Argument Contained Ellipsis Revisited*

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This paper investigates an unusual identity constraint on English verb phrase ellipsis which imposes the following requirement: when an elliptical relation holds between two verb phrases A and B such that A is contained in an argument b of B, then the corresponding argument a of A must be identical to b. I argue that these facts provide evidence for a semantic theory of the interpretation of variables in which assignment functions are partial, and binding involves adding new variable/value pairs to an assignment, rather than reassigning new values to (possibly previously used) variables. Based on additional data, I argue that the identity conditions on ellipsis must be stated in terms of semantic parallelism between constituents (potentially) larger than the elided phrases, as advocated in Rooth 1992; Fox 1999a; Merchant 2001, and that the syntactic representation of binding structures must crucially encode binding indices on binders, rather than as adjuncts on their scope as in Heim and Kratzer 1998. I conclude by demonstrating that the analysis proposed here has broader empirical coverage than current variable-free analyses, and so potentially constitutes an argument for adopting a semantic framework that makes use of variables.

1 Argument identity effects in ellipsis

Wasow (1972) notes the impossibility of verb phrase ellipsis in sentences such

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as (1a-b):

(1) a. *A proof that God exists doesn't ∅.
b. *Your proof that my proof is valid isn't ∅.

Wasow accounts for these and similar sentences with a constraint that prohibits an elided VP from finding an antecedent within its subject.

The contrasts in (2) and (3) (originally observed by Jorge Hankamer) shows that this constraint is too strong: ellipsis is allowed in this configuration, but only if the subject of the elided VP is identical to the subject of its antecedent.

(2) a. Everyone who wants to eat some fugu should ∅.
b. *Everyone who wants Jason to eat some fugu should ∅.

(3) a. The woman who said she would buy the tuna did ∅.
b. *The woman who said Kim would buy the tuna did ∅.

These generalizations hold for other types of subjects as well. The sentential subject in (4) is analogous to Wasow's example:

(4) *That you think that these facts are surprising isn't ∅.

Examples with free relative subjects behave like Hankamer's examples:

(5) a. What you think is surprising isn't ∅.
b. *What convinced you that this fact is surprising isn't ∅.

Moving to internal arguments, Kennedy (1994) shows that the argument identity effects observed in subject containment structures are even stronger and more robust when we consider argument (non-)identity in antecedent-contained deletion (ACD) configurations. (6)-(7) involve canonical cases of ACD with direct objects.[1]

(6) a. Polly visited every town Erik did ∅.

[1]Note that the interpretation of (6b) that is unavailable is illustrated in (ia). If the relative clause is construed as just modifying *town* (which is somewhat difficult in this example), as in (ib), then ellipsis is possible.

(i) a. For every x such that x is a town and there is a y such that y is a country and x is in y and Erik visited y, Polly visited x
b. For every x such that x is a town and there is a y such that y is a country and x is in y and Erik visited x, Polly visited x

b. *Polly visited every town located in a country Erik did ∅.

(7) a. Max fooled none of the senators that Hector will ∅.
b. *Max fooled none of the aides of the senators that Hector will ∅.

(8) involves an indirect object, and (9) an embedded subject.

(8) a. Erik sent letters to every senator Polly did ∅.
b. *Erik sent letters to every aide who worked for a senator Polly did ∅.

(9) a. Mona wants the candidates that Jack does ∅ to be successful.
b. *Mona wants the rivals of the candidates that Jack does ∅ to be successful.

Finally, as with the subject cases, free relatives show similar identity effects:

(10) a. I'll order what(ever) Jason does ∅.
b. *I'll order whatever goes well with what(ever) Jason does ∅.

(11) a. Kim always votes for whoever Lee does ∅.
b. *Kim always votes for whoever is competing against whoever Lee does ∅.

Referring to this set of facts as 'Argument Contained Ellipsis', Kennedy (1994, p. 2) draws the descriptive generalization in (12).

(12) *Argument Contained Ellipsis*
Ellipsis between VP_1 and VP_2, VP_1 contained in an argument A_2 of VP_2, is licensed only if A_2 is identical to the parallel argument A_1 of VP_1.

This generalization assumes both that the identity constraint holds equally of subject-containment and ACD structures, and moreover that the facts are the same regardless of which VP is elided. In the case of ACD, this is clearly the case, though to show this we have to look at examples that strictly speaking do not involve antecedent-contained deletion, but rather backwards deletion of a VP that is part of a fronted argument of the matrix VP. The following examples, in which a VP contained in a fronted *wh*-phrase has been elided, show that the facts are indeed symmetrical:

(13) a. Which town that Erik did ∅ has Polly visited?
b. *Which town located in a country that Erik did ∅ has Polly visited?

Kennedy (1994) claims that the judgments in the subject-containment

examples are also the same regardless of whether the elided VP is the embedded or the matrix VP. It is not clear that this is actually correct, however: speakers agree that (14b) and (15b), for example, are worse than the (a) examples, but they are consistently judged to be more acceptable than the examples presented above.

(14) a. Everyone who wants to ∅ should eat some fugu.
b. ?Everyone who wants Jason to ∅ should eat some fugu.

(15) a. The woman who said she would ∅ bought the tuna
b. ?The woman who said Kim would ∅ bought the tuna.

More importantly, it is already pointed out in Kennedy 1994, fn. 3 that the judgments on all of the subject-containment examples are highly variable. In particular, for many speakers, addition of *too* or *instead* to the end of the ungrammatical examples makes them more acceptable:

(16) a. ?Everyone who wants Jason to eat fugu should ∅ too.
b. ?The woman who said Kim would buy the tuna did ∅ instead.

Although there does not appear to be a comparable degree of improvement in acceptability with Wasow's original example in (17a), this may have to do with the fact that the VP *exists* is being predicated of semantically distinct sorts of things (*God* and *a proof*; this observation is due to Polly Jacobson, p.c.). If we look at an example that controls for this, such as (17b), we seem to get an improvement in acceptability similar to what we find for the examples in (16).

(17) a. *A proof that God exists does ∅ too.
b. ?Your proof that my proof is valid is ∅ as well.

There is no variability in judgments when it comes to the ACD examples, however: speakers consistently judge the cases involving argument non-identity to be unacceptable. Furthermore, the addition of particles like *too, as well* and so forth does nothing to improve these examples; if anything, it makes them less acceptable:

(18) a. *Polly visited every town located in a country that Erik did ∅ as well.
b. *Erik sent letters to every aide who worked for a senator that Polly did ∅ too.

There are two possible explanations for the variability in judgments of

the subject-contained examples, and the improvement in acceptability triggered by the addition of particles. One the one hand, it may be the case that these sorts of constructions actually are not ill-formed at all, but are instead somehow infelicitous or difficult to interpret (for reasons that would have to be made clear; see Hardt and Asher 1997 for one promising suggestion), and the addition of *too*, *instead*, etc. improves their felicity or interpretability. On the other hand, it is possible that these sorts of constructions are all basically ill-formed, but the addition of these particles somehow makes it easier for the hearer to assign an interpretation to them, giving the illusion of well-formedness.

Kennedy (1994) assumes that the latter is the case, and develops an analysis (described in section 3.1 below) that is general enough to include both these cases and the clearer, more robust cases of containment in an internal argument.[2] I now believe that this was the wrong move, however. First, this approach simply fails to explain the difference in acceptability between the subject-contained cases and the ACD cases. If such an approach could be augmented with some explanation for this difference, it could be made to work, but at the moment at least, I do not see how to do this.

Second, and more importantly, new data appear to provide fairly clear evidence that any analysis that rules out the subject-contained cases in terms of purely formal properties of the syntactic or semantic representation is doomed to failure. These facts are presented in (19)-(20), which show that when the subject-containment structures are embedded in a subordinate clause, the resulting sentences are almost perfectly acceptable in the case of the Hankamer examples (19), and at least significantly improved in the case of the Wasow examples (20).

(19) a. Jason said that everyone who wants him to eat fugu should ∅.
b. I wish that the woman who said Kim caught a tuna had ∅.

(20) a. ?History suggests that a proof that God exists never will ∅.
b. ?I hope that my proof that your proof is invalid isn't ∅.

Based on these considerations, I conclude that the full range of examples that fall under the descriptive generalization in (12) actually represent two distinct analytical classes — 'subject-contained ellipsis' constructions and ACD constructions — which should be given different kinds of analyses. My

[2]The analysis developed in Heim 1997, discussed below in section 3.2, is also designed to account for the subject cases as well as the internal argument cases, though other analyses focus on just the subject cases (Hardt and Asher 1997) or just the internal argument cases (Jacobson 1998; Sauerland 1998, 2004).

goal in this paper is to develop an analysis of the ACD subcases which, given the consistency and robustness of the judgments about unacceptability in cases of argument non-identity, suggest the role of some principle of grammar. In contrast, the variability in judgments surrounding the subject cases suggest the action of some kind of discourse/felicity condition, as suggested in Hardt and Asher 1997. While such a principle may be active in the ACD cases as well, the fact that judgments of unacceptability in cases of argument mismatch remain robust no matter how we manipulate the examples shows that there are important grammatical principles at work as well, which I will try to uncover in this paper.

2 The problem of argument identity in ellipsis

To understand the problem presented by the argument identity effects discussed in the previous section, let take as our starting point the hypothesis that ellipsis is licensed by semantic identity between an elided XP and its antecedent, as has been recently argued in particularly convincing form by Merchant (2001). In particular, let's adopt the hypothesis in (21) for VP ellipsis, which is an updated version of original proposals along this line in Sag 1976 and Williams 1977. (The following discussion is modeled after Heim 1997, though essentially the same points are made in Kennedy 1994.)

(21) *The Sag/Williams theory of VP-ellipsis*
Delete a VP_e at PF only if there is a VP_a in the surrounding discourse such that for all variable assignments g, $[\![\text{VP}_e]\!]^g = [\![\text{VP}_a]\!]^g$.

At first glance, this looks like a good basis for an account of the argument identity facts, and indeed, the theory developed in Sag 1976 explicitly rules out very similar sorts of constructions. The minimal set of assumptions we need to account for the contrasts in section 1 are the following:

(22) *Initial assumptions*
a. For $\alpha \in \{pro,\ t\}$, $[\![\alpha_i]\!]^g = g(i)$
b. A relative operator and the categories it binds use the same index as the DP modified by the relative clause and the categories it binds.
c. Otherwise, distinct binders use distinct indices.

Consider (23a-b), which have the LFs in (24a-b), respectively.

(23) a. Polly visited every town Erik did.

b. *Polly visited every town located in a country Erik did.

(24) a. $[_{\text{DP}}$ every town wh_1 Erik did ~~$[_{\text{VP}_e}$ visit $t_1]$~~$]_1$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]$

b. *$[_{\text{DP}}$ every town wh_1 t_1 located in $[_{\text{DP}}$ a country wh_2 Erik did ~~$[_{\text{VP}_e}$ visit $t_2]]$~~$]_2]_1$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]$

In (24a), the identity condition on ellipsis is satisfied: since the VP-interal traces have the same indices, the identity condition in (21) will hold for all assignments. In (24b), however, the traces are bound by distinct binders, so they must bear different indices, with the result that the identity condition in (21) will fail to hold for any assignment in which 1 and 2 are mapped to distinct values. Since such assignments can be easily constructed, ellipsis is correctly predicted to be impossible in (23b).

This approach makes a clear prediction: we should never find examples of VP-ellipsis in which the elided and antecedent VPs contain variables bound by distinct binders. Sag (1976) cites the impossibility of a wide-scope interpretation of the universal quantifier in the first clause of examples like (25a), which would involve the LF in (25b), as evidence for exactly this conclusion.

(25) a. Some nurse visited every patient, and Dr. Jones did too.

b. *[every patient]$_1$ some nurse PAST $[_{\text{VP}_a}$ visited $t_1]$ and [every patient]$_2$ Dr. Jones did ~~$[_{\text{VP}_e}$ visit $t_2]$~~ too

However, subsequent research has shown that a wide scope interpretation of the universal is possible when the second conjunct also contains an indefinite in subject position (see in particular Hirschbühler 1982; Fox 2000), as shown in (26a), which can have the LF in (26b).

(26) a. Some nurse visited every patient, and some intern did too.

b. [every patient]$_1$ some nurse PAST $[_{\text{VP}_a}$ visited $t_1]$ and [every patient]$_2$ some intern did ~~$[_{\text{VP}_e}$ visit $t_2]$~~ too

Furthermore, examples like those in (27), first discussed by Evans (1988), show that ellipsis tolerates overt binding into antecedent and elided VP in non-argument containment configurations:

(27) a. Peanuts, I like; walnuts, I don't.

b. The problems you can see are easier to deal with than the ones you can't.

c. I know which books you read and which articles you did too.

According to the non-coindexing assumption (22c), (27a) should have a LF like (28a), which should not license ellipsis, not one like (28b), which does.

(28) a. Peanuts$_1$ I PRES [$_{\mathrm{VP_a}}$ like t_1], walnuts$_2$ I PRES NOT ~~[$_{\mathrm{VP_e}}$ like t_2]~~
b. Peanuts$_1$ I PRES [$_{\mathrm{VP_a}}$ like t_1], walnuts$_1$ I PRES NOT ~~[$_{\mathrm{VP_e}}$ like t_1]~~

The conclusion, then, is that something is wrong with our initial set of assumptions; the strategy now is to figure out what needs to be changed. Two obvious alternatives present themselves. The first option is to maintain the 'logical equivalence' analysis of ellipsis and change our assumptions about indexing, allowing the 'reuse' of variable names in LFs like (28b) but not in argument containment configurations. The second option is to maintain our assumptions about indexing and the non-reuse of variable names but to change our assumptions about how ellipsis works so that it is licensed in examples like (28a) but not in argument containment configurations.

Of course, there are presumably other options as well (in particular, options that forego the use of variables at all, as in Jacobson 1992, 1998; I will discuss this sort of approach in section 5.3 below). I want to focus here on different versions of the two approaches outlined above, however, since 1) all of the current analyses of the argument-identity facts in ACD discussed in section 1 fall into these two categories, and 2) on the whole, the set of assumptions I have laid out form the basis for a quite general framework for the interpretation of variable binding and the licensing of ellipsis.

3 Previous analyses of argument identity effects

3.1 Kennedy 1994

Kennedy (1994) develops an analysis of argument identity effects in ACD that is essentially a version of option 1 above: VP-deletion requires logical equivalence of VPs, but semantically distinct DPs are not prohibited from reusing indices to encode binding relations. The crucial assumptions are given in (29).

(29) Kennedy's analysis of argument identity effects
a. *The Sag/Williams theory of ellipsis*
Delete a VP_e at PF only if there is a VP_a in the surrounding discourse such that for all variable assignments g, $[\![\mathrm{VP}_e]\!]^g = [\![\mathrm{VP}_a]\!]^g$.
b. *The Reinhart 1983 theory of binding and coindexation*
The interpretation of coindexation is semantic binding.
c. *The i-within-i constraint*

$^*[_\alpha \ldots i \ldots]_i$ when α-internal i is not bound by α.

The consequence of assumption (29b) for Kennedy's analysis is that there is no general prohibition on semantically distinct DPs bearing the same index; in particular, DPs in distinct clauses can bear identical indices with no problem. Kennedy does not provide an explicit semantics for variable binding, but if we adopt for example the analysis of variable binding in Heim and Kratzer 1998, we can see that the desired result is obtained.

In this system, the scope of a binder is indicated in a Logical Form by adjoining the binder's index to its sister, and interpreting the resulting expression by the Predicate Abstraction rule stated in (30a).[3] Pronouns and traces denote variables named by their indices, and are interpreted with respect to an assignment function as indicated in (30b); the constraint in (30c) ensures that all variable-denoting expressions in a LF have an interpretation.

(30) a. *Predicate Abstraction*
If α is of the form $[_\alpha \ i \ \beta]$, then for any assignment function g, $[\![\alpha]\!]^g = \lambda x.[\![\beta]\!]^{g[x/i]}$

b. *Pronouns and Traces Rule*
If $\alpha \in \{pro, t\}$, then for any assignment function g, $[\![\alpha_i]\!]^g = g(i)$

c. A context c is appropriate for a LF ϕ only if c determines a variable assignment g_c whose domain includes every index that has a free occurrence in ϕ.

Given these assumptions, (31b) is a perfectly legitimate LF for (31a): the VP-internal traces in the two conjuncts will end up bound to different binders in the course of the interpretation, and so will correspond to arguments of distinct functions.[4]

(31) a. Peanuts, I like; walnuts, I don't.

b. Peanuts$_1$ I PRES $[_{\text{VP}_\text{a}}$ like $t_1]$, walnuts$_1$ I PRES NOT ~~$[_{\text{VP}_\text{e}}$ like $t_1]$~~

[3]Note that (30a) is shorthand for $\ldots[\![\alpha]\!]^g = \lambda x \in D_e.[\![\beta]\!]^{g[x/i]}$. In general, I will omit specifications of the domain of functions when the domain is the set of individuals.

[4]For representational simplicity, I will affix binding indices to binders, rather than to their sisters, unless this distinction is relevant. The first clause in (31b), for example, should be understood as shorthand for (i).

(i) Peanuts [1 [I PRES $[_{\text{VP}}$ like $t_1]$]]

In section 5.2, I will argue that in fact binding must be represented as in (31b), rather than as in (i).

More importantly, since the VP-internal traces can use the same indices, the identity condition in (29a) is satisfied, and we correctly predict ellipsis to be possible here.

Of course, there is no general requirement that variable names get reused in different LFs. The crucial prediction of the set of assumptions in (29), however, is that in the case of variables that are bound from outside an elided and antecedent constituent, the same variabes must be used; if indexical identity were somehow prohibited in this context, ellipsis would be impossible. This, in a nutshell, is Kennedy's claim about what is going on in argument contained ellipsis: in an example like (32), only the representation in (32a), in which the VP-internal traces bear distinct indices, is a possible LF; the one in (32b), which satisfies the identity condition on ellipsis, is impossible.

(32) *Polly visited every town located in a country Erik did.

a. $[_{\text{DP}}$ every town $[_{\text{CP}}$ wh_1 t_1 located in $[_{\text{DP}}$ a country $[_{\text{CP}}$ wh_2 Erik did ~~$[_{\text{VP}_e}$ visit $t_2]$~~$]]_2]]_1$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]$

b. $[_{\text{DP}}$ every town $[_{\text{CP}}$ wh_1 t_1 located in $[_{\text{DP}}$ a country $[_{\text{CP}}$ wh_1 Erik did ~~$[_{\text{VP}_e}$ visit $t_1]$~~$]]_1]]_1$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]$

The question is why (32b) is ruled out. According to Kennedy, such representations violate a constraint on referential circularity: the so-called *i-within-i* constraint stated in (29c). This constraint is designed to rule out configurations in which a variable inside a DP cannot be interpreted as bound by the DP; (33a) is a typical example, and (33b) is an example in which this constraint is apparently circumvented.

(33) a. *[Every proof $[_{\text{CP}}$ that it_1 is correct$]]_1$ is bound to be circular.

b. [Every proof $[_{\text{CP}}$ wh_1 that convinces us that it_1 is correct$]]_1$ is elegant.

Roughly speaking, unless a pronoun can be bound inside DP (in (33b), by the relative operator), it cannot end up being interpreted as bound by the DP (or more properly, by the determiner) (see in particular Jacobson 1977; Higginbotham 1983; Haïk 1984, 1987). Kennedy (1994) claims that the representation in (32b) violates this constraint because the occurrence of the index 1 inside the elided VP is bound by a distinct DP, not by the relative operator of the DP that binds the index 1 in the antecedent VP.

The problem with this proposal is that when we take a closer look at the principles underlying *i-within-i* effects, the result Kennedy wants to derive doesn't actually follow from anything. In particular, this result doesn't follow from the assumptions about binding presented in (30) above, though

these assumptions do derive standard *i-within-i* effects, such as the contrast between (33a) and (33b).

Let us consider (33a-b) first. The assumptions in (30) conspire to ensure that pronouns and traces are interpreted as bound variables only if they are c-commanded by a coindexed expression at LF. If this relation does not obtain, a bound interpretation is unavailable, and pro_i/t_i is interpretable only if i is in the domain of the contextually determined assignment g_c. In (33b), the pronoun is interpreted as a variable bound by the quantifier by virtue of being coindexed with the relative operator. The crucial parts of the composition of the relative clause are as shown in (34) (here I assume that the relative operator is semantically vacuous).

(34) $[\![[_{CP} wh_1$ [that t_1 convinces us that it$_1$ is correct]]$]\!]^g =$
$\lambda x.[\![$that t_1 convinces us that it$_1$ is correct$]\!]^{g[x/1]} =$
$\lambda x.x$ convinces us that x is correct

The relative clause may then be combined with the nominal head by predicate modification, and the whole thing supplied as the restriction argument to the quantifier, with the result that the pronoun ends up bound by the quantifier.

In constructions like (33a), however, in which the pronoun it_1 is contained in a clausal complement of the noun, there is nothing to bind it inside the DP. Only those expressions contained inside the sister of the whole DP — its nuclear scope — can be interpreted as bound:

(35) $[\![[_\gamma$ [every proof that it$_1$ is correct$]_1$ $\beta]]\!]^g =$
$[\![$[every proof that it$_1$ is correct]$]\!]^g(\lambda x.[\![\beta]\!]^{g[x/i]})$

As a result, the pronoun will be interpretable only if the index 1 is in the domain of g_c, which means that it is (at best) free, not bound.

The problem for the Kennedy 1994 analysis of argument containment effects is that nothing really goes wrong in the cases we're interested in. In particular, the Predicate Abstraction rule in (30a) (or any other set of assumptions that derives *i-within-i* effects; see e.g. Jacobson 2000) doesn't have any problem interpreting a structure like (36) in just the right way, since thethis rule can reassign a new value to a previously introduced variable. In the example under consideration, repeated in (36), when the embedded relative clause CP^2 is interpreted, the index 1 is reassigned as shown in (37b).

(36) [$_{\text{DP}}$ every town [$_{\text{CP}^1}$ wh_1[$_{\text{IP}^1}$ t_1 located in [$_{\text{DP}}$ a country [$_{\text{CP}^2}$ wh_1 [$_{\text{IP}^2}$ Erik did ~~[$_{\text{VP}_e}$ visit t_1]~~]]]]]]$_1$ [Polly PAST [$_{\text{VP}_a}$ visit t_1]]

(37) a. $[\![CP^1]\!]^g = \lambda x.[\![IP^1]\!]^{g[x/1]}$

b. $[\![CP^2]\!]^{g[x/1]} = \lambda z.[\![IP^2]\!]^{g[x/1][z/1]}$

The result is a perfectly interpretable structure that both has the intended interpretation and should license ellipsis according to the assumptions laid out in (29).

The result of these considerations is that at best, Kennedy's analysis can be maintained only by stipulating that the representations that are needed to license ellipsis are ruled out by a syntactic constraint on the distribution of indices, not by the general semantic principles underlying *i-within-i* effects. It might be hypothesized that this constraint is a kind of syntactic 'over-generalization' based on what the semantics derives, but this would be a 'patch' at best, and certainly should be dispreferred to an analysis that actually derives the result we want.

3.2 Heim 1997

Heim (1997) presents an analysis of argument identity effects in ellipsis that is a version of the second option discussed above: Heim maintains the assumption that semantically distinct DPs have to bear distinct indices, but jettisons the Sag/Williams analysis of ellipsis in favor of the focus-based approach advocated in Rooth 1992. The crucial assumptions are given in (38).

(38) Heim's analysis of argument identity effects

a. *Rooth's (1992) analysis of ellipsis*
   i. A deleted VP and its antecedent must have the same lexical material up to indexical values on traces, pronouns, etc.
   ii. A deleted VP must be contained in a phrase that contrasts appropriately with some phrase that contains the antecedent VP.

b. *No Meaningless Coindexing*
   If a LF contains an occurrence of a variable v that is bound by a node α, then all occurrences of v in this LF must be bound by the same node α.

The notion of 'appropriate contrast' appealed to here is the same one that is relevant for the licensing of focus/deaccenting in Rooth's theory:

(39) A constituent ϕ contrasts appropriately with a constituent ψ iff:

a. ϕ and ψ don't overlap, and

b. for all assignments g, the regular semantic value of ψ with respect to g is an element of the focus value of ϕ with respect to g.

An additional crucial component of Heim's analysis is the hypothesis that quantificational determiners take open propositions as arguments, rather than functions of type $\langle e, t\rangle$. The determiner *every*, for example, has the denotation in (40a), rather than the more commonly assumed denotation in (40b).[5]

(40) a. $[\![every_i]\!]^g = \lambda\phi \in D_t.\lambda\psi \in D_t.$*for every x such that* $[\![\phi]\!]^{g[x/i]} = 1, [\![\psi]\!]^{g[x/i]} = 1$

b. $[\![every]\!]^g = \lambda\phi \in D_{et}.\lambda\psi \in D_{et}.$*for every x such that* $[\![\phi]\!]^g(x) = 1, [\![\psi]\!]^g(x) = 1$

According to Heim, argument identity effects arise because the relevant configurations present a problem for the appropriate contrast condition. Essentially, in these configurations, it is not possible to satisfy the 'identity' component of this condition (39b) without violating the 'no overlap' component (39a). Heim shows that this follows only on the 'forumals' analysis of quantificational determiners represented by (40a), not under the more standard 'predicates' analysis in (40b), thus argument identity effects constitute an argument for analyzing quantificational determiners as (in effect) relations between open propositions.

Consider the acceptable and unacceptable examples of ACD in (41a)-(42a), and potential LFs in (41b)-(42b).[6] Note that in (42b), the indices on the VP-internal traces for VP_a and VP_b are distinct, in accord with the 'No meaningless coindexing' constraint (38b).

(41) a. Polly visited every town Erik did.

b. [$_{\text{DP}}$ every$_1$ town Erik did ~~[$_{\text{VP}_e}$ visit t_1]~~] [Polly PAST [$_{\text{VP}_a}$ visit t_1]]

(42) a. *Polly visited every town located in a country Erik did.

b. [$_{\text{DP}}$ every$_1$ town t_1 located in [$_{\text{DP}}$ a$_2$ country Erik did ~~[$_{\text{VP}_e}$ visit t_2]~~]] [Polly PAST [$_{\text{VP}_a}$ visit t_1]]

The analysis runs as follows. In both (41b) and (42b), the syntactic identity requirement on deletion is met. In (41b), the appropriate contrast condition

[5]Heim doesn't actually provide denotations for quantificational determiners, but rather interpretation rules for LFs with (raised) QPs. (40a) captures the essence of Heim's proposal, however (cf. Sauerland 2004, p. 79).

[6]To keep the representations as clear as possible, I indicate only the semantically relevant portions. In particular, I will leave out relative operators, since these play no role in the interpretation in Heim's analysis. I will also leave out explicit marking of the variables that must be associated with the nominal heads of DPs in this analysis (see Heim 1997, p. 198 for discussion).

is also met: let $\phi = \sout{[_{\text{VP}_e}\text{ visit } t_1]}$ and $\psi = [_{\text{VP}_a}\text{ visit } t_1]$. In this case, the focus value of ϕ for any g is the unit set containing the proposition *visit* $g(1)$, which is the same as the regular value of ψ for any g. Note that this is possible precisely because the traces inside the two VPs can (in fact, must) be coindexed here.

In (42b), however, there is no way to satisfy the appropriate contrast condition given the relevant possible values of ϕ stated in (43).

(43) $\phi =$

a. $\sout{[_{\text{VP}_e}\text{ visit } t_2]}$

b. [Erik did $\sout{[_{\text{VP}_e}\text{ visit } t_2]}$]

c. [a_2 country Erik did $\sout{[_{\text{VP}_e}\text{ visit } t_2]}$]

DP every$_1$ town t_1 located in [$_{\text{DP}}$ a_2 country Erik did $\sout{[_{\text{VP}_e}\text{ visit } t_2]}$] [Polly PAST [$_{\text{VP}_a}$ visit t_1]]

The condition won't be satisfied for for $\phi =$ (43a), since there is no phrase that in the representation that expresses *visit* $g(2)$. Here the 'no meaningless coindexing' constraint is crucial: if it were possible to reuse indices, then there would be a LF for this example in which the trace in the elided VP had the same index as the trace in the antecedent VP, licensing ellipsis in the same way as for the good example of ACD above.

The condition also won't be satisfied for $\phi =$ (43b), for the same reason. The focus value of this for any g is $\{x \textit{ visit } g(2) \mid x \in D_e\}$, assuming focus on *Erik*, but there is nothing in the representation whose meaning is an element of this set.[7] (43c) does not run into any problems with assignment-dependent interpretations of free variables, but its denotation includes the contribution of the indefinite determiner (and the head noun *country*), so again there will

[7] This is the case that Heim uses to argue for that quantificational determiners must take open propositions as arguments: if the relative clause had a standard type $\langle e, t\rangle$ interpretation, then it would denote the function in (ia), and its focus value would be (ib).

(i) a. $[\lambda y.\textit{Erik visited } y]$

b. $\{[\lambda x.y \textit{ visited } x] \mid y \in D\}$

The IP out of which the entire QDP has raised is a member of this set, on the standard analysis, since its denotation is (ii).

(ii) $[\lambda z.\textit{Polly visited } z]$

A Rooth-style analysis of ellipsis together with the standard analysis of quantificational determiners would therefore incorrectly predict that ellipsis should be licensed here. I return to a more detailed discussion of this point in section 5.2 below, where I propose a modification to the syntactic representation of binding that allows us to maintain both a standard analysis of quantificational determiners and a Rooth-style analysis of ellipsis.

be no other constituent in the sentence that is a member of its focus value. Finally, the computation will fail for ϕ = (43d) (the whole sentence), because this would (among other things) violate the 'no overlap' condition.

In short, given Heim's assumption about the interpretation of quantificational determiners, the 'no overlap' condition and the 'no meaningless coindexing' condition conspire to ensure that all of the potential focus values for various choices of ϕ are assignment-dependent, with the result that identity will never be satisfied, and ellipsis will not be licensed. Setting aside for the moment potential worries about the analysis of quantification that Heim is led to, the two absolutely crucial components of Heim's proposal is the 'no overlap' component of the appropriate contrast condition and the 'no meaningless coindexing' assumption.

The former can arguably be made to follow from more general principles (such as the *i-within-i* constraint, in which case the Kennedy and Heim analyses share a crucial property, or maybe Condition C of the binding theory, as argued in Rooth 1992). 'No meaningless coindexing' is not so obviously justified, however: given the assumptions about the interpretation of binding/coindexation in (30), this constraint does not follow. Moreover, it seems that the simplest theory of the representation and interpretation of binding configurations is one in which coindexation of variables bound by distinct binders should not matter. In fact, Heim's analysis would be compatible with a slightly different version of this constraint that disallowed reuse of indices *only in argument-containment configurations*, but not elsewhere. The goal of section 4 of this paper is to argue in favor of of a system that derives exactly this result.

3.3 Sauerland 1998, 2002

Sauerland (1998, 2004) develops an analysis of ACE that is in some ways quite different from the Kennedy and Heim analyses, though roughly speaking it is an instance of an approach that says our assumptions about indexing need to be revised. The crucial bit of Sauerland's analysis is his analysis of the interpretation of $\overline{\text{A}}$-chains, stated in (44). Sauerland's analysis could in principle be implemented in either the Sag/Williams theory of ellipsis or a Rooth-style approach; I will present his proposals in terms of the former. (Sauerland himself adopts the extension of Rooth's approach advocated in Fox 1999a.)

The central assumption of Sauerland's analysis of $\overline{\text{A}}$-chains is that $\overline{\text{A}}$-movement is a 'copy and delete' operation, such that the trace of $\overline{\text{A}}$-movement contains a copy of the nominal head of the moved phrase, which I will represent

as $\langle NP \rangle$ (Chomsky 1995; Sauerland 1998; Fox 1999b, 2002). The interpretation rule for copies is stated in (44) (cf. Fox 1999b).

(44) *The interpretation of copies*
$[\![\langle NP_i \rangle]\!]^g = g(i)$ if $[\![NP]\!]^g(g(i)) = 1$, otherwise undefined.

On this analysis, the contrast in (45) is straightforwardly explained.

(45) a. Polly visited every town Erik did.
b. *Polly visited every town located in a country Erik did.

These examples have the LFs in (46). Here I assume that like-indexing on bound expressions is in principle possible (though there might be other reasons to rule it out).

(46) a. [every town [$_{\text{CP}}$ ~~town~~$_1$ Erik did ~~[$_{\text{VP}_e}$ visit $\langle town_1 \rangle$]~~]]$_1$ [Polly PAST [$_{\text{VP}_a}$ visit $\langle town_1 \rangle$]]
b. [every town [$_{\text{CP}}$ ~~town~~$_1$ located in a country [$_{\text{CP}}$ ~~country~~$_1$ Erik did ~~[$_{\text{VP}_e}$ visit $\langle country_1 \rangle$]~~]]]$_1$ [Polly PAST [$_{\text{VP}_a}$ visit $\langle town_1 \rangle$]]

(46a) is unremarkable: VP_a and VP_e are identical down to lexical content of traces, and so have the same denotations for all assignments. The problem with (45b) is not in the indexical values (assuming for the sake of argument that reassignment of the index 1 is taken care of when the relative operator composes with its scope), but in the semantic contributions of the traces in the two VPs. According to (44), the lexical content of the traces has to be factored into the interpretation as a presupposition on the possible values of the variables they introduce, giving us the denotations for VP_a and VP_e in (47).

(47) a. $[\![[_{VP_a}$ visit $\langle town_1 \rangle]]\!]^g = visit\ g(1)\ if\ g(1)\ is\ a\ town$
b. $[\![[_{VP_e}$ visit $\langle country_1 \rangle]]\!]^g = visit\ g(1)\ if\ g(1)\ is\ a\ country$

These are distinct denotations, so the identity condition fails to be met, and ellipsis should be impossible.

An important prediction of this analysis is that we should not see argument identity effects when the distinct arguments in ACE configurations have the same lexical content, and this is indeed what Sauerland claims. He presents data like (48)-(49) as evidence (these are Sauerland's judgments):

(48) a. *Polly visited every town that's near the lake Erik did.
b. Polly visited every town that's near the town Erik did.
c. Polly visited every town that's near the one Erik did.

(49) a. *Satoshi ordered a drink that was more expensive than the dish Jason did.
b. Satoshi ordered a drink that was more expensive than the drink Jason did.
c. Satoshi ordered a drink that was more expensive than the one Jason did.

However, my own judgments and those of my informants differ: for many speakers, the (b) examples above ungrammatical, though the (c) examples are significantly more acceptable. One empirical difficulty here is that there is not systematic agreement on the data: it is possible to find speakers who share my judgments and others who agree with Sauerland's.

One important fact to note, however, is that in Sauerland's data, the most acceptable examples are those in which the second DP is headed by anaphoric *one*, and that the others are definite. If the second DP is indefinite, the examples are systematically worse. For illustration, consider the following examples, describing the results of a cognitive psychology experiment in which the task is for a child to reproduce the actions of another child when facing a board covered with different shapes (circles, squares, triangles).

(50) a. *Nicholas touched every circle above a circle Julian did.
b. *Nicholas touched every circle above some circles Julian did.
c. *?Nicholas touched every circle above some of the circles Julian did.
d. ?Nicholas touched every circle above the one Julian did.

Evidently, the less definite the second DP, the less acceptable the ellipsis. Note that the unelided counterparts of these examples, in comparison, are perfect.

(51) a. Nicholas touched every circle above a circle Julian touched.
b. Nicholas touched every circle above some circles Julian touched.
c. Nicholas touched every circle above some of the circles Julian touched.
d. Nicholas touched every circle above the one Julian touched.

The bottom line here is that there is evidently some effect of lexical identity and definiteness of the second DP, but it is not yet clear just what this effect is, how systematic it is, and how much we want to base a general explanation of argument identity effects in ellipsis on it. At the very least, more experimentation needs to be done to decide what the facts are before we draw any conclusions.[8]

[8]Polly Jacobson (p.c.) suggests that the improvement observed in the examples with

Setting these cases aside, however, there are other examples that are clearly problematic for Sauerland's proposal. Recall from the initial discussion of the facts in section 1 that free relatives show ACE effects:

(52) a. I'll order what(ever) Jason does.
b. *I'll order whatever goes well with what(ever) Jason does.

(53) a. Kim always votes for whoever Lee does.
b. *Kim always votes for whoever is competing against whoever Lee does.

According to Sauerland's analysis, ellipsis is impossible in the ungrammatical argument containment configurations because the VPs in such examples contain traces that have non-identical lexical content, where lexical content is determined by the nominal head of the relative clause. The free relatives in (52b) and (53b) do not have lexical heads, however, so there should be no such effects, and (52b)-(53b) are predicted to be well-formed. So even if Sauerland turns out to be right about the interpretation of chains, we will need to say more to account for these cases.

A final, more general question about this analysis is whether the sort of meaning introduced by the lexical content of traces should be relevant for the calculation of identity in ellipsis in the first place. One potential argument against this viewpoint comes from the absence of 'lexical content' effects in cases of sloppy identity involving pronouns with different gender or number features, such as (54a-b).

(54) a. Julian touched his nose, and Olive did ~~[VP touch her nose]~~ too.
b. Julian touched his nose, and the girls did ~~[VP touch their noses]~~ too.

The semantic contribution of number and gender features on pronouns can be analysed in the same way as the lexical content of traces in Sauerland's analysis: this information restricts the domain from which the value of the variable contributed by the pronoun may be selected. For example, the denotations of

definite DPs may somehow stem from the fact that use of the definite sets up a presupposition that there are pairs of objects and individuals connected by some salient relation, in these cases, the relation expressed by the overt verb. If something like this is correct, then it may be possible to analyze ellipsis as being licensed not literally by the matrix VP, but rather by these presuppositions. Crucially, this would allow the indexical values on the variables inside the elided VP to differ from those inside the antecedent, as long as we use the same variables in the representation of the meaning of the presupposed information. Whether this hypothesis can actually be implemented remains to be seen.

his, *her* and *their* can be defined as in (55a-b) (cf. Heim and Kratzer 1998, p. 244).

(55) a. $[\![his]\!]^g = g(i)$ if $g(i)$ is a male atomic individual, otherwise undefined.
b. $[\![her]\!]^g = g(i)$ if $g(i)$ is a female atomic individual, otherwise undefined.
c. $[\![their]\!]^g = g(i)$ if $g(i)$ is a plural individual, otherwise undefined.

If the domain restrictions imposed by number and gender features played a role in licensing ellipsis, just like the lexical content of traces in Sauerland's analysis, then we would incorrectly predict that the sloppy interpretations of the pronouns indicated in (54a-b) should be impossible. One conclusion we could draw, then, is that this sort of information is simply not relevant to the calculation of identity in ellipsis, in which case Sauerland's explanatioin of argument identity effects disappears.

There is an alternative response to this problem, however, which has recently been advocated by von Stechow (2003) (see also Kratzer 1998). Von Stechow proposes that number and gender features on bound pronouns may be deleted at LF, leaving a 'pure variable' behind. According to von Stechow, this is independently necessary to account for the possibility of a 'sloppy' interpretation of the first person pronoun in (56), paraphrased in (56a). (Von Stechow refers to unpublished work by Irene Heim for the initial obeservation of this problem and an alternative 'feature agreement' mechanism to solve it; cf. Kratzer 1998.)

(56) Only I touched my nose.
a. No x other than the speaker is such that x touched x's nose.
b. No x other than the speaker is such that x touched the speaker's nose.

If the first person pronoun *my* restricted its value to the speaker of the sentence, then only the 'strict' interpretation in (56b) should be available. The fact is that (56) is ambiguous, however, having both the strict interpretation in (56b) and the sloppy interpretation in (56a).

If von Stechow's proposals are correct, they would eliminate the problem presented by number and gender mismatch in sloppy interpretations of ellipsis. However, they raise a new question for an advocate of a Sauerland-style analysis of argument identity effects in ellipsis: if the lexical content of bound pronouns can be deleted at LF, then why can't the lexical content of bound traces be deleted? Arguably, the latter information is even more re-

dundant than the former, since there is a full copy of the trace elsewhere in the representation. There may indeed be a principled answer to this question, but at the very least, it is one that needs to be addressed.

3.4 Summary

To summarize, I have presented three analyses of argument identity facts in ellipsis, each with its own set of problems. Kennedy (1994) accounts for the facts but relies on a stipulation about the distribution of indices (his version of the *i-within-i* constraint) that doesn't really follow from anything. Heim (1997) also accounts the facts, but relies on a stipulation about the distribution of indices (the 'no meaningless coindexation condition') that doesn't really follow from anything either. Sauerland (1998, 2004) argues that the argument identity facts follow from general conditions on the interpretation of chains, but his predictions about the role of lexical identity disagree with the judgments of many speakers, and the analysis clearly overgenerates in the case of free relatives.

The Kennedy and Heim analyses therefore have the same basic theoretical problem, but arguably better empirical coverage than the Sauerland analysis, suggesting that a more explanatory and descriptively adequate analysis of argument identity will be found by focusing on the representation and interpretation of binding configurations. It is to this that I now turn.

4 Partial assignment functions

4.1 No variable reassignment

As noted above, even though Heim adopts the 'no meaningless coindexing' constraint, really all that is crucial is that 'meaningless' coindexing is ruled out in argument containment configurations — the analysis would still make the correct predictions if bound variables in independent clauses were allowed to use the same indices. This result is the mirror image of what is required in Kennedy's analysis: the only place we need to *disallow* like-indexed bound variables is in argument containment configurations. In other words, what both analyses need to rule out in a principled way are configurations in which a variable indexed i in the scope of a binder over i is 're-bound' by a distinct binder, schematically represented in (57).

(57) $[\ \mathrm{XP}_i\ [\ \ldots\ v_i\ \ldots\ [\ \mathrm{YP}_i\ [\ \ldots\ v_i\ \ldots\ ]\ ]\ ]\ ]$

The problem is that the rules for interpreting variable binding that I introduced in (30) above and repeat in (58) below do not rule out such configurations.

(58) a. *Predicate Abstraction*
If α is of the form $[_\alpha\ i\ \beta]$, then for any assignment function g, $[\![\alpha]\!]^g = \lambda x.[\![\beta]\!]^{g[x/i]}$

b. *Pronouns and Traces Rule*
If $\alpha \in \{pro, t\}$, then for any assignment function g, $[\![\alpha_i]\!]^g = g(i)$

c. A context c is appropriate for a LF ϕ only if c determines a variable assignment g_c whose domain includes every index that has a free occurrence in ϕ.

As we saw in the discussion of Kennedy's analysis of argument identity effects, because the Predicate Abstraction rule in (58a) can reassign new values to previously used variables, structures of the form in (57) are perfectly interpretable (see the discussion of (36) above).

If, however, the grammar disallowed reassignment of values to variables, representations with the indexing relation in (57) would be ruled out. This hypothesis is encoded in the constraint in (59).

(59) *No variable reassignment*
For any constituent of the form $[_\alpha\ \ldots\ v_i\ \ldots\ ]$ where v_i is a variable-denoting expression, and for any assignment g that includes the assignment $[i \rightarrow \gamma]$, if $[\![\alpha]\!]^g$ then $*[\![v_i]\!]^{g[\delta/i]}$ for $\delta \neq \gamma$.

The intuition that this constraint is designed to implement is that when the value of a particular variable is fixed in an assignment function — either structurally, by the Predicate Abstraction rule, or contextually — it is fixed for all constituents that are interpreted with respect to any assignment based on that one. In the next subsection, I will present an approach to the semantics of variables that derives this result; before doing this, however, I will show that if (59) is part of the grammar, it accounts for the facts of argument contained ellipsis.

First consider acceptable examples of ellipsis in argument containment configurations, such as the ACD example in (60). Let us assume with Kennedy 1994 that an elided VP must have the same denotation as its antecedent under all assignments (the Sag/Williams theory of ellipsis) and that a relative operator must introduce the same binding index as the DP that the relative clause modifies. (I will discuss this assumption in more detail below.)

(60) Polly visited every town that Erik did.

This example may be assigned the LF (61), which satisfies the identity conditions on ellipsis: since the VP-internal traces bear the same indices, the VPs have the same denotations under all assignments.

(61) $[_{\text{DP}}$ every town $[_{\text{CP}}$ wh_1 Erik did ~~$[_{\text{VP}_e}$ visit $t_1]$~~$]]_1$ $[_{\text{IP}}$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]]$

Crucially, although the VP-internal variables use the same indices, they do not run afoul of (59), since neither is in the scope of the other's binder.

Now consider the case of an ungrammatical example like (62), in which the internal arguments of the elliptically related VPs are non-identical.

(62) *Polly visited every town located in a country that Erik did.

In order to license ellipsis, (62) should have the LF in (63).

(63) $[_{\text{DP}}$ every town $[_{\text{CP}^1}$ wh_1 t_1 located in $[_{\text{DP}}$ a country $[_{\text{CP}^2}$ wh_1 Erik did ~~$[_{\text{VP}_e}$ visit $t_1]$~~$]]]]_1$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]$

This representation is ill-formed according to (59), however, because it requires modifying the assignment to the index 1 inside a constituent where 1 is already assigned, namely in the relative clause modifier of *every town*. The crucial nodes are CP^1 and at CP^2, where Predicate Abstraction applies.[9] The interpretations we get for these constituents are stated in (64a-b).

(64) a. $[\![[_{CP^1} wh_1\ \alpha]]\!]^g = \lambda x.[\![\alpha]\!]^{g[x/1]}$
b. $[\![[_{CP^2} wh_1\ \beta]]\!]^{g[x/1]} = \lambda z.[\![\beta]\!]^{g[x/1][z/1]}$

Crucially, since CP^2 is a subconstituent of α in (64a), it is interpreted with respect to the modified assignment function introduced by application of Predicate Abstraction at the higher node, CP^1. Predicate Abstraction at CP^2 therefore reassigns the value of the index 1, in violation of (59), and the structure is ruled out.

[9] Actually, Predicate Abstraction applies just below CP, to index-adjunction structure that is the sister of the relative operator in SpecCP: recall that (ia) is shorthand for (ib).

(i) a. XP_i $[_\alpha$ ... $]$
b. XP [i $[_\alpha$ ... $]$

This detail doesn't affect the argument, however, so to keep the discussion clearer I will talk in terms of the CP nodes.

A representation that doesn't run afoul of (59), however, such as (65), fails to license ellipsis: since the VP-internal traces bear distinct indices, the VPs fail to have the same denotations under all assignments, and so are not logically equivalent.

(65) $[_{\text{DP}}$ every town wh_1 t_1 located in $[_{\text{DP}}$ a country wh_2 Erik did ~~$[_{\text{VP}_e}$ visit $t_2]$~~$]]]_1$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]$

The result is that there is no LF that both satifies the identity conditions on ellipsis and the constraint against variable reassignment in (59), and the sentence is therfore predicted to be ungrammatical. This result will hold of any structure in which the binder of a variable internal to one VP is contained in the binder of a variable internal to the other VP, since this will involve a configuration like (57). We therefore rule out ellipsis in argument containment configurations.

It should be acknowledged here that the assumption that a relative operator introduces the same binding index as the DP that the relative clause modifies is crucial. If it were possible for a relative operator to use a distinct index, then (62) could be assigned a LF such as (66), which is just like (65) except that the indices used in the two relative clauses are switched.

(66) $[_{\text{DP}}$ every town $[wh_2$ t_2 located in $[_{\text{DP}}$ a country $[wh_1$ Erik did ~~$[_{\text{VP}_e}$ visit $t_1]$~~$]]]]_1$ Polly PAST $[_{\text{VP}_a}$ visit $t_1]$

This representation both satisfies the identity conditions on ellipsis and does not violate (59), since the two applications of Predicate Abstraction at the two CP nodes assign values to distinct indices. The fact that ellipsis is impossible here therefore indicates that such an indexing configuration must be ruled out. For now, I will assume that the requirement that a relative operator introduce the same index as the DP that the relative clause modifies is a form of agreement (parallel to e.g. case matching effects), an assumption that I will have more to say about in section 5.2 below.

Turning to Heim's (1997) analysis of argument identity effects, (59) has similar consequences. Recall that the only candidates for licensing ellipsis in argument containment configurations are ones in which the VP-internal variables are free inside the compared constituents. In Heim's analysis, the bad examples of ACD like (62) are ruled out because 'no meaningless coindexing' stipulates that the variables in the elided and antecedent VP must be distinct, ensuring that the latter will never be a member of the focus value of the former for all assignments. (Good examples of ACD are allowed to use the same indices in both VPs, avoiding this problem.) In other words, 'no meaning-

less coindexing' rules out the LF in (67), which would otherwise satisfy the conditions on ellipsis based on the contrast between VP_e and VP_a.

(67) $[_{\mathrm{DP}}$ every$_1$ [town t_1 located in $[_{\mathrm{DP}}$ a$_1$ [country Erik did ~~$[_{\mathrm{VP_e}}$ visit t_1~~]]]]] [Polly PAST $[_{\mathrm{VP_a}}$ visit t_1]]

Given the semantics for quantifiers that Heim assumes, however (stated above in (40a)), (59) also rules out (67). Specifically, since a quantifier Q_i fixes the assignment functions to the variable i for its restriction and scope (see Heim's semantics for *every* in (40a) in section 3.2 and note 11 below), a second quantifier embedded in the first's restriction (or scope) must use a new index in order to be consistent with the prohibition on variable reassignment in (59). The result is that it is not necessary to stipulate 'no meaningless coindexing' as a general constraint on LFs.

More generally, the discussion here shows that the argument containment facts can be explained either within a Sag/Williams theory of ellipsis or within a Rooth-style analysis. If a choice is to be made between these two analyses of ellipsis, then, it will have to be based on a consideration of additional data. I will address this issue in section 5.1.

4.2 Assignment functions are partial

Of course, the 'no variable reassignment' constraint in (59) is subject to the same criticisms as Kennedy's (1994) original invocation of the *i-within-i* constraint or Heim's 'no meaningless coindexing' constraint if it can't be made to follow from anything. In this case, however, we are in better shape. As I will demonstrate, (59) follows automatically if we revise our interpretation rules for variables so that assignment functions are partial, and the Predicate Abstraction rule only introduces new assignments into the assignment function; it does not reassign new values to previously used variables.

As stated above, the intuition that (59) is designed to implement is that when the value of a particular variable i is fixed in the assignment function, its value is fixed for all constituents that are interpreted with respect to that assignment function; reassignment of values to variables is not an option. Formally, we can derive this result within the current set of assumptions — in particular, in terms of the 'index adjunction' representation of binding posited in Heim and Kratzer 1998 — by revising the Predicate Abstraction rule as in (68).[10]

[10]This reformulation of Predicate Abstraction was originally suggested by Irene Heim in the Fall 2002 introductory semantics class at MIT in a different analytical context.

(68) *Predicate Abstraction*
If α is of the form $[_\alpha\ i\ \beta]$, then for any assignment function g, $[\![\alpha]\!]^g = \lambda x.[\![\beta]\!]^{g\cup[i\rightarrow x]}$

(68) should be understood as indicating that the sister of a binding index i is interpreted with respect to an assignment that is just like the one used to evaluate the mother node, except that the index i is added to its domain and mapped to the argument of the λ-operator. Put another way, taking the assignment function to be a set of ordered pairs of variable names (indices) and values, (68) adds the pair $\langle i, x\rangle$ to the assignment.[11]

The rule for the interpretation of variable-denoting expressions (pronouns and traces) remains the same, as does the general constraint that the context must support assignment of values values for free variables. However, we also make explicit the (otherwise implicit) constraint in (69), which simply ensures that the assigment function is a function.

(69) Every element in the domain of the assignment function must have a unique value in the range of the assignment function.

The final piece of the puzzle is the assumption that (except for the special case of predicate abstraction structures) daughter nodes are evaluated with respect to the same assignment as their mothers, which is encoded in the rule of Function Composition in (70).

(70) *Function Compositon*
If α is a node with daughters β and γ, and β denotes a function with the denotation of γ in its domain, then $[\![\alpha]\!]^g = [\![\beta]\!]^g([\![\gamma]\!]^g)$.

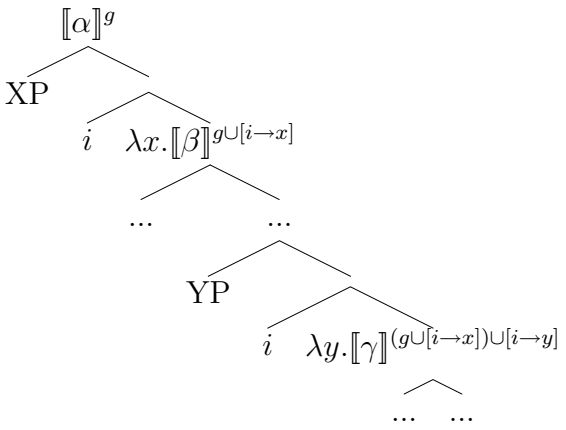
Given (70), the combination of (68) and (69) derives the 'no variable reassignment' constraint in (59). The Predicate Abstraction rule in (68) only adds variable/value mappings to the assignment function; it does not reassign new values to variables. It follows that for any variable i mapped to some value x via Predicate Abstraction, it must be the case either that this particular mapping is already part of the assignment, or that i is not already in the domain of the assignment function. If it were already in the domain and mapped to some distinct value, then the addition of the new mapping of i to x

[11] To derive the same result in Heim's (1997) system, we would need to make the same assumptions about assignment functions outlined here, and modify the interpretation rule for quantifiers as in (i), where the notation is interpreted in the same way as for (68).

(i) $[\![every_i]\!]^g = [\lambda\phi \in D_t[\lambda\psi \in D_t.$*for every x such that* $[\![\phi]\!]^{g\cup[x\rightarrow i]} = 1, [\![\psi]\!]^{g\cup[x\rightarrow i]} = 1]]$

would violate the uniqueness condition in (69). It follows that the 'argument containment' binding configuration schematized above in (57) is impossible. As shown in the tree in (71), if an index i is reused within the scope of a higher binder, the two corresponding applications of Predicate Modification entail that i is assigned two distinct values, in violation of (69).

(71)



A variable may may be reused outside the scope of its binder, however. In effect, when composition moves on to a constituent outside the scope of the binder of index i, the mapping of i to its value is 'erased' from the assignment function. More precisely, this mapping is not there to begin with, since a more general consequence of these assumptions is that assignment functions must be *partial*. At the text level, the contextual assignment g_c with respect to which the interpretation of the root node of a LF is determined must contain only assignments of values to free variables in that LF. Variables that are bound in a LF must not be in the domain of g_c, since if they were, they would be assigned new values by the Predicate Modification rule, violating the requirement that all elements in the domain of the assignment function have unique values. It therefore follows that g_c contains only assignments of values to free variables.

The general result of these assumptions, then, is that variable names (indices) in binding configurations typically do not matter: the same index may be reused for distinct binding relations, as long as neither is in the scope of the other. Since the interpretation of a binding structure involves adding an ⟨index, value⟩ pair to the assignment function, though, and since daughter nodes 'inherit' the assignments of their mothers, the requirement that the assignment function be a *function* will ensure that within the scope of a binder of index i, all new binding relations must use distinct indices. Likewise, it must also be the case that the names of free and bound variables have to be distinct, and that the text-level assignment function is partial, containing only

assignments of values to free variables.

5 Implications of the analysis

5.1 The theory of ellipsis

As demonstrated in 4.1, the new proposals for the interpretation of variables appear to provide the basis for an account of argument identity effects in ellipsis regardless of whether we adopt a Sag/Williams 'logical equivlance' identity condition as advocated in Kennedy 1994 or Rooth's 'parallelism' identity condition together with Heim's (1997) 'formulas' analysis of quantificational determiners. The crucial difference between the two identity conditions is that the former licenses ellipsis strictely on the basis of identity identity between an elided constituent and its antecedent, while the latter involves a more general identity relation between constituents that *contain* the elided constituent and its antecedent.[12] Such constituents may be just the related VPs, as in the case of (good) examples of ACD, but they may in principle be larger. A question worth asking, then, is whether the proposals that I have introduced to account for argument identity effects also bear on the choice of one analysis of ellipsis over the other.

In fact, there is evidence that they do. The crucial data involves examples like (72), discussed in Jacobson 1998.

(72) One picture that Erik didn't take was paired with every picture he did.

Recall first that the Sag/Williams identity condition requires that VP-internal variables in an elided and antecendent VP be identical, and second, that we have assumed that relative operators introduce the same index as the DP that the relative clause modifies. Given that (72) allows an interpretation in which *every picture* has scope over *one picture*, and that ellipsis is licensed, it should have a Logical Form like (73).[13]

[12]In addition, in Rooth's analysis ellipsis is just a special case of a larger class of redundancy relations (deaccenting, etc.), all of which are subject to the same general constraints. See Tancredi 1992 for relevant discussion.

[13]To maximize the chance of building an interpretable LF, I assume that the subject DP doesn't have to bind any variables inside the matrix predicate, since its semantic type allows it to compose directly with the predicate. (Though here I ignore the fact that this is a passive construction, and so presumably involves movement of the subject from a predicate-internal position.) If it did, then we would be in even bigger trouble, since it would be impossible to ensure that the right variable in the matrix predicate gets matched to the right binder:

(73) [every picture wh_1 he did ~~[$_{\text{VP}_e}$ take t_1]~~]$_1$ [one picture wh_1 that Erik didn't [$_{\text{VP}_a}$ take t_1]] [was paired with t_1]

The problem is that under the assumptions introduced in the previous section, the representation in (73) is uninterpretable. According to the revised Predicate Abstraction rule in (68), the interpretation assigned to the scope of *every* is (74), which introduces an assignment to the variable 1 into the assignment function.

(74) $\lambda x.[\![$[one picture wh_1 that Erik didn't [$_{\text{VP}_a}$ take t_1]]$_1$ [t_1 was paired with t_1]$]\!]^{g \cup [1 \rightarrow x]}$

According to the Function Application rule, this assignment is shared by the daughter nodes, including the DP headed by *one*. Since the relative operator inside this DP must bind a trace indexed 1 as well, however (in order for the VPs to satisfy the identity condition on ellipsis), Predicate Abstraction inside the relative clause will introduce a new assignment to this index, in violation of the requirement that all elements in the domain of the assignment function have unique values in its range.

In order to satisfy this requirement, (72) should be assigned a Logical Form for like (75).

(75) [every picture wh_1 he did ~~[$_{\text{VP}_e}$ take t_1]~~]$_1$ [one picture wh_2 that Erik didn't [$_{\text{VP}_a}$ take t_2]] [was paired with t_1]

(75) fails to license ellipsis under the Sag/Williams theory, however, since the elided and antecedent VPs do not have the same denotations under all variable assignments.

Examples like (72) are also problematic for Heim's analysis of argument identity effects. A LF for (72) in which the VP-internal variables are identical is ruled out within the current set of assumptions for essentially the same reasons as described above for the Kennedy/Sag/Williams structure (and by 'no meaningless coindexing' in Heim's orginal account). Furthermore, as pointed out by Jacobson (1998), a LF that satisfies the constraints on indexing, such as (76), fails to license elllipsis.

(76) [every$_1$ [picture$_1$ he did ~~[$_{\text{VP}_e}$ take t_1]~~] [one$_2$ [picture$_2$ that Erik didn't [$_{\text{VP}_a}$ take t_2]] [t_2 was paired with t_1]

(i) [every picture wh_1 he did ~~[$_{\text{VP}_e}$ take t_1]~~]$_1$ [one picture wh_1 that Erik didn't [$_{\text{VP}_a}$ take t_1]]$_1$ [t_1 was paired with t_1]

Jacobson points out that the only potential candidates for licensing the 'appropriate contrast' condition on ellipsis (i.e, candidates that do not obviously involve assignment-dependent values to variables) are the two quantificational DPs. Using the version of Heim's semantics for quantificational determiners introduced in section 3.2, the focus value of the former (assuming focus on *did* generates alternatives to a positive assertion, here represented as POS) is (77a), and the regular semantic value of the latter is (77b).

(77) a. $\{\lambda\phi \in D_t.$*for every x such that x is a picture and* $f($*Erik took x*$) = 1, [\![\phi]\!]^{g\cup[1\rightarrow x]} = 1 \mid f$ an alternative to POS$\}$

b. $\lambda\phi \in D_t.$*for one y such that y is a picture and Erik didn't take y,* $[\![\phi]\!]^{g\cup[2\rightarrow y]} = 1$

Clearly, (77b) is not a member of (77a), and will fail to be so for any example in which the determiners are distinct.

Intuitively, what we need to be able to do to license ellipsis in examples like (72) is to compare constituents that are big enough to ensure that the VP-internal variables are bound within them and so do not have assignment-dependent interpretations, which will allow for indexical variation between elided and antecedent VPs, but small enough to avoid unwanted inteference from non-redundant information higher in the structure. Two such constituents are in fact available: the relative clause modifiers of the quantificational DPs. However, these constituents will satisfy the requirement that the VP-internal variables be bound inside them only if we adopt a 'standard' syntax and semantics for relative clauses, in which they denote functions of type $\langle e, t\rangle$ rather than Heim's 'formulas'.

Consider again the LF presented above in (75), which fails to license ellipsis under a Sag/Williams identity condition due to the mismatch between the VP-internal variables. If we assume a standard semantics for relative clauses instead of Heims's 'formulas' analysis, the focus value of the relative clause containing the elided VP is (78a), and the regular semantic value of the relative clause containing the antecedent is (78b).

(78) a. $\{\lambda x.f($*Erik took x*$) \mid f$ an alternative to POS$\}$

b. $\lambda y.$NOT$($*Erik took y*$)$

(78b) is an element of (78a), therefore a Rooth-style identity condition correctly predicts ellipsis to be possible here. We therefore appear to have an argument for a 'parallelism' licensing condition on ellipsis over one based on logical equivalence of elided and antecedent VPs.

5.2 The representation of binding

The conclusion of the previous section was that in order to account for examples like (72), we need to both adopt a Rooth-style identity condition for ellipsis and give up Heim's 'formulas' analysis of quantificational determiners. As Heim herself points out, however, this has the unwelcome consequence of licensing ellipsis in examples like (79)— precisely the cases that we originally intended to rule out!

(79) *Polly visited every town that was located in a country that Erik did.

Our assumptions about the representation of binding configurations, in particular, the 'index adjunction' structures of Heim and Kratzer 1998, allow (80) as a possible LF for (79) (here I explicitly indicate index adjunction).

(80) [every town wh [1 [t_1 was located in a country wh [$_{\text{E}}$ 2 [Erik did [$_{\text{VP}_e}$ ~~visit t_2~~]]]]]] [$_{\text{A}}$ 1 [Polly PAST [$_{\text{VP}_a}$ visit t_1]]]

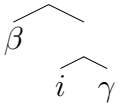
One way to license ellipsis is to check for appropriate contrast between the constituent marked E and the constituent marked A. Assuming focus on *Polly* and *Erik*, the focus value of E is (81a), and the regular semantic value of A is (81b).

(81) a. $\{\lambda x.z \textit{ visited } x \mid z \in D_e\}$
b. $\lambda x.\textit{Polly visited } x$

But (81b) is a member of (81a), so ellipsis is incorrectly predicted to be possible in (79).

The problem here is that if we assume Heim and Kratzer's index adjunction structures, there is no (relevant) syntactic or semantic difference between a relative clause and the syntactic scope (the sister) of a DP that has undergone Quantifier Raising. The compared constituents are both predicate abstraction structures in which the VP-internal variables are bound, so the fact that these variables are distinct is therefore irrelevant to the calculation of identity for ellipsis. It is precisely this problem that leads Heim to adopt the 'formulas' analysis in the first place.

There is a solution to this problem, however, which is to give up Heim and Kratzer's index adjunction structures in favor of a more standard syntactic structure in which a 'binding index' is syntactically represented on a binder itself. Thus instead of representing a constituent α consisiting of a binder β and its scope as in (82a), we have representations like (82b).

(82) a. 

b. 

Before providing a semantics for structures like (82b) and showing how this allows us to account for the full range of facts, however, it is worth stepping back to see what issues motivate structures like (82a) in the first place (see also Heim and Kratzer 1998, pp. 187-8). One concern is that a structure like (82b) is ambiguous: we don't know whether β is a variable or a binder. We could simply write a rule that stipulates that β not be a variable-denoting expression, but this would actually be incorrect: as shown by Heim (1993), we need to allow for the possibility of (at least) pronouns being interpreted as both variables and binders.

To eliminate the ambiguity of representations like (82b), and to allow for the possiblity that some expressions may be both variables and binders, I will adopt a proposal in Heim 1993 and assume that there are two distinct types of indices: those that specify the name of a variable-denoting expression, and those that indicate which variables an expression binds (Heim's 'inner' and 'outer' indices, respectively). This assumption can be formally implemented by assuming that features of XPs are represented as attribute value matrices, and positing a complex feature INDEX which has two types of values: a BIND value and a VAR value, as shown in (83).

(83) $$\begin{bmatrix} \text{INDEX} & \begin{bmatrix} \text{BIND} & i \\ \text{VAR} & j \end{bmatrix} \end{bmatrix}$$

With these representational assumptions, we can now revise our interpretation rules for variables and binding as in (84)-(85).

(84) *Variables*
If α is a constituent with a non-nil VAR feature, then $[\![\alpha_{[\text{VAR } i]}]\!]^g = g(i)$

(85) *Predicate Abstraction* (final)
If α is a constituent consisting of daughters $\beta_{[\text{BIND } i]}$ and γ, $[\![\alpha]\!]^g = [\![\beta]\!]^g(\lambda x.[\![\gamma]\!]^{g \cup [i \rightarrow x]})$

(84) simply says that the denotation of an expression with a VAR value i is whatever the assignment function returns for i; this is unremarkable. The interesting linguistic question is what expressions can have non-nil VAR values in the first place. One possibility is that every DP can have this feature, but

that it in the case of non-pronominals it is introduced only derviationally, as part of the movement (copy and delete) operation (i.e., on traces). These are issues that go beyond the scope of this paper, however, and indeed can be asked of any theory that uses indices, so I will set them aside here.[14]

What is of primary concern to us here is the revised Predicate Abstraction rule in (85). This rule maintains the core of the proposal in section 4.2, that binding involves adding index/value pairs to the assignment function, but it has the effect of 'closing off' the scope of a binder only when the latter composes with the former; on its own, the scope of a binder is an open expression.[15] In most contexts, this fact will be irrelevant, since the intepretation of a constituent consisting of a binder and its scope will be the same as it was for the index adjunction analysis: the latter will be turned into a function of type $\langle e, t\rangle$ and supplied as the argument to the former. The fact that the interpretation of the scope constituent on its own is an open expression does make a difference for the analysis of the ellipsis sentences we are concerned with here, however.

Consider first the argument identity facts, in particular the contrast between (86a) and (87a), which have the LFs indicated in the respective (b) examples.

(86) a. Polly visited every town Erik did.
b. [every town wh_1 Erik did ~~$[_{\mathrm{VP_e}}$ visit $t_1]$~~]$_1$ [Polly PAST [$_{\mathrm{VP_a}}$ visit t_1]]

(87) a. *Polly visited every town located in a country that Erik did.
b. [every town wh_1 t_1 located in [a country wh_2 Erik did ~~$[_{\mathrm{VP_e}}$ visit $t_2]$~~]]$_1$ [Polly PAST [$_{\mathrm{VP_a}}$ visit t_1]]

The explanation of the acceptability of (86a) and the unacceptability of (87a) is essentially the same as that of Heim 1997, as described in section 3.2. In (86b), the appropriate contrast condition can be satisfied by just comparing the elided and antecedent VPs, since the VP-internal variables are (allowed to be) the same. In (87b), on the other hand, this is not an option since the semantics of Predicate Abstraction forces us to use a variable inside the elided VP that is distinct from that used in the antecedent VP. We therefore have to look at larger constituents to calculate the appropriate contrast condition. Crucially, however, there is no constituent containing the antecedent VP in

[14]Of particular interest is how these assumptionis interact with the proposals for the interpretation of traces in Sauerland 1998, 2004; Fox 1999b, 2002 and related work.

[15](85) also entails that all DPs with BIND values are interpreted as generalized quantifiers, requiring type-shifing for referential terms (cf. Reinhart 1983).

which the antecedent-internal trace t_1 is bound that does not also overlap with a constituent containing the elided VP. Appropriate contrast therefore fails, and ellipsis is correctly predicted to be impossible.

In contrast, an example like (88a), which can be assigned the LF in (88b), does not run into this problem.

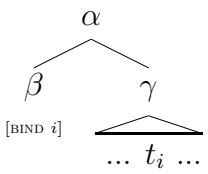
(88) a. One picture that Erik didn't take was paired with every picture he did.

b. [every picture [wh_1 he did ~~[$_{\text{VP}_e}$ take t_1]~~]]$_1$ [one picture [wh_2 that Erik didn't [$_{\text{VP}_a}$ take t_2]]]$_2$ [t_2 was paired with t_1]

Assuming that the relative operator is semantically vacuous (i.e., that its denotation is the identity condition on functions), both relative clauses denote functions in which the VP-internal variables are bound. Specifically, the focus value for the relative clause modifier of *every picture* and the regular semantic value for the relative clause modifier of *one picture* are exactly what we saw above in (78), licensing ellipsis.

In sum, the crucial consequence of assuming the representation of binding structures in (89) and the semantic rule of Predicate Abstraction in (85) is that relative clauses, by virtue of syntactically including both a binder (the relative *wh*-operator) and a variable (its trace), directly denote functions, while the syntactic scope of a moved XP (γ in (89)) does not.

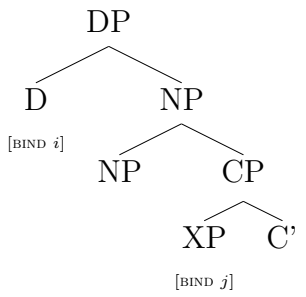
(89)



Variable-denoting expressions are therefore semantically bound only within a constituent that syntactically includes their binders; not within the syntactic scope (the sister) of their binders. In this way, the proposals made here concerning the representation of binding configurations posit an even tighter fit between (observable) syntax and interpretation than those in Heim and Kratzer 1998.

Finally, if the general approach to the representation of syntactic indices outlined here is correct, then it allows us to clarify the constraints on the indexing relation holding between relative claues and the DPs they modify. As I acknowledged in section 4.1, it is crucial to the analysis that the binding index on a relative operator in SpecCP be the same as that on the DP it modifies, since if these values were allowed to vary, we would license the bad

cases of argument contained ellipsis. I suggested there that this restriction is a form of agreement, similar to case-matching effects in relative clauses. Using the proposals outlined here, this hypothesis can be made more precise: in the configuration in (90), D and XP must agree in values of the BIND feature. (I assume that features on a phrase are also represented on its head.)

(90) * 

if $i \neq j$.

5.3 The theoretical status of variables

I conclude with some remarks on the implications of the data and the analysis for semantic theory more generally, in particular for the question of whether variables are a necessary component of an empirically adequate theory of grammar. The analysis of argument identity facts that I have proposed in this paper clearly crucially requires a positive answer to this question, since the facts are ultimately explained in terms of the proposals made in section 4.2 about how variables are assigned values. If there are no variables, then there are no assignment functions, and the analysis developed in this paper disappears. To the extent that the proposals made here best explain the facts, then, we have an argument for a semantic theory that includes variables.

There is an important body of recent work that questions this assumption, however, which is perhaps best represented by a series of papers by Polly Jacobson (Jacobson 1992, 1998, 1999, 2000). In order to determine whether such an analysis can account for the argument identity facts, we must first see how it handles antecedent-contained deletion in general. The basic approach is described in Jacobson 1992. As Jacobson shows, ACD in an example like (91) can be handled straightforwardly without variables or a level of Logical Form by assuming that all that is 'missing' here is a transitive verb meaning.

(91) Polly visited every country that Erik did.

Such a meaning can be recovered from the denotation of the matrix verb *visit*, and can then be function-composed with the type-shifted denotation of the DP *Erik*, as shown in (92a), to derive the correct denotation for the relative

clause, shown in (92b). (I am ignoring tense morphology throughout, which just requires another application of function composition.)

(92) a. $\lambda f \in D_{et}.f(Erik) \circ \lambda x.\lambda y.y \textit{ visit } x =$
b. $\lambda x.Erik \textit{ visit } x$

As Jacobson (1998, p. 87) acknowledges, however, this account does not support an explanation of the argument identity facts that have been the empirical focus of this paper. Specifically, nothing about the proposal should prohibit the same interpretive strategy used to derive the right meaning of (91) from applying to (93).

(93) *Polly visited every town that was located in a country that Erik did.

If we go through the same steps that we did for (91) — use the matrix verb *visit* to supply the missing transitive verb meaning — then we should derive exactly the same interpretation for the embedded relative clause *that Erik did* in (93) that we derived above in (92b). All other things being equal, then, (93) is predicted to be just as acceptable as (91).

However, Jacobson (1998) also introduces a set of facts which she claims to be problematic for a variable-based analysis of the argument identity facts and for the analysis of ACD more generally (in particular, the analysis developed in Heim 1997). Specifically, Jacobson shows that it is possible to have distinct internal arguments of an elided and antecedent VP in ACD configurations when the object of the elided verb is pied-piped, as in (94).

(94) Polly visted every country the capital of which Erik did.

At first, it appears that this sort of example can be handled straightforwardly within the set of assumptions developed in this paper. Let us assume first that pied-piping structures are interpreted without reconstruction, and second that the index-agreement relation posited at the end of the previous section is a purely syntactic constraint that holds between any XP in SpecCP and a higher D^0, regardless of whether that XP is a lexical *wh*-expression or not. If these assumptions are correct, a possible LF for (94) is (95).

(95) [every country [[the capital of which]$_1$ Erik did ~~[$_{VP_e}$ visit t_1]~~]]$_1$ Polly PAST [$_{VP_a}$ visit t_1]

It should be clear that if this were the correct LF, ellipsis would licensed: since the VP-internal variables are the same, the appropriate contrast condition will be satisfied for the elided and antecedent VPs, just as in standard cases of

ACD.

The problem for this analysis comes from a second set of facts introduced by Jacobson. Jacobson first observes that an analysis of ACD that has the basic characteristics of the one outlined here (in particular, one that adopts Rooth's licensing condition and makes crucial use of variables), predicts that in examples that are just like standard cases of ACD except that the object DP is overtly preposed, ellipsis of either the embedded or matrix VP should be possible. This follows from the fact that ellipsis can be licensed strictly on the basis of an appropriate contrast relation between the elided and antecedent VP, as we have seen, and indeed, (96a-b) suggest that this prediction is correct. (I have modified Jacobson's examples slightly to make the preposing sound more natural independent of ellipsis.)

(96) a. Any country that Erik does, Polly visits.
b. Any country that Erik visits, Polly does.

If the analysis of pied-piping examples like (94) is essentially the same as that of standard cases of ACD, as in the derivation sketched above, then the prediction is that they should behave just like (96a-b) in preposing. However, as Jacobson shows, this is not the case: when the object DP in (94) only the embedded VP may be elided. This is illustrated by the contrast in (97).

(97) a. Any country the capital of which Erik does, Polly visits.
b. *Any country the capital of which Erik visits, Polly does.

Moreover, as Jacobson demonstrates, the contrast in (97) follows automatically within the variable-free analysis from independent assumptions about the interpretation of pied-piping structures. We thus seem to be at a stalemate: the variable-free analysis fails on the argument identity facts but accounts for (97); the variable-based analysis presented here accounts for agument identity but fails on (97).

In fact, however, both (94) and (97) can be accomodated within the framework developed in this paper, and in fact provide further arguments for adopting a Rooth-style analysis of ellipsis (though a slightly modified version, as we will see below). Let us first assume, contrary to what I suggested above, that pied-piped XPs undergo reconstruction at LF. On this view, the LF of the non-preposed example (94) is (98).

(98) [every country [which$_1$ Erik PAST ~~[$_{\text{VP}_e}$ visit the capital of t_1]~~]]$_1$ [Polly PAST [$_{\text{VP}_a}$ visit t_1]]

Let us further assume following Jacobson 1998 that the denotation of a re-

lational DP like *the capital of* x is a function of type $\langle e, e\rangle$ applied to an individual, where the function comes from the head noun *capital* and the argument comes from the object of the preposition x. We may now check to see whether the appropriate contrast condition is satisfied, starting with the elided and antecedent VPs. As Jacobson also shows, in an example like (98), *capital* must be focused, which means that the focus value of the elided VP is (99a) and the regular semantic value of the antecedent VP is (99b).

(99) a. $\{\lambda x.x \textit{ visit } f(g(1)) \mid f \in D_{\langle e,e\rangle}\}$
b. $\lambda y.y \textit{ visit } g(1)$

Is (99b) a member of (99a)? According to Jacobson, it is, since (99b) is equivalent to the function in (100), where IDENT is the identity function on individuals (a function of type $\langle e, e\rangle$).[16]

(100) $\lambda y.y \textit{ visit } \text{IDENT}(g(1))$

This is not quite enough to license ellipsis under the current set of assumptions, however. Recall that the version of Rooth's theory presented in section 3.2 actually requires that two conditions be satisfied in order to license deletion: a constituent that contains the deleted VP must contrast appropriately with a constituent that contains its antecedent, and the deleted VP itself must contain the same lexical/syntactic material as the antecedent. In the example under discussion, only the former condition is met: if we reconstruct the pied-piped DP, the syntactic identity condition is clearly no longer satisfied.

In fact, however, there is a growing body of evidence that ellipsis is not subject to a lexical/syntactic identity condition at all, but can (and should) be explained strictly in terms of semantic identity. The most compelling arguments for this position come from Merchant (2001), who documents a range of cases in which 'form identity' can be sacrificed in ellipsis as long as semantic identity holds (among which are Fiengo and May's (1994) 'vehicle change' effects, finite-nonfinite mismatches in sluicing, etc.). For our purposes, we may assume the version of Rooth's analysis developed in Fox 1999a, which is essentially the same as the one introduced in section 3.2 except that it eliminates the lexical identity condition. If appropriate contrast (Fox's 'parallelism') is enough to license deletion, then the analysis of (94) described above goes through.[17]

[16]Jacobson responds to the objection that invoking the identity condition here is a 'cheat' by showing that we need to do essentially the same thing in certain examples of focus licensing; see Jacobson 1998, p. 83 for discussion.

[17]The identity condition proposed in Merchant 2001 is somewhat different from the one

Turning to the preposing examples, it should be clear that (97a) follows straightforwardly, since its LF will be just like that of (94) (again, assuming that the pied-piped DP is reconstructed). (97b) is the interesting case. According to the assumptions I have laid out here, it should have a LF like (101).

(101) [Any country [which$_1$ Erik PRES [$_{\text{VP}_\text{a}}$ visit the capital of t_1]]] [Polly does ~~[$_{\text{VP}_\text{e}}$ visit t_1]~~]

In (101), the elided and antecedent VPs are reversed, so we now need to check whether the regular semantic value of the embedded VP (or a constituent that contains it) is a member of the focus value of the matrix VP (or a constituent that contains it). It is enough just to look at the regular semantic value of the antecedent VP — which will necessarily be a part of the semantic value of any constituent that contains it — to see that this condition will never be satisfied:

(102) $\lambda x.x$ *visit the capital of* $g(1)$

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developed in Rooth 1992 and extended in Fox 1999a, though similar in spirit. Merchant proposes the licensing condition in (i), where 'e-GIVENness' is defined as in (ii).

(i) A VP α can be deleted only if α is e-GIVEN.

(ii) An expression E counts as e-GIVEN iff E has a salient antecedent A and, modulo $\exists$-type shifting,
   a. A entails F-clo(E) and
   b. E entails F-clo(A).

Here $\exists$-type shifting is an operation that raises expressions to type t and existentially binds unfilled arguments (e.g., the external argument of a VP), and the F-clo(sure) of an expression α is the result of replacing focused parts of α with existentially bound variables of the appropriate type.

If the analysis of Jacobson's pied-piping examples developed here is correct, then Merchant's licensing condition won't actually work. The problem is in the the second part of the licensing condition (ib): in general, it will not be the case that E will entail F-clo(A) when the internal argument of the elided VP is derived by applying a relational noun meaning to the corresponding argument of the antecedent, as shown schematically in (iii).

(iii) a. $\exists x \exists y[x \textit{ visit } y] \rightarrow \exists x \exists y \exists f \in D_{\langle e,e \rangle}[x \textit{ visit } f(y)]$
   b. $\exists x \exists y[x \textit{ visit } f(y)] \not\rightarrow \exists x \exists y[x \textit{ visit } y]$

More generally, since the definition of e-GIVENness always binds off free variables inside an elided constituent (see Merchant 2001, p. 26, fn. 9), this type of licensing condition will make the wrong predictions for the core cases of argument contained ellipsis as well.

The problem is that this VP contains the meaning of the reconstructed DP *the capital of g(1)*, and so will necessarily differ in meaning from any possible focus value based on a VP of the form *visit g(1)*. Appropriate contrast therefore fails, and ellipsis is correctly predicted to be impossible.

For exactly this reason, a Sag-Williams 'logical equivalence' analysis will also fail to account for these facts, since the reconstructed material will have the consequence that the elided and antecedent VPs in all of the pied-piping examples (with or without preposing) will fail to be semantically equivalent. In short, only in examples in which the elided VP is the one that contains the focused pied-piped material will we effectively be able to 'ignore' it for the purpose of licensing ellipsis, through the mechanisms involved in building alternative sets. We thus have yet another argument for adopting a Rooth-style analysis of ellipsis, and more specifically, the one proposed in Fox 1999a which relies only on a contrast condition, and not also on a lexical/syntactic identity condition. More generally, if the analysis presented here is correct, we have further confirmation of Merchant's (2001) claims that ellipsis is subject (only) to a semantic identity condition, not (also) to a syntactic identity condition.

6 Conclusion

Focusing on argument identity effects in ellipsis, I have argued for a semantic theory of the interpretation of variables in which assignment functions are partial, and binding involves adding new variable/value pairs to an assignment, rather than reassigning new values to (possibly previously used) variables. I further argued that the representation of binding structures crucially encodes binding indices on binders, rather than as adjuncts on their scope as in Heim and Kratzer 1998. Regarding the nature of ellipsis, I have shown that an analysis stated in terms of parallelism between constituents (potentially) larger than the elided phrases, as advocated originally in Rooth 1992 and further developed in Fox 1999a, is empirically superior to one that requires logical equivalence between elided and antecedent constituents. Finally, I have shown that the empirical coverage of the analysis developed here, which crucially relies on the semantic principles governing the assignment of values to variables, is broader than that of current accounts that assume a variable-free semantics.

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