" corresponds to the last elementary predication and is assumed to be true if and only if the denotation of j and the denotation of i are identical.

(25) $i = \text{Chris} \wedge \text{some}(j, j \rightarrow i, \text{like}(i, j))$

What is shown in (24) is both the initial semantic representation and the final semantic representation for the sentence in (23). The fourth elementary predication in (24) is not an exempt anaphor according to (21), because this EP list contains an elementary predication in which the REFLEXIVE value of that elementary predication (namely j) is outranked by some other variable (namely the second elementary predication). Thus Binding Condition A needs to be satisfied, and it *is* satisfied because (24) contains an elementary predication whose RELN value is *like* in which the REFLEXIVE value of the fourth elementary predication (namely j) is outranked by its ANTECEDENT value (namely i).

Next, let us consider the sentence in (15) above, which involves *respectively* interpretation. Since the subject *John and Mary* in this sentence needs to be given distributive interpretation, it is necessary to state here how distributive interpretation is handled by the grammar. I will use the sentence in (26a) as an example.

(26)   a. Three students sang.

    b. [$_\text{S}$ Three students [$_\text{VP}$ DIST1 [$_\text{VP}$ sang]]]

    c. $\text{some}(X, |X| = 3 \land \text{students}(X), \text{every}(z, \text{member\_of}(z, X), \text{sang}(z)))$

In Yatabe (2021), I propose an analysis of sentence (26a) in which it is given a syntactic structure like (26b), where the unpronounced lexical item DIST1 functions like the floated quantifier *each*. Like many previous analyses such as those presented in Heim et al. (1991) and Kamp & Reyle (1993), this analysis ultimately assigns to the sentence a semantic interpretation like (26c), where a formula of the form "member_of(*a*, *b*)" is assumed to be true if and only if the denotation of the first argument is a member of the group consisting of the denotation of the second argument.

    Assuming this analysis of distributive interpretation, the initial semantic representation for sentence (15) is constructed as in (27), disregarding the presence of the word *respectively*. The semantic coordinators that are to be given *respectively* interpretation are assigned a subscript here, in accordance with the theory of Yatabe & Tam (2021).

(27)
$$
\left\langle
\begin{bmatrix}
\text{HNDL} & gtop \\
\text{RELN} & \text{some} \\
\text{VARIABLE} & z \\
\text{RESTRICTOR} & h1 \\
\text{SCOPE} & h2
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & h1 \\
\text{RELN} & \text{identical} \\
\text{ARG1} & z \\
\text{ARG2} & x +_i y
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & gtop \\
\text{RELN} & \text{identical} \\
\text{ARG1} & x \\
\text{ARG2} & \text{John}
\end{bmatrix},
\right.
$$

$$
\begin{bmatrix}
\text{HNDL} & gtop \\
\text{RELN} & \text{identical} \\
\text{ARG1} & y \\
\text{ARG2} & \text{Mary}
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & h2 \\
\text{RELN} & \text{every} \\
\text{VARIABLE} & w \\
\text{RESTRICTOR} & h3 \\
\text{SCOPE} & h4
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & h3 \\
\text{RELN} & \text{member\_of} \\
\text{ARG1} & w \\
\text{ARG2} & z
\end{bmatrix},
$$

$$
\begin{bmatrix}
\text{HNDL} & h4 \\
\text{RELN} & \text{and}_i \\
\text{CONJUNCTS} & \langle h5, h6 \rangle
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & h8 \\
\text{RELN} & \text{hired} \\
\text{SUBJECT} & w \\
\text{OBJECT} & u
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & h5 \\
\text{RELN} & \text{some} \\
\text{VARIABLE} & u \\
\text{RESTRICTOR} & h7 \\
\text{SCOPE} & h8
\end{bmatrix},
$$

$$
\begin{bmatrix}
\text{HNDL} & h7 \\
\text{RELN} & \text{anaphora} \\
\text{REFLEXIVE} & u \\
\text{ANTECEDENT} & w
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & h10 \\
\text{RELN} & \text{nominated} \\
\text{SUBJECT} & w \\
\text{OBJECT} & v
\end{bmatrix},
$$

$$
\left.
\begin{bmatrix}
\text{HNDL} & h6 \\
\text{RELN} & \text{some} \\
\text{VARIABLE} & v \\
\text{RESTRICTOR} & h9 \\
\text{SCOPE} & h10
\end{bmatrix},
\begin{bmatrix}
\text{HNDL} & h9 \\
\text{RELATION} & \text{anaphora} \\
\text{REFLEXIVE} & v \\
\text{ANTECEDENT} & w
\end{bmatrix}
\right\rangle
$$

The representation in (27) is equivalent to (28), where *and*(*X*, *Y*) is meant to be equivalent to $X \land Y$.

(28) $x = \text{John} \wedge y = \text{Mary}$
$\wedge \text{some}(z, z = x +_i y,$
$\qquad \text{every}(w, \text{member\_of}(w, z),$
$\qquad\qquad \text{and}_i(\text{some}(u, u \rightarrow w, \text{hired}(w, u)),$
$\qquad\qquad\qquad \text{some}(v, v \rightarrow w, \text{nominated}(w, v)))))$

("x is John, y is Mary, and for every member w of an entity z that is a group made up of x and y, it can be said that w hired u that is identical to w and that w nominated v that is identical to w.")

By assumption, the rewriting mechanism can target any subpart of a semantic representation that contains all the semantic coordinators with a given subscript such as i, so it can target the portion that starts with the first occurrence of *some*, i.e. what is shown in (29), in the present case. The single-conjunct extract of that portion of the semantic representation that we get by consistently choosing the first conjunct of each coordinator with subscript i is (30), and the single-conjunct extract we get by consistently choosing the second conjunct is (31).

(29) $\text{some}(z, z = x +_i y,$
$\qquad \text{every}(w, \text{member\_of}(w, z),$
$\qquad\qquad \text{and}_i(\text{some}(u, u \rightarrow w, \text{hired}(w, u)),$
$\qquad\qquad\qquad \text{some}(v, v \rightarrow w, \text{nominated}(w, v)))))$

(30) $\text{some}(z, z = x,$
$\qquad \text{every}(w, \text{member\_of}(w, z),$
$\qquad\qquad \text{some}(u, u \rightarrow w, \text{hired}(w, u))))$

(31) $\text{some}(z, z = y,$
$\qquad \text{every}(w, \text{member\_of}(w, z),$
$\qquad\qquad \text{some}(v, v \rightarrow w, \text{nominated}(w, v))))$

By replacing (29) with the conjunction of (30) and (31) in (28), the rewriting mechanism arrives at the final semantic representation, which is shown in (32). In (32), two of the bound variables in (31), namely w and z, have been replaced by w' and z' respectively in order to satisfy the variable-binding condition, which prohibits a variable bound by a quantifier from being reused as a free variable or as a variable bound by another quantifier.[5]

(32) $x = \text{John} \wedge y = \text{Mary}$
$\wedge \text{and}(\text{some}(z, z = x,$
$\qquad\qquad \text{every}(w, \text{member\_of}(w, z),$
$\qquad\qquad\qquad \text{some}(u, u \rightarrow w, \text{hired}(w, u)))),$
$\qquad \text{some}(z', z' = y,$
$\qquad\qquad \text{every}(w', \text{member\_of}(w', z'),$
$\qquad\qquad\qquad \text{some}(v, v \rightarrow w', \text{nominated}(w', v)))))$

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[5] In Yatabe & Tam (2021), it was assumed that final semantic representations do not have to satisfy the variable-binding condition. Here I drop that assumption because it is incompatible with the theory formulated in the present paper.

This is an adequate if long-winded semantic representation that expresses the *respectively* reading of sentence (15).

Binding Condition A is satisfied by sentence (15) when its initial semantic representation is (27) and its final semantic representation is (32). The official MRS version of the final representation, which I do not show here, contains two elementary predications of the form shown in (17), corresponding to "$u \rightarrow w$" and "$v \rightarrow w'$" in (32), both of which come from a counterpart in the initial semantic representation that was not an exempt anaphor there. The elementary predication corresponding to "$u \rightarrow w$" satisfies Binding Condition A because its REFLEXIVE value (namely u) is outranked by its ANTECEDENT value (namely w) in the elementary predication corresponding to "hired(w,u)". The elementary predication corresponding to "$v \rightarrow w'$" likewise satisfies Binding Condition A because its REFLEXIVE value (namely v) is outranked by its ANTECEDENT value (namely w') in the elementary predication corresponding to "nominated(w',v)".

Note that (22) states that an anaphor is exempted from Binding Condition A if it is an exempt anaphor in the *initial* semantic representation. The reason the exempt status of an anaphor needs to be determined according to the configuration of the initial semantic representation is that a sentence like (33) is acceptable.

(33)   The artist$_i$ says that the characters in her comics are based on her favorite colors, purple and grey, and represent herself$_i$ and her boyfriend respectively.
https://www.demilked.com/adorable-relationship-comics-the-avr-method/

The reflexive pronoun *herself* in this example would be incorrectly predicted not to be exempt from Binding Condition A if the exempt status of an anaphor were to be determined according to the configuration of the final semantic representation.

6   Raising predicates

The theory proposed in Section 5 is incompatible with some standard assumptions about the semantics of raising predicates, since a sentence like (34) is possible.

(34)   The students seemed to themselves to be tired.

If the verb *seemed* in this sentence is semantically a two-place predicate as it is standardly assumed to be, then the variable contributed by the reflexive *themselves* is not outranked by any other variable in any of the elementary predications, in violation of the version of Binding Condition A formulated above. Reinhart & Reuland (1993) and Müller (2021) state that an observation like this constitutes evidence that Binding Condition A needs to make reference to syntactic representations as opposed to semantic representations.

In fact, however, a sentence like (34) does not necessarily show that Binding Condition A needs to make reference to syntactic structure. It is possible to maintain the version of Binding Condition A stated in (22) if we assume that raising predicates

such as *seem* are syntactically ambiguous and that they each have a homophonous control-predicate counterpart. Given that assumption, a sentence like (34) is no longer a problem for the proposed account because the verb *seemed* here can then be semantically a three-place predicate whose second argument, which is in this case a variable contributed by a reflexive, is anteced by its first argument.

7 The necessity of syntactic antecedents

Let us now come back to the issue posed by the contrast between (10) and the second sentence in (11). Bošković (to appear) interprets this contrast as indicating that the two sentences have fundamentally different syntactic structures. As noted above, however, the contrast can also be interpreted as showing that each reflexive pronoun must have a syntactic antecedent, that is, a syntactic entity that can be regarded as the antecedent of the reflexive pronoun. The reflexives in (10) have syntactic antecedents, namely *Bill* and *Sue*, whereas the reflexives in (11) do not have syntactic antecedents.

There are three slight complications that we need to consider before we attempt to formulate the constraint in question. First, if we are to maintain the standard HPSG view that the grammatical subject position of an infinitival clause like *to defend themselves* can be truly missing rather than filled by an unpronounced pronominal element, we need to say that not only an overt DP but also an unsaturated DP argument slot can serve as the syntactic antecedent of a pronoun.

The second complication comes from cases where the antecedent of a pronoun is a plural DP that receives distributive interpretation. Consider sentence (26a) again. Notice that, in order for this sentence to be associated with the semantic representation shown in (26c), the INDEX value of the subject DP must be the variable X, a variable different from the SUBJECT value of the elementary predication contributed by the verb *sang*, which has to be something like (35).

$$(35) \quad \begin{bmatrix} \text{HNDL} & h1 \\ \text{RELN} & \text{sang} \\ \text{SUBJECT} & z \end{bmatrix}$$

When the same analysis of distributive interpretation is applied to a sentence like (36a), as in (36b) and (36c), Binding Condition A requires the ANTECEDENT value of the elementary predication contributed by the reflexive pronoun to be z, a variable different from the INDEX value of the subject DP, i.e. X.

(36)   a.   Three scholars cited themselves.
       b.   [$_S$ Three scholars [$_{VP}$ DIST1 [$_{VP}$ cited themselves]]]
       c. $\text{some}(X, |X| = 3 \land \text{scholars}(X),$
            $\text{every}(z, \text{member\_of}(z, X), \text{some}(y, y \rightarrow z, \text{cited}(z, y))))$

This means that the DP that we would like to identify as the syntactic antecedent of a reflexive pronoun may have an INDEX value that is different from the ANTECEDENT

value of the elementary predication contributed by the reflexive pronoun as well as from the INDEX value of the reflexive pronoun.

And the third complication, which is analogous to the second one, comes from sentences like (10). In the semantic representation of (10) shown in (32), the variable w, which outranks the variable u contributed by the reflexive *himself* in the elementary predication contributed by the verb *hired*, is the only possible ANTECEDENT value of the elementary predication contributed by the reflexive, but the INDEX value of the DP *John*, which we would like to say is the syntactic antecedent of the reflexive, is not w but x.

In light of these considerations, I hypothesize that the grammar of English contains the constraint stated in (37).[6] The term *syntactic antecedent*, used in (37), is defined in (38), and the term *source variable*, used in (38), is defined in (39).

(37)   For each elementary predication that has the REFLEXIVE feature, the following two conditions must be satisfied.
First, there must be either a DP or an unsaturated DP argument slot which is a syntactic antecedent of that elementary predication.
And second, the pronoun that contributed that elementary predication to the semantic representation and the syntactic antecedent of the elementary predication must agree in gender, number, and person.

(38)   Definition of *syntactic antecedent*:
Let E be an elementary predication whose ANTECEDENT value is a variable j. Then a DP or a DP argument slot whose INDEX value is a variable i is a *syntactic antecedent* of E if and only if i is a source variable of j.

(39)   Definition of *source variable*:
A variable x is a *source variable* of a variable y if and only if (i) x and y are the same variable, or (ii) y is a variable bound by a quantifier whose restrictor is of the form "member_of(y, x)", or (iii) y is a variable bound by a quantifier whose restrictor is of the form "$y = x$", or (iv) x is a source variable of a variable that is a source variable of y.

This way of formulating the constraint allows us to circumvent the three potential problems noted above.

8   Reformulating Binding Condition B

Finally, let us consider how Binding Condition B can be reformulated as a constraint on semantic representations. The view that Binding Condition B is a constraint on semantic representations has a precedent in Reinhart & Reuland (1993), so let us examine what is proposed in that article first. The version of Binding Condition B that Reinhart and Reuland propose is (41), and the terms that are used in that

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[6]A constraint like (37) needs to be postulated even if the second sentence in (11) is only slightly less acceptable than (10), as long as there is any systematic difference in acceptability.

statement are defined as in (40). The verbiage following "i.e." has been added by me to clarify the meaning.

(40) Definitions
   a. The *semantic predicate* formed of P is P and all its arguments at the relevant semantic level.
   b. A predicate is *reflexive* iff two of its arguments are coindexed (i.e. are the same variable).
   c. A predicate (formed of P) is *reflexive-marked* iff either P is lexically reflexive or one of P's arguments is a SELF anaphor (i.e. a variable contributed by a reflexive pronoun).

(41) Condition B proposed in Reinhart & Reuland (1993)
    A reflexive semantic predicate is reflexive-marked.

Reinhart and Reuland claim that this condition accounts for the low acceptability of an example like (42).

(42) *Felix and Lucie$_i$ praised her$_i$.

In their view, (42) is ruled out by Binding Condition B because the sentence is associated with a semantic representation like (43).

(43)   Felix ($\lambda x(x$ praised her)) & Lucie ($\lambda x(x$ praised x))

The representation in (43) is ruled out by the condition because the semantic predicate "x praised x" contained in it is reflexive but not reflexive-marked.

It is reasonably clear what kind of theory Reinhart and Reuland are proposing, but it is not necessarily clear what prediction their theory makes for each specific example, because they do not state the rules according to which each sentence is given a specific semantic representation. For instance, it is not clear what ensures that sentence (42) is associated with the representation in (43) and not with a semantic representation like (44), which is not ruled out by their Binding Condition B.

(44) $\forall x[x \in \{\text{Felix}, \text{Lucie}\} \rightarrow x$ praised her]

Here, I will formulate a version of Binding Condition B that does what Reinhart and Reuland's condition is supposed to do, presupposing that sentences are given the kinds of semantic representations that I have been assuming that they are given. The condition stated in (45) is the version of Binding Condition B that I propose. The expression *illicit-antecedent set*, used in the statement, is defined in (46), and the expression *referential equivalent*, used in (46), is defined in (47).

(45) Binding Condition B:
    Let E be an elementary predication of the form shown in (16) which is contained in a final semantic representation M. Suppose that the ANTECEDENT

value and the PRONOMINAL value of E are a and p respectively. Then a must not be an element of the illicit-antecedent set of p in M.

(46) Definition of *illicit-antecedent set*:
The *illicit-antecedent set* of a variable x in a semantic representation M is the minimal set A such that
  (a) for any variable y that outranks x in an elementary predication contained in M, $y \in A$,
  (b) for any variable $y \in A$, $\{z: z$ is a referential equivalent of $y\} \subset A$, and
  (c) for any variable $y \in A$, if (i) a referential equivalent of y is bound in M by a quantifier whose restrictor is of the form "member_of(y, z)" and (ii) there is a referential equivalent of z that is bound in M by a quantifier whose restrictor is of the form "$z = w_1 + \cdots + w_n$", then $\{w_1, \ldots, w_n\} \subset A$.

(47) Definition of *referential equivalent*:
A variable x is a *referential equivalent* of a variable y if and only if (i) x and y are the same variable, or (ii) x is bound by a quantifier whose restrictor is of the form "$x \rightarrow y$", or (iii) y is bound by a quantifier whose restrictor is of the form "$y \rightarrow x$", or (iv) x is a referential equivalent of some variable that is a referential equivalent of y.

Let us see how the proposed Binding Condition B applies to a few concrete examples. The first example that I consider is (48), an example discussed in Berman & Hestvik (1994). This sentence is acceptable when the pronoun *them* refers to John and his mother.

(48) John's mother protected them from the robbers.

Assuming that the pronoun *them* is not given distributive interpretation, this example is associated with a semantic representation like (49).

(49) $j = \text{John} \wedge \text{the}(x, \text{mother}(x, j),$
$\qquad\qquad \text{some}(y, y \rightarrow j + x,$
$\qquad\qquad\qquad \text{the}(z, \text{robbers}(z),$
$\qquad\qquad\qquad\qquad \text{protected}(x, y, z))))$

Binding Condition B requires that $j + x$ should not be an element of the illicit-antecedent set of y here. Since the illicit-antecedent set of y here is $\{x\}$ and does not contain $j + x$, Binding Condition B is satisfied, and the sentence is correctly predicted to be acceptable.

Next, let us see how sentence (12), repeated here as (50), is analyzed in the proposed account.

(50) John and Mary saw him and a cow respectively.

Suppose that the subject *John and Mary* receives distributive interpretation. Suppose also that this sentence involves conjunction of two VPs out of which the verb

saw is left-node-raised, because I wish to avoid having to discuss here the issue of how best to deal with coordination of quantifiers within Minimal Recursion Semantics. Then the sentence can be associated with the following initial semantic representation.

(51) $j = \text{John} \wedge m = \text{Mary}$
    $\wedge \text{some}(x, x = j +_i m,$
        $\text{every}(w, \text{member\_of}(w, x),$
            $\text{and}_i(\text{some}(y, y \rightarrow j, \text{saw}(w, y)),$
               $\text{a}(z, \text{cow}(z), \text{saw}(w, z)))))$

The rewriting mechanism responsible for *respectively* interpretation can target the portion that starts with the first occurrence of *some*. The single-conjunct extract that we get by consistently choosing the first conjunct is (52), and the single-conjunct extract that we get by consistently choosing the second conjunct is (53).

(52) $\text{some}(x, x = j,$
      $\text{every}(w, \text{member\_of}(w, x),$
         $\text{some}(y, y \rightarrow j, \text{saw}(w, y))))$

(53) $\text{some}(x, x = m,$
      $\text{every}(w, \text{member\_of}(w, x),$
         $\text{a}(z, \text{cow}(z), \text{saw}(w, z))))$

Conjoining the two single-conjunct extracts after renaming two of the bound variables in (53), and then putting the result back into (51), we get the following final semantic representation.

(54) $j = \text{John} \wedge m = \text{Mary}$
    $\wedge \text{and}(\text{some}(x, x = j,$
          $\text{every}(w, \text{member\_of}(w, x),$
             $\text{some}(y, y \rightarrow j, \text{saw}(w, y)))),$
        $\text{some}(x', x' = m,$
          $\text{every}(w', \text{member\_of}(w', x'),$
            $\text{a}(z, \text{cow}(z), \text{saw}(w', z)))))$

In (54), Binding Condition B requires that j should not be an element of the illicit-antecedent set of y. Since the illicit-antecedent set of y is $\{w, j\}$ and contains j, the sentence fails to be licensed.

Like the version of the condition proposed in Reinhart & Reuland (1993), the Binding Condition B proposed in this section does not rule out sentences like (55) and (56), and hence has to be augmented with a separate condition.

(55) *Mary$_i$ expects her$_i$ to win.

(56) *John$_i$ would like very much for him$_i$ to win.

What is needed is a constraint like (57).

(57) Suppose that the SUBJECT value x of an elementary predication E whose RELN value is an infinitive verb meaning (such as *to_win* in (58) below) is bound by a quantifier whose restrictor consists of an elementary predication whose PRONOMINAL value is x and whose ANTECEDENT value is y. Then the HNDL value of E must not be outscoped by the HNDL value of an elementary predication F such that (i) the SUBJECT value or the OBJECT value of F is a referential equivalent of y, and (ii) there is no elementary predication which has the SUBJECT feature and whose HNDL value is outscoped by that of F and outscopes that of E.

This condition correctly rules out sentence (55), which is associated with a semantic representation like (58), as well as sentence (56).

(58) $m = \text{Mary} \land \text{expects}(m, \text{some}(x, x \rightarrow m, \text{to\_win}(x)))$

9 Summary

In this paper, I have argued (i) that Yatabe and Tam's theory of *respectively* interpretation entails that Binding Conditions A and B need to be formulated as constraints on the form of semantic representations and (ii) that it is possible to formulate the two binding conditions as such constraints if anaphoric relations are encoded in semantic representations in a way analogous to the way they are encoded in Discourse Representation Theory, although a separate, purely syntactic constraint needs to be postulated that requires each reflexive pronoun to have a syntactic antecedent.

Appendix

In this Appendix, I will show that examples like *They live in New York and Chicago respectively* can be properly dealt with in the theory of *respectively* interpretation proposed in Yatabe & Tam (2021) if we add to the theory the assumption that the index value of a plural DP can be of the form $x_1 + \cdots + x_n$. A composite variable of the form $x_1 + \cdots + x_n$ is already used in Yatabe & Tam (2021) as a variable whose denotation is the sum of the denotations of the variables $x_1, \ldots, x_n$, but no statement was made in that article regarding under what circumstances a composite variable is allowed to occur.

In order to show that addition of this assumption to the theory is indeed sufficient to solve the problem, I will show how the second sentence in (59) can be analyzed in the revised theory.

(59) John, Bill, and Pete were invited to the party. I like, dislike, and like these three men respectively. (from Dalrymple & Kehler (1995))

According to the theory of distributive interpretation described in Yatabe (2021, Sect. 3.1), the second sentence in (59) can contain an unpronounced distributive operator adjoined to the object DP, as shown in (60), where DIST2 is the silent distributive operator. The lexical entry for this silent distributive operator is given in Yatabe (2021, Sect. 3.1).

(60) I like, dislike, and like [$_{\text{DP}}$ [$_{\text{DP}}$ these three men] DIST2] respectively.

What is shown in (61) can be assigned to the structure in (60) as its initial semantic representation. Recall that an elementary predication of the form "member_of(a, b)", which comes from the silent distributive operator and occurs in the fifth line of (61), is true if and only if the denotation of the first argument is a member of the group consisting of the denotation of the second argument.

(61) $s = \text{Speaker}$
$\land \text{some}(x_1 + x_2 + x_3,$
$\qquad \text{these}(x_1 + x_2 + x_3) \land \text{three}(x_1 + x_2 + x_3) \land \text{men}(x_1 + x_2 + x_3),$
$\qquad \text{every}(y,$
$\qquad\qquad \text{member\_of}(y, x_1 +_i x_2 +_i x_3),$
$\qquad\qquad \text{and}_i(\text{like}(s, y),$
$\qquad\qquad\qquad \text{dislike}(s, y),$
$\qquad\qquad\qquad \text{like}(s, y))))$

As has been noted in the main portion of the present paper, in the theory proposed in Yatabe & Tam (2021), semantic coordinators like + and *and* can optionally come with a subscript like *i*, and semantic coordinators with the same subscript are given *respectively* interpretation together. Thus, while the variable $x_1 +_i x_2 +_i x_3$ itself is to be given the same denotation that the variable $x_1 + x_2 + x_3$ is given, the subscript *i* contained in it indicates that the conjunction expressed by the semantic coordinator + here is to be given *respectively* interpretation. The subscript *i* on the predicate symbol *and* likewise means that the conjunction expressed by this semantic coordinator is also to be given *respectively* interpretation.

The rewriting mechanism responsible for *respectively* interpretation can target any constituent of a semantic representation as long as the constituent contains all occurrences of a given subscript. In the case at hand, the mechanism can target the constituent that starts with the predicate *every*. When we construct a single-conjunct extract of that constituent choosing the first semantic conjunct consistently, we get (62). When we construct a single-conjunct extract choosing the second semantic conjunct consistently, we get (63). And when we construct a single-conjunct extract choosing the third semantic conjunct consistently, we get (64).

(62) $\text{every}(y, \text{member\_of}(y, x_1), \text{like}(s, y))$

(63) $\text{every}(y, \text{member\_of}(y, x_2), \text{dislike}(s, y))$

(64) $\text{every}(y, \text{member\_of}(y, x_3), \text{like}(s, y))$

Conjoining these three and substituting the result for the constituent that starts with *every* in (61), we arrive at the representation in (65).

(65) $s = \text{Speaker}$
$\wedge \text{some}(x_1 + x_2 + x_3,$
$\qquad \text{these}(x_1 + x_2 + x_3) \wedge \text{three}(x_1 + x_2 + x_3) \wedge \text{men}(x_1 + x_2 + x_3),$
$\qquad \text{and}(\text{every}(y, \text{member\_of}(y, x_1), \text{like}(s, y)),$
$\qquad\qquad \text{every}(y', \text{member\_of}(y', x_2), \text{dislike}(s, y')),$
$\qquad\qquad \text{every}(y'', \text{member\_of}(y'', x_3), \text{like}(s, y''))))$

This representation means "There are these three men, x_1, x_2, and x_3, such that the speaker likes every entity that is a member of the group consisting only of x_1, dislikes every entity that is a member of the group consisting only of x_2, and likes every entity that is a member of the group consisting only of x_3", which is precisely the *respectively* reading of the second sentence in (59).

Incidentally, if the object DP in the second sentence in (59) does not have a silent distributive operator adjoined to it, the grammar cannot assign a *respectively* reading to the sentence. It might seem that the grammar could assign to the sentence an initial semantic representation like (66) and later turn that initial representation into a representation expressing the *respectively* reading.

(66) $s = \text{Speaker}$
$\wedge \text{some}(x_1 + x_2 + x_3,$
$\qquad \text{these}(x_1 + x_2 + x_3) \wedge \text{three}(x_1 + x_2 + x_3) \wedge \text{men}(x_1 + x_2 + x_3),$
$\qquad \text{and}_i(\text{like}(s, x_1 +_i x_2 +_i x_3),$
$\qquad\qquad \text{dislike}(s, x_1 +_i x_2 +_i x_3),$
$\qquad\qquad \text{like}(s, x_1 +_i x_2 +_i x_3)))$

A representation like (66), however, cannot actually be produced by the grammar because of what is called the *i*-within-*i* constraint on *respectively* interpretation in Yatabe & Tam (2021). The constraint prohibits the EP values of prosodic constituents coordinated by a semantic coordinator bearing a subscript *i* from containing a semantic coordinator bearing the same subscript *i*. In order for the grammar to create a representation like (66), the EP values of the prosodic constituents that are coordinated by "and$_i$" (namely the three prosodic constituents that are pronounced *like*, *dislike*, and *and like* respectively) have to contain the variable $x_1 +_i x_2 +_i x_3$, violating the constraint.

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