Exceptional Wide Scope as Anaphora to Quantificational Dependencies

Adrian Brasoveanu* Donka F. Farkas**
*Stanford University **University of California at Santa Cruz

Abstract

The paper proposes a novel solution to the problem of exceptional scope (ES) of (in)definites, e.g. the widest and intermediate scope readings of the sentence *Every student of mine read every poem that a famous Romanian poet wrote before World War II.* We propose that ES readings are available when the sentence is interpreted as anaphoric to quantificational domains and quantificational dependencies introduced in the previous discourse. For example, the two *every* quantifiers and the indefinite in the example above may elaborate on the sets of individuals and the correlations between them introduced by a previous sentence like *Every student chose a poet and read every poem written by him* (for the intermediate scope reading) or a sentence like *Every student chose a poet - the same poet - and read every poem written by him* (for the widest scope reading). Our account, formulated within a compositional dynamic system couched in classical type logic, relies on two independently motivated assumptions: (a) the discourse context stores not only (sets of) individuals, but also quantificational dependencies between them, and (b) quantifier domains are always contextually restricted. Under this analysis, (in)definites are unambiguous and we do not resort to movement or special storage mechanisms, nor do we posit special choice-functional variables.

1 The Problem and the Basic Proposal

The paper proposes a novel solution to the problem of exceptional scope (ES) of (in)definites (first noticed in [4]), a problem that is still open despite the many insightful attempts in the literature to solve it. The ES cases we focus on here are the widest and the intermediate scope readings of (1), given below in first order translations:

1. Every student of mine read every poem that a famous Romanian poet wrote before World War II.
2. Narrowest scope (NS) indefinite:
   $\forall x(student.o.m(x) \rightarrow \forall y(poem(y) \wedge \exists z(r.poet(z) \wedge write(z,y)) \rightarrow read(x,y)))$
3. **a.** Intermediate scope (IS) indefinite:
   $\forall x(student.o.m(x) \rightarrow \exists z(r.poet(z) \wedge \forall y(poem(y) \wedge write(z,y) \rightarrow read(x,y))))$
   b. Context for the IS reading:
   Every student chose a poet and read every poem written by him.
4. **a.** Widest scope (WS) indefinite:
   $\exists z(r.poet(z) \wedge \forall x(student.o.m(x) \rightarrow \forall y(poem(y) \wedge write(z,y) \rightarrow read(x,y))))$
   b. Context for the WS reading:
   Every student chose a poet – the same poet – and read every poem written by him.

We start from the observation that the availability of the ES readings is crucially dependent on the discourse context relative to which sentence (1) is interpreted. In particular, the IS reading is available when (1) is interpreted in the context provided by (3b), which, in fact, forces an IS interpretation. Similarly, the WS reading is the only available one in the discourse context provided by (4b).

Consequently, we propose that ES readings are available when sentence (1) is interpreted as anaphoric to quantificational domains and quantificational dependencies introduced in the previous discourse, i.e. when the two *every* determiners and the indefinite article in (1) further elaborate on the sets of individuals and the correlations between them introduced in (3b) and (4b) – as shown in (5), (6) and (7) below (the superscripts and subscripts indicate the antecedent-anaphor relations). The IS interpretation arises because of the presence in the input discourse context of a function pairing u-students and u''-Romanian poets that rules out the possibility of co-variation between u''-poets and u'-poems. The WS reading arises because the value of the discourse referent (dref) r'', i.e. the value of the domain restrictor for the indefinite, is constant, thereby ruling out any possibility of co-variation. Finally, the NS reading arises by default, when there are no special contextual restrictions on the indefinite article and the *every* determiners.

5. Intermediate scope (IS) context:
   Every^{r} student chose a$^{r''}$ poet and read every$^{r'}$ poem written by him$_{r''}$.
6. Widest scope (WS) context:
   Every^{r} student chose a$^{r''}$ poet – the$_{r''}$ same$_{r''}$ poet – and read every$^{r'}$ poem written by him$_{r''}$.
7. Anaphora to previously introduced quantificational dependencies:
   Every$^{u \sqsubseteq r}$ student of mine read every$^{u' \sqsubseteq r'}$ poem that a$^{u'' \sqsubseteq r''}$ famous Romanian poet wrote.

Unlike the tradition inaugurated in [7] and varied upon in [16] and [13], we take (in)definites to be unambiguous. Moreover, we do not resort to movement or special storage mechanisms (as in [1]), nor do we posit special choice-functional variables (as in [20]). Our proposal builds on the insight in [18] concerning the crucial role of contextual restrictions in the genesis of ES readings without, however, relying on the singleton quantifier domain restriction that [18] makes use of. We follow [5] in treating ES readings as being the result of the *interaction* between the indefinite and the other quantifiers present in its sentence, but we do not resort to assignment indices on determiners. Our account relies on two independently motivated assumptions: (*i*) the discourse context stores not only (sets of) individuals that are mentioned in discourse, but also dependencies between them (as motivated in [19] and [2]), and (*ii*) quantifier domains are always contextually restricted.

2 The analysis

The account is formulated within the Plural Compositional DRT (PCDRT) system in [2], which extends Compositional DRT ([15]) with plural information states. Following [19], PCDRT models plural info states as sets of variable assignments, which can be represented as matrices with assignments (sequences) as rows. Plural info states enable us to account for anaphora to both individuals and dependencies between them: as shown in the matrix below, individuals are stored column-wise and dependencies are stored row-wise[1].

Info State I	...	u	u'	u''	...
i_1	...	x_1 (i.e. ui_1)	y_1 (i.e. $u'i_1$)	z_1 (i.e. $u''i_1$)	...
i_2	...	x_2 (i.e. ui_2)	y_2 (i.e. $u'i_2$)	z_2 (i.e. $u''i_2$)	...
i_3	...	x_3 (i.e. ui_3)	y_3 (i.e. $u'i_3$)	z_3 (i.e. $u''i_3$)	...
...	...	...	...	...	...
Quantifier domains (sets) are stored column-wise: $\{x_1, x_2, x_3, \dots\}$, $\{y_1, y_2, y_3, \dots\}$, $\{z_1, z_2, z_3, \dots\}$			**Quantifier dependencies** (relations) are stored row-wise: $\{(x_1, y_1), (x_2, y_2), (x_3, y_3), \dots\}$		

We formalize the analysis in a Dynamic Ty2 logic, i.e. the Logic of Change in [15], which reformulates dynamic semantics ([12], [11]) in Gallin's Ty2 ([8]). We have three basic types: type t (truth-values), type e (individuals; variables: x, x' etc.) and type s ('variable assignments'; variables: i, j etc.)[2].

A dref for individuals u is a function of type se from 'assignments' i_s to individuals x_e (the subscripts on terms indicate their type). Intuitively, the individual $u_{se}(i_s)$ is the individual that the 'assignment' i assigns to the dref u. Thus, we model dref's in much the same way as individual concepts are modeled in Montague semantics. A dynamic info state I is a set of 'variable assignments' (type st). An individual dref u stores a set of individuals with respect to an info state I, abbreviated as $uI := \{u_{se}(i_s) : i_s \in I_{st}\}$, i.e. uI is the image of the set of 'assignments' I under the function u.

A sentence is interpreted as a Discourse Representation Structure (DRS), which is a relation of type $(st)((st)t)$ between an input state I_{st} and an output state J_{st}, as shown in (8) below. A DRS requires: (*i*) the input state I to differ from the output state J at most with respect to the **new dref's** and (*ii*) all the

[1] Mixed weak & strong donkey sentences and quantificational and modal subordination discourses provide independent empirical motivation for a semantics based on plural info states – see [2] for more discussion.

[2] A suitable set of axioms ensures that the entities of type s do behave as variable assignments; see [15] for more details.

conditions to be satisfied relative to the output state J. For example, the DRS $[u, u' \mid student\{u\}, poem\{u'\}, read\{u, u'\}]$ abbreviates the term $\lambda I_{st}.\lambda J_{st}.\ I[u, u']J \wedge student\{u\}J \wedge poem\{u'\}J \wedge read\{u, u'\}J$ [3]. Conditions denote sets of information states and are interpreted *distributively* relative to an info state, e.g. $read\{u, u'\}$ is basically the term $\lambda I_{st}.\ I \neq \emptyset \wedge \forall i_s \in I(read(ui, u'i))$ of type $(st)t$ (see the definition in the **Appendix**).

8. $[\textbf{new dref's} \mid \textbf{conditions}] := \lambda I_{st}.\lambda J_{st}.\ I[\textbf{new dref's}]J \wedge \textbf{conditions}J$

Given the underlying type logic, compositionality at sub-clausal level is achieved in the usual Montague-style way. More precisely, the compositional aspect of interpretation in an extensional Fregean/Montagovian framework is largely determined by the types for the (extensions of the) 'saturated' expressions, i.e. names and sentences. Abbreviate them as **e** and **t**. An extensional static logic identifies **e** with e and **t** with t. The denotation of the noun `poem` is of type **et**, i.e. et: `poem` $\rightsquigarrow \lambda x_e.\ poem_{et}(x)$. The determiner `every` is of type $(\mathbf{et})((\mathbf{et})\mathbf{t})$, i.e. $(et)((et)t)$.

PCDRT assigns the following dynamic types to the 'meta-types' **e** and **t**: **t** abbreviates $(st)((st)t)$, i.e. a sentence is interpreted as a DRS, and **e** abbreviates se, i.e. a name is interpreted as a dref. The denotation of the noun `poem` is still of type **et** – as shown in (9) below. The determiners `every` and `a` are still of type $(\mathbf{et})((\mathbf{et})\mathbf{t})$, as shown in (10) and (11); their translations make use of the maximization and distributivity operators $\mathbf{max}^u(\dots)$ and $_u(\dots)$ defined in the **Appendix**. Maximization stores all and only the individuals that satisfy some property P, while distributivity ensures that *each* stored individual satisfies property P and is associated with whatever dependencies P introduces. Crucially, these operators enable us to extract and store the sets of individuals involved in the interpretation of quantifiers, indefinites etc., as well as their associated dependencies. The compositionally obtained update contributed by (1) is provided in (15) below (see (12), (13) and (14) for some of the intermediate translations[4]).

9. `poem` $\rightsquigarrow \lambda v_{\mathbf{e}}.\ [poem_{et}\{v\}]$, i.e. `poem` $\rightsquigarrow \lambda v_{\mathbf{e}}.\lambda I_{st}.\lambda J_{st}.\ I = J \wedge poem_{et}\{v\}J$
10. `every`$^{u \sqsubseteq r} \rightsquigarrow \lambda P_{\mathbf{et}}.\lambda P'_{\mathbf{et}}.\ \mathbf{max}^{u \sqsubseteq r}(_u(P(u)));\ _u(P'(u))$
11. `a`$^{u'' \sqsubseteq r''} \rightsquigarrow \lambda P_{\mathbf{et}}.\lambda P'_{\mathbf{et}}.\ [u'' \mid u'' \sqsubseteq r'', \mathbf{const\_val}\{u''\}];\ _{u''}(P(u''));\ _{u''}(P'(u''))$,
    where $\mathbf{const\_val}\{u''\} := \lambda I_{st}.\ I_{u'' \neq \#} \neq \emptyset \wedge \forall i_s \in I_{u'' \neq \#} \forall i'_s \in I_{u'' \neq \#}(u''i = u''i')$
12. `every`$^{u \sqsubseteq r}$ `student of mine` $\rightsquigarrow \lambda P_{\mathbf{et}}.\ \mathbf{max}^{u \sqsubseteq r}([student.o.m\{u\}]);\ _u(P(u))$
13. `a`$^{u'' \sqsubseteq r''}$ `Romanian poet` $\rightsquigarrow \lambda P_{\mathbf{et}}.\ [u'' \mid u'' \sqsubseteq r'', \mathbf{const\_val}\{u''\}, r.poet\{u''\}];\ _{u''}(P(u''))$
14. `read` $\rightsquigarrow \lambda Q_{(\mathbf{et})\mathbf{t}}.\lambda v_{\mathbf{e}}.\ Q(\lambda v'_{\mathbf{e}}.\ [read\{v, v'\}])$
15. `every`$^{u \sqsubseteq r}$ `student of mine read every`$^{u' \sqsubseteq r'}$ `poem that a`$^{u'' \sqsubseteq r''}$ `Romanian poet wrote` $\rightsquigarrow$
    $\mathbf{max}^{u \sqsubseteq r}([student.o.m\{u\}]);$
    $_u(\mathbf{max}^{u' \sqsubseteq r'}([poem\{u'\}];\ _{u'}([u'' \mid u'' \sqsubseteq r'', \mathbf{const\_val}\{u''\}, r.poet\{u''\}, write\{u'', u'\}])));\ [read\{u, u'\}]$

The update in (15) can be paraphrased as follows: first, we introduce the dref u and store in it all the speaker's students among the previously introduced r-individuals (as required by $\mathbf{max}^{u \sqsubseteq r}$). Then, relative to each u-student (as required by the distributivity operator $_u(\dots)$), we introduce the set of all poems (among the r'-entities) written by a Romanian poet and store these poems in dref u', while storing the corresponding poets in dref u''. Finally, we test that each u-student read each of the corresponding u'-poems. The output info state obtained after updating with (15) stores the set of all r-students in dref u, the set of all r'-poems written by a Romanian poet in u' and the corresponding r''-Romanian poets in u''.

The update in (15) yields the NS indefinite reading if there are no special constraints on the restrictor dref's r, r' and r''. If the discourse context places particular constraints on these dref's, as the sentences in (5) and (6) above do, the update in (15) yields different truth-conditions, namely the truth-conditions associated with the IS and WS readings. Consider the update contributed by sentence (5) first, provided in (16) below: the output info state obtained after we process (16) stores a functional dependency associating each r-student with the one r''-poet that s/he chose. Consequently, the update in (15) above will retrieve this functional dependency and further elaborate on it, thereby yielding the IS indefinite reading.

Similarly, the update contributed by sentence (6), which is provided in (17) below, ensures that the output info state stores the same r''-poet relative to every r-student. This is required by the update-final $\mathbf{const\_val}\{r''\}$ condition contributed by the parenthetical `the`$_{r''}$ `same`$_{r''}$ `poet`; crucially, the condition is outside the scope of the distributivity operator $_r(\dots)$ introduced by `every`^{r} `student`, unlike the similar condition contributed by

[3] See the **Appendix** for the definition of dref introduction (a.k.a. random assignment).
[4] The update and the intermediate translations are simplified in inessential ways.

the indefinite $\mathtt{a}^{r''}$ $\mathtt{poet}$. When the update in (15) anaphorically retrieves and elaborates on this *contextually* singleton indefinite (i.e. singleton in the plural info state, but not necessarily relative to the entire model), we obtain the WS indefinite reading.

16. The context for the IS indefinite reading:
    $\mathtt{every}^{r}\,\mathtt{student\ chose\ a}^{r''}\,\mathtt{poet\ and\ read\ every}^{r'}\,\mathtt{poem\ written\ by\ him}_{r''} \rightsquigarrow$
    $\mathbf{max}^{r}([student\{r\}]);$
    $_{r}([r'' \,|\, \mathbf{const\_val}\{r''\}, poet\{r''\}, choose\{r, r''\}];\ \mathbf{max}^{r'}([poem\{r'\}, write\{r'', r'\}]);\ [read\{r, r'\}])$
17. The context for the WS indefinite reading:
    $\mathtt{every}^{r}\,\mathtt{student\ chose\ a}^{r''}\,\mathtt{poet\ -\ the}_{r''}\,\mathtt{same}_{r''}\,\mathtt{poet\ -\ and\ read\ every}^{r'}\,\mathtt{poem\ written\ by\ him}_{r''} \rightsquigarrow$
    $\mathbf{max}^{r}([student\{r\}]);$
    $_{r}([r'' \,|\, \mathbf{const\_val}\{r''\}, poet\{r''\}, choose\{r, r''\}];\ \mathbf{max}^{r'}([poem\{r'\}, write\{r'', r'\}]);\ [read\{r, r'\}]);$
    $[\mathbf{const\_val}\{r''\}]$

3 Conclusion

The readings of sentence (1) differ with respect to whether the indefinite co-varies with another DP or not, and if it does, which of the two *every*-DPs it co-varies with. Traditionally, this sort of (in)dependence was the result of the structural relation between the existential quantifier contributed by the indefinite and the two universal quantifiers contributed by the two *every*-DPs. *In situ* analyses employed implicit arguments present in the interpretation of the indefinite (as arguments of a choice function or as implicit arguments in the restrictor) that could be left free (WS reading) or that could be bound by the first universal (IS reading) or the second (NS reading).

Our account dispenses with bound implicit arguments in favor of independently needed contextually introduced and stored dependencies. We predict that the context is the main factor that determines the choice of interpretation for a sentence like (1). Our approach leads us to expect that particular determiners may vary with respect to their sensitivity to the presence of interpretational dependencies. 'Ordinary' indefinites, such as *a(n)*, are indifferent to this issue, which is why (1) is three-way ambiguous. We take 'special' indefinite determiners, such as *egy-egy* in Hungarian and its equivalents in other languages, to require the presence of a particular type of interpretational dependency (see [6]). We conclude by suggesting that a crucial parameter in the semantic typology of DPs is the issue of variation vs. constancy of values of the dref the DP introduces, a parameter that our formal system is well equipped to handle.

Appendix: The Formal System

The Basic Dynamic System

1. $R\{u_1, \ldots, u_n\} := \lambda I_{st}.\ I_{u_1 \neq \#, \ldots, u_n \neq \#} \neq \emptyset \wedge \forall i_s \in I_{u_1 \neq \#, \ldots, u_n \neq \#}(R(u_1 i, \ldots, u_n i))$,
   where $I_{u_1 \neq \#, \ldots, u_n \neq \#} := \{i_s \in I : u_1 i \neq \# \wedge \ldots \wedge u_n i \neq \#\}$
2. $\mathbf{const\_val}\{u\} := \lambda I_{st}.\ I_{u \neq \#} \neq \emptyset \wedge \forall i_s \in I_{u \neq \#} \forall i'_s \in I_{u \neq \#}(ui = ui')$
3. $\mathbf{vary\_val}\{u\} := \lambda I_{st}.\ I_{u \neq \#} \neq \emptyset \wedge \exists i_s \in I_{u \neq \#} \exists i'_s \in I_{u \neq \#}(ui \neq ui')$
4. $D; D' := \lambda I_{st}.\lambda J_{st}.\ \exists H_{st}(DIH \wedge D'HJ)$, where D, D' are DRS's (type $\mathbf{t}$).
5. $[R\{u_1, \ldots, u_n\}] := \lambda I_{st}.\lambda J_{st}.\ I = J \wedge R\{u_1, \ldots, u_n\}J$
6. $[Condition_1, \ldots, Condition_m] := [Condition_1]; \ldots ; [Condition_m]$
7. $[u] := \lambda I_{st}.\lambda J_{st}.\ \forall i_s \in I(\exists j_s \in J(i[u]j)) \wedge \forall j_s \in J(\exists i_s \in I(i[u]j))$
8. $[u_1, \ldots, u_n] := [u_1]; \ldots ; [u_n]$
9. $[u_1, \ldots, u_n \,|\, Condition_1, \ldots, Condition_m] := [u_1, \ldots, u_n];\ [Condition_1, \ldots, Condition_m]$
10. A DRS D of type $\mathbf{t}$ is *true* with respect to an input info state I_{st} iff $\exists J_{st}(DIJ)$.

Structured Inclusion, Maximization and Distributivity

11. $u \sqsubseteq r := \lambda I_{st}.\ (u \Subset r)I \wedge \forall i_s \in I(ri \in uI_{u \neq \#} \rightarrow ri = ui)$,
    where $u \Subset r := \lambda I_{st}.\ \forall i_s \in I(ui = ri \vee ui = \#)$ [5].

[5] The definition of structured inclusion in (11), where we go from a superset r to a subset u by discarding cells in a matrix/plural info state (thereby preserving the superset dependencies in the subset dref) employs a dummy/exception individual $\#$ that is used

12. $\mathbf{max}^u(D) := \lambda I_{st}.\lambda J_{st}.\ ([u];D)IJ \wedge \forall K_{st}(([u];D)IK \rightarrow uK_{u\neq\#} \subseteq uJ_{u\neq\#})$
13. $\mathbf{max}^{u\sqsubseteq r}(D) := \mathbf{max}^u([u \sqsubseteq r];D)$
14. $\mathbf{dist}_u(D) := \lambda I_{st}.\lambda J_{st}.\ uI = uJ \wedge \forall x_e \in uI(DI_{u=x}J_{u=x}),$ where $I_{u=x} = \{i_s \in I : ui = x\}$.
15. ${}_u(D) := \lambda I_{st}.\lambda J_{st}.\ I_{u=\#} = J_{u=\#} \wedge I_{u\neq\#} \neq \emptyset \wedge \mathbf{dist}_u(D)I_{u\neq\#}J_{u\neq\#}$

Translations for Basic Expressions

16. $\mathtt{poem} \rightsquigarrow \lambda v_{\mathbf{e}}.\ [poem_{et}\{v\}]$
17. $\mathtt{every}^{u\sqsubseteq r} \rightsquigarrow \lambda P_{\mathbf{et}}.\lambda P'_{\mathbf{et}}.\ \mathbf{max}^{u\sqsubseteq r}({}_u(P(u)));\ {}_u(P'(u))$ [6]
18. $\mathtt{a}^{u''\sqsubseteq r''} \rightsquigarrow \lambda P_{\mathbf{et}}.\lambda P'_{\mathbf{et}}.\ [u'' \mid u'' \sqsubseteq r'', \mathbf{const\_val}\{u''\}];\ {}_{u''}(P(u''));\ {}_{u''}(P'(u''))$
19. $\mathtt{every}^{r} \rightsquigarrow \lambda P_{\mathbf{et}}.\lambda P'_{\mathbf{et}}.\ \mathbf{max}^{r}({}_r(P(r)));\ {}_r(P'(r))$
20. $\mathtt{a}^{r''} \rightsquigarrow \lambda P_{\mathbf{et}}.\lambda P'_{\mathbf{et}}.\ [r'' \mid \mathbf{const\_val}\{r''\}];\ {}_{r''}(P(r''));\ {}_{r''}(P'(r''))$
21. $\mathtt{he}_{r''} \rightsquigarrow \lambda P_{\mathbf{et}}.\ [\mathbf{const\_val}\{r''\}];\ {}_{r''}(P(r''))$
22. $\mathtt{they}_{r} \rightsquigarrow \lambda P_{\mathbf{et}}.\ {}_r(P(r))$
23. $\mathtt{the}_{r''} \rightsquigarrow \lambda P_{\mathbf{et}}.\lambda P'_{\mathbf{et}}.\ {}_{r''}(P(r''));\ {}_{r''}(P'(r''))$
24. $\mathtt{same}_{u} \rightsquigarrow [\mathbf{const\_val}\{u\}]$
25. $\mathtt{egy\text{-}egy}_{u} \rightsquigarrow [\mathbf{vary\_val}\{u\}]$

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as a tag for the discarded cells; # is the universal falsifier, i.e. any lexical relation that takes # as an argument is false.

[6] See [2] for the general definition of dynamic quantification in PCDRT.