Wide Scope *in situ*

Wolfgang Sternefeld, Universität Tübingen[*]

1. Overview

In this paper I will analyze specific opaque indefinite NPs as well as non-specific transparent indefinites in intensional contexts by proposing a semantic theory that interprets quantificational structures in situ, without recourse to LF operations. Assuming the usual tripartite quantificational structure consisting of a quantifier, a restriction, and the scope of the quantifier, I argue that the interpretation of the quantifier and the restriction are independent of each other in that the two can have different scopal options. Whereas a transparent interpretation of the restriction will be analyzed as presuppositional, potential wide scope of the quantifier is interpreted as scope independence. The latter concept is formalized in a way resembling a game theoretical interpretation of quantifiers.

The paper is organized as follows. Having introduced the tripartite structure of natural language quantification, we address some well-known data showing that the quantifier itself and its restriction can be interpreted independently from each other. We first concentrate on the restriction of the quantifier and its so-called value-loaded (transparent) interpretation, arguing that this interpretation is presuppositional in nature. We then turn to the wide scope of the quantifier itself. We propose a new formalization of the data, using the idea that wide scope is implemented in situ as scope

[*]*The first version of this paper was presented to the Graduiertenkolleg at the Johann Wolfgang Goethe Universität Frankfurt and at the University of Leipzig in November 2008, the present version was prepared for a talk at the University of Tübingen in November 2009. I would like to thank Magdalena Schwager, Cécile Meyer, Janina Radó, Ede Zimmermann, Oliver Bott, and Gerhard Jäger for useful discussions. Usual disclaimers apply.
Postscript January 2010: I would like to address the reader's attention to the following recent papers that I didn't have a chance to see early enough for discussion: First there is Magdalena Schwager's contribution to the SALT conference 2009; second, you should consult Zoltán Szabó's contribution to the proceedings of the 17th Amsterdam Colloquium in December 2009.

independence, which in turn is interpreted as lack of information about the current assignment function, ie. the function that assigns values to variables. Finally we discuss various applications of this mechanism, extending the framework from specific (world-independent) readings to other cases of scope independent interpretations of quantification.

2. Basic Assumptions and Data

Natural language quantification is assumed to exhibit a tripartite structure, consisting of a quantifier Q, the restriction of Q, and the scope of Q. This we will represent in the format shown in (1).

(1) $(Qx)[R :: p(x)]$

Here, x is a variable, the restriction of Q is a property R, and the scope of the quantifier is an open proposition with x occurring free in p. Note that we depart from the seemingly simpler scheme $Q[R :: P]$ (with R and P being properties) for reasons that will become apparent as the analysis unfolds.

Given (1), the standard semantics for universal and existential quantification can be stated as in (2), where $[\![\alpha]\!]^g_{I,w}$ denotes the extension of α with respect to an interpretation I, a possible world w, and a value assignment for variables g:

(2) a. $[\![(\forall x)[R :: p(x)]]\!]^g_{I,w} = 1$ iff for all $a \in [\![R]\!]^g_{I,w} : [\![p(x)]\!]^{g[x/a]}_{I,w} = 1.$

b. $[\![(\exists x)[R :: p(x)]]\!]^g_{I,w} = 1$ iff for some $a \in [\![R]\!]^g_{I,w} : [\![p(x)]\!]^{g[x/a]}_{I,w} = 1.$

Turning next to the data, various readings of (3) formalized in (3-a,b,c) are discussed in the literature.[1] Following the tradition of epistemic logic, where *John knows* is abbreviated as K_j, we use S as intensional operator for *suspect*. The various readings got different names in the literature, in particular, the de re/de dicto distinction is often used in connection with analogous readings for definite descriptions.[2]

(3) John suspects that a witch is after him

[1] Cf. Fodor (1970) and Ioup (1977) for earily discussions. The critical reading called "specific opaque" below is also attributed to Fodor and Ioup in the literature, but I find it hard to tell whether this reading is indeed the one intended by these authors.

[2] The term "referential de dicto" for the reading (3-c) suggests that the de dicto qualification refers to the restricting property rather than to the *res* talked about. I find this misleading, so I will try to avoid this terminology. There is a lot of terminological and conceptual confusion in the literature showing that a proper formalization is essential.

a. non-specific opaque reading: (non-referential (attributive) de dicto)
$S_j((\exists x)[\textbf{witch} :: \textbf{iah}(x)])$

b. specific transparent reading: (referential de re)
$(\exists x)[\textbf{witch} :: S_j(\textbf{iah}(x))]$

c. specific opaque reading: (referential de dicto)
$(\exists x)(S_j(\textbf{witch}(x) \wedge \textbf{iah}(x)))$

(3-a) is the unmarked narrow scope reading for the existential quantifier *a witch*; (3-b) is its usual wide scope reading. (3-c) represents a mixed reading in that there is still a specific entity or person with respect to which John suspects that she is a witch (who is after him). Note that the representation in (3-c) seems to contradict our assumptions about the tripartite structure of quantification in (1); due to the non-local relation between quantifier and restriction, this representation also militates against the theory of Generalized Quantifiers (GQ). We'll come back to this issue in section 5.

3. "Loaded" Interpretation of *R*

It has also been observed in the literature that there is a fourth reading:

(3) d. non-specific transparent reading: (non-referential de re)
$S_j((\exists x)[\textbf{witch-in-the-actual-world} :: \textbf{iah}(x)])$

In this reading it is John, rather than the speaker, who is responsible for ascribing to x the property *witch*.

In the context of definite descriptions, the transparent construal of the restriction has been called "value loaded" (cf. Barwise and Perry (1983)). It seems that such a loaded interpretation is available for all quantifiers alike; a nice example for value loaded universal quantification is (4), adopted from Bäuerle (1983).

(4) Georg glaubt, dass eine Stuttgarterin jeden VfB-Spieler liebt
George believes that a woman-from-Stuttgart every VfB-player loves

Bäuerle describes the intended reading as follows:

"Die Identifizierung dieser Herren als die Gesamtheit der VfB-Spieler stammt also von dem, der den Satz äußert, ist damit nicht selber Gegenstand des Glaubens und somit transparent" [Identifying these gentlemen as the totality of VfB-players (VfB = a soccer club) originates from the person who utters the sentence; thereby, it is not part of the belief and is therefore transparent.]

Here is a similar example from Zimmermann (p.c.):

(5) The antique dealer convinced the farmer that only very few of the highly valuable pieces were worth anything.

Again, the responsibility of ascribing the property "highly valuable pieces" is the speaker's, otherwise the farmer's conviction would be contradictory. The same transparency also licenses the following inference:

(6) a. John wants to marry Amy, Berta, or Carla
b. Amy, Berta, and Carla are sisters of mine
c. Therefore:
John wants to marry a sister of mine
(though he does not know them to be my sisters, and does not want them to be my sisters)

The value loaded interpretation has been analyzed as wide scope interpretation of the restriction, as shown in (7):

(7) a. $(\exists P)(P = \textbf{VFB-player} \wedge \textbf{believe}(g, \hat{}(\exists x)(\textbf{girl-from-S}(x) \wedge (\forall y)(P(y) \rightarrow \textbf{love}(x,y)))))$
b. $(\exists P)(P = \textbf{witch} \wedge \textbf{suspect}(j, \hat{}(\exists x)(P(x) \wedge \textbf{iah}(x))))$
c. $(\exists P)(P = \textbf{my-sister} \wedge \textbf{want}(j, \hat{}(\exists x)(P(x) \wedge \textbf{marry}(j,x))))$

Note that P is a variable of type $\langle e,t\rangle$ that rigidly denotes a certain set, whereas *witch* and *VfB-player* are constants of type $\langle e,t\rangle$ whose extensions may vary from world to world (cf. Montague (1973)). Moreover, (7) seems to require quantifying-in of the restriction, a syntactic operation that is often avoided in favor of introducing quantification over possible worlds in a Ty2 language (cf. Gallin (1975)). In Ty2, (7) can equivalently be expressed as:

(8) a. $\textbf{believe}(w, g, (\lambda w')(\exists x)(\textbf{girl-from-S}(w', x) \wedge (\forall y)(\textbf{VFB-player}(w, y) \rightarrow \textbf{love}(w', x, y))))$
b. $\textbf{suspect}(w, j, (\lambda w')(\exists x)(\textbf{witch}(w, x) \wedge \textbf{iah}(w', x)))$
c. $\textbf{want}(w, j, (\lambda w')(\exists x)(\textbf{my-sister}(w, x) \wedge \textbf{marry}(w', j, x)))$

The effect of value loading comes about by interpreting the restrictions *girl-from-Stuttgart*, *witch*, and *my-sister* not in the local world of evaluation w', but in the outermost world w, which is assumed to be the world of the utterance.

4. "Loading" is Presuppositional

Unfortunately, the analysis couched in Ty2 is a simplification. My objection is this: Loading R with the actual world seems too weak to capture the intended meaning. In the case of VfB-players, this reading implies that the speaker knows the extensions of the predicate *VfB-player*, but this does not follow from the above analysis. To see this, assume that the speaker knows what he is saying. If so, uttering (4) implies (9), with S representing the speaker:

(9) $K_S((\exists P)(P = \textbf{VfB-player} \wedge \ldots P \ldots))$

Here P may vary from world to world, it does not refer to the actual extension of *VfB-player*, and for this reason (9) does not express that the speaker knows something *about* this set (namely that this is the set of VfB-players). We actually want something stronger, which is expressed in (10):

(10) $(\exists P)(K_S(P = \textbf{VfB-player} \wedge \ldots P \ldots))$

Furthermore, the speaker also seems to presuppose that the extension of *VfB-player* is non-empty.

We thus have to deal with two presuppositions: familiarity with the extension and non-triviality. In Ty2, familiarity could be represented as in (11).

(11) $\textbf{know}(w, s, (\lambda w')(\textbf{VfB-player}(w) = \textbf{VfB-player}(w')))$

In intensional logic this reads as (12):

(12) $(\exists P)((\forall x)(P(x) \leftrightarrow \textbf{VfB-player}(x)) \wedge \textbf{know}(s, {}^\wedge[P = \textbf{VfB-player}]))$

The second presupposition is familiar from other contexts: value loading is meaningful only if the restriction is non-empty. Embedding these presuppositions into the truth conditions for the tripartite structure, we propose the following (where R is a constant whose extension varies from world to world):

(13) $[\![(\forall x)[R :: p(x)]]\!]^g_{I,w} = 1$ iff for all $a \in D$, $[\![p(x)]\!]^{g(x/a)}_{I,w} = 1$, where either

a. (opaque, default:) $D = [\![R]\!]^g_{I,w}$ or

b. (transparent, value loaded:) D is non-empty, $D = [\![R]\!]^g_{I,w_0}$ (with w_0 the actual world) and the proposition $\{w : D = [\![R]\!]^g_{I,w}\}$ is presupposed by the speaker.

Note that D varies in (13-a), depending on the world of evaluation, whereas D in (13-b) is constant, being uniquely determined by the actual extension of R. Moreover, the alternatives represent readings, so that it is necessary to stipulate that it is impossible to choose (13-a) when evalutating the expression for a world w, and choose (13-b) for an evaluation in w'. Technically, we would need two definitions and a disambiguating notation. For ease of comparison and in order to avoid redundancies, I leave matters as they are. The same remarks also apply to the definitions to follow.[3]

While givenness of an extension by "familiarity" seems to be a preferred option for transparent universal quantification,[4] it is less clear whether this also holds for the transparent interpretation of indefinites. It seems to me that it is not necessary for value loading to know the exact extension of the predicate. Rather, the following weaker statement seems to be sufficient to define truth and presupposition of the loaded interpretation:

(14) $[\![(\exists x)[R :: p(x)]]\!]^g_{I,w} = 1$ iff for some $a \in D$, $[\![p(x)]\!]^{g(x/a)}_{I,w} = 1$, where either
   a. (opaque, default:) $D = [\![R]\!]^g_{I,w}$ or
   b. (transparent, value loaded:) D is non-empty, and $d \in D$ iff the proposition $\{w : [\![R(x)]\!]^{g(x/d)}_{I,w}\}$ is presupposed by the speaker.

The value loaded reading of sentence (3) then implies that among the elements in D are those for which the speaker knows they are witches. This does not imply that the speaker knows the actual extension of *witch* because D could be a subset of witches. As for (6), D contains at least Amy, Berta, and Carla. The reading therefore does not imply that John wants to marry just someone (unspecifically), or that he wants to marry any sister of mine. On the other hand, as the only restriction on D is that it is not empty, there might only be one single individual in D, but in that extreme case the reading would no longer be called non-specific.

We might also consider several weaker readings. e.g. by replacing "iff" in (14-b) by "if". The set D would then effectively be determined by the possible values

---

[3] Note that in "ordinary" sentences like

(i) The woman loves every VfB-player

the speaker may also pick out a certain set which he characterizes as VfB-players. But this is not part of the unmarked reading of (i), which only says that if someone is an VfB-player, the woman loves him. Value loading in (i) would be possible (and perhaps be part of pragmatics, but it would not change truth conditions in (i). It does change truth conditions in the examples under discussion.

[4] Perhaps there are other ways of picking out a certain set and name it; some of these options are described below when we discuss the restriction of indefinite NPs.

for x in the relevant possible worlds that satisfy the scope of the quantifier. The essential property of these readings is that, in a sense, they are all about a particular set of alternative indiviuals, chosen as values for the existential in possible words, but having the property described by the restriction in the actual world.[5] Another much weaker construal could be paraphrased as: There is a certain property P such that John thinks that someone with this property is after him, and the extension of P in the actual world is the (actual) set of witches. This reading would no more be about individuals chosen in the attitude worlds, as the choice of an individual there is no more restricted by the actual set of witches.[6]

Due to the great variety of different construals and some disagreement and vagueness in the literature about which readings are possible, I will not pursue the matter any further. Rather, I will stick to (14-b) as an interesting relevant construal (one that, as far as I know, has not yet been formalized in the literature), but much of what is being said in what follows will also apply to these alternative construals.

(14-b) states that value loading is always induced *by the speaker*; this, however, does not hold in general, but seems to be due to the simplicity of our previous examples. So let's consider a more complicated case:

(15) John suspects that Mary believes that a witch is after her

Here is another value loaded reading which, for ease of exposition, is again approximated in Ty2:

(16) $\textbf{suspect}(w_0, j, (\lambda w)(\textbf{believe}(w, m, (\lambda w')((\exists x)(\textbf{witch}(w, x) \wedge \textbf{iah}(w', x))))))$

(16) makes it clear that the value loading is not imposed by the speaker; this follows since *witch* is not evaluated at w_0. Rather, value loading with w as shown in (16) suggests that we are considering x's such that *John* suspects them to be witches.

According to my intuitions, however, sentence (15) might also imply that John would *refer* to the values of x as witches, not that he *suspects* these to be witches. What is involved is a *referential presupposition* on John's part (cf. also Cresti (1995) and Romoli and Sudo (2008) for the presuppositional nature of value loading). On the other hand, consider

(17) John doubts that Mary believes that a witch is after her/him

[5] So these readings are in a sense "de re", but see fn. 2 above.

[6] In fact, such a reading would no more be "de res".

Isn't there also a reading where John doubts that whatever is believed to be after her/him is a witch? I must admit that my intuitions are shaky, but some of my colleagues convinced me that such a reading indeed exists (informants also found a difference in acceptability between *her* and *him*, which I must ignore). This amounts to saying that D is pragmatically determined either (a) by the "*referential* beliefs" (beliefs about certain *res*) of the speaker or (b) of previously mentioned holders of propositional attitudes, or (c) by the propositional attitudes and their bearers mentioned in the contexts that embed the quantifier. We therefore have to modify (14-b) by adding further alternatives for all these possible readings.

As a formal implementation we suggest the following. We interpret the restriction of a quantifier with respect to a context set C. This is a set of sets C_0, C_1, C_2 ... of disambiguations that will be built up during the evaluation of a formula. C_0 is the set of referential beliefs of the speaker, ie. a set of propositions presupposed by the speaker (Mary is a witch, Berta is a witch etc.), and initially C = $\{C_0\}$ Whenever we encounter a situation where we have to evaluate a propositional attitude, eg. *John doubts that p*, C can be enlarged and we interpret p with respect to a (potentially) larger set C'. There are two ways of enlarging C (by adding two new sets of propositions, possibly empty, if irrelevant for the further evaluation of p). We may add C_i as a set of "referential *beliefs*" of John's, and we may add C_j as a set of propositions John doubts (e.g. if he doubts that Mary is a witch). We now interpret the transparent construal with respect to one of those sets C_k:

(18) $[\![(\exists x)[R :: p(x)]]\!]^{g,C}_{I,w} = 1$ iff for some $a \in D$, $[\![p(x)]\!]^{g(x/a),C}_{I,w} = 1$, where either

a. (opaque, default:) $D = [\![R]\!]^{g,C}_{I,w}$ or

b. (transparent, value loaded:) D is non-empty, and for some $C_i \in C$, $d \in D$ iff the proposition $\{w : [\![R(x)]\!]^{g(x/d),C}_{I,w}\}$ is in C_i.

The construction of C is defined more formally in (19). Each time we evaluate a propositional attitude (with α as its subject) we may add to C either some of α's de re beliefs or some of the relevant attitudes (or both), depending on their potential usefulness in order to satisfy the presuppositions that might come up with the evaluation of p:

(19) $[\![\textbf{attitude-verb}(w, \alpha, p)]\!]^{g,C}_{I,S} = 1$ iff $\langle [\![\alpha]\!]^{g,C}_{I,S}, [\![p]\!]^{g,C'}_{I,S} \rangle \in I(\textbf{attitude-verb})(w)$ and C' is like C except for the possible difference that $C' = C \cup \{C_i\} \cup \{C_j\}$, where

a. $q \in C_i$ only if $\langle [\![\alpha]\!]^{g,C}_{I,S}, q \rangle \in I(\textbf{believe})(w)$, and

b. $q \in C_j$ only if $\langle [\![\alpha]\!]^{g,C}_{I,S}, q\rangle \in I(\textbf{attitude-verb})(w)$

5. Scope Independence

Having discussed the loaded reading, it remains to account for the specific readings where the existential quantifier has wide scope. As noted above, the wide scope opaque reading is problematic because it separates the quantifier from its restriction. I will now show that this reading can nonetheless be accounted for in a way that is consistent with an in situ interpretation of the quantifier (and therefore consistent with the tripartite structure of quantification). It is inconsistent, however, with the theory of Generalized Quantifiers.

In my view, this inconsistency is not a problem at all, because I never endorsed the theory of GQ: Not only have I always believed that the primitive quantifiers of natural language(s) can be counted on one hand—there simply is no need for a theory that accounts for nothing else than just the universal and the existential quantifier, plus perhaps the proportional *most* (with its diverging readings). GQs also exhibit the counterintuitive feature of not being quantifiers at all: they cannot bind variables and require a *syntactic* operation, namely quantifier raising (QR), which, in my view, is not independently motivated. The data considered here thus support and further strengthen my negative attitude against QR and GQs.

5.1 The Basic Idea: Wide Scope = Scope Independance

What I would like to propose instead is an in situ interpretation of scope independence the linguistic motivation of which can be traced back to Liu (1990) where wide scope is interpreted in situ as scope independence. Modifying the proposal slightly and applying it to the problem at hand, this means that the interpretation of an existential quantifier, namely the choice of a particular individual, does not depend on the current world of evaluation w, but on some world considered previously in the evaluation, for example the actual world of utterance, or the world John lives in in the specific opaque reading (3-c). Anticipating at this point, I also claim that the wide scope reading of (20-a), which I symbolize as in (20-b) (to be explained further below) should be analyzed as saying that the choice of a value for x does not depend on the choice of y (suggested by the notation $\exists x \backslash y$).

(20) a. every man loves a woman

b. $(\forall y)[\textbf{man} :: (\exists x\backslash y)[\textbf{woman} :: \textbf{love}(y, x)]]$

This choice (for x) cannot depend on the value for y or any (other) variable but rests on the speaker, implying that the restriction is loaded by the speaker's presuppositions, namely that the individual chosen is a woman. Scope independence uniformly holds across both types of variables (worlds and individuals), and in both types it gives the impression of apparent wide scope.

Before formally implementing scope independence, let us summarize our current assumptions:

- Seemingly wide scope (in specific or de re-readings) is to be analyzed as scope independence
- Scope independence can go along with a value loaded interpretation of the restriction
- As suggested by Liu (1990), scope independence can be formalized within decision theory or game theoretic semantics (cf. Hintikka und Saarinen (1979), but see below)
- The way this kind of semantics is implemented is "surface true" (no LF needed), hence compositional.[7]

5.2 Implementation

As in standard implementations of scope dependence we use value assignments for variables. At the point of evaluation of an existential quantifier such an assignment depends on the values previously chosen by the assignment function. Scope independence will now be implemented by blocking access to certain values of previous value assignments at the actual point of interpretation, resulting in a lack of information about recent parts of the assignments. Assignments therefore must be partial, and we follow the Heim and Kratzer (1998) style of incrementally building up (partial) value assignments for variables.

(21) A value assignment g is a finite sequence of pairs $\langle \alpha, \beta \rangle$ with α a variable and β the value of α.

[7] Strictly speaking, this is not correct, but not even the standard interpretation of predicate logic is compositional. As is standard practice, the denotations of the parts are relativized to assignments, but the interpretation of the quantifier requires the evaluation of *different* denotations, varying with the assignments. So it is not only one denotation of an expression that determines the denotation of the whole, thus rendering the computation of meaning non-compositional. Of course, there are ways to make such a system compositional by making value assignments part of the denotation, cf. Bennett (1979) (who refers back to Tarski and Vaught (1957)) or Sternefeld (2006), so we will not bother with compositionality any further.

Usually, it is assumed that if $\langle\alpha,\beta\rangle$ and $\langle\alpha,\gamma\rangle$ are in the sequence, then $\beta=\gamma$, ie. g is a function.[8]

In such a system, the standard interpretation of a quantifier is (22-b/c):

(22) a. $[\![\Psi]\!]_{I,w}$ is true in w iff $[\![\Psi]\!]^{\Lambda}_{I,w}$ = 1 with Λ being the empty assignment.

b. $[\![(\exists x)\Phi]\!]^{g}_{I,w}=1$ iff for some a, $[\![\Phi]\!]^{g+\langle x,a\rangle}_{I,w}$.

c. $[\![(\forall x)\Phi]\!]^{g}_{I,w}=1$ iff for all a, $[\![\Phi]\!]^{g+\langle x,a\rangle}_{I,w}$.

The notation $g+\langle x,a\rangle$ of course symbolizes the incremental growth of g.

We now reformulate (22-b) in terms of "choice functions" or "winning strategies", the latter term being perhaps a bit misleading because there is only one player in this game, namely the one that interprets the indefinite NP. We nonetheless use the terminology from game theory in order to avoid confusion with the choice functions in Reinhart (1997). We define:

(23) A winning strategy S is a function that assigns an individual β to a variable α and an assigment g.

Intuitively, S assigns a value to the variable on the basis of the information about previous value assigments for other variables encoded in g. The standard truth condition for existential quantification can then be reformulated as:

(24) $[\![(\exists x)\Phi]\!]^{g}_{I,w}=1$ iff there is an S such that $[\![\Phi]\!]^{g+\langle x,S(x,g)\rangle}_{I,S,w}$.

Note that S assigns a value to x on the basis of the previous "shorter" assignment g, whereas Φ is evaluated on the basis of the "longer" assignment that provides a value for x.

The next step is to introduce scope independence. This means that the choice made by S does not depend on the entire (but still finite or partial) g, but only on a subsequence of g.

(25) Let $g\backslash\alpha$ be the subsequence g' of g up to and excluding the first occurence of α.

Intuitively, the notation $(\exists x\backslash y)\Phi$ is intended to express that Φ is evaluated not with respect to $S(x,g)$ but $S(x,g\backslash y)$. In particular, $(\exists x\backslash w)\Phi$ will say that the choice of a value for x does not depend on the current evaluation world w. Given that

[8] Alternatively, we could stipulate that α may occur only once in the sequence, reducing sequences to ordinary sets. We will see later, however, that even if α occurs only once, the ordering in the sequence is important.

in complex situations we must have access to any world previously considered in an evaluation, we have to resort to Ty2 in order to express independence of world variables. Moreover, we assume that the translation algorithm uses "new variables" when embedding propositions (or quantifiers). This is required to avoid confusion of variables. Eg., if two existential NPs A and B are to have wide scope over C, then using identical variables for A and B would imply that S chooses the same individual for A and B, which is of course not intended and would not represent a possible reading.[9]

In the first clause of the recursive definition of truth we want to say that the matrix sentence is evaluated w.r.t. the actual word @ which, by convention, is the value of the variable w_0:

(26) $[\![\Phi]\!]_I$ is true in the actual world @ iff there is an S such that $[\![\Phi]\!]^{\{\langle w_0,@\rangle\}}_{I,S} = 1$ (ie. S and the initial assignment g that interprets the free world variable w_0 satisfy Φ with respect to the interpetation I).

The tripartite structure of universal quantification is interpreted as before:

(27) $[\![(\forall x)[R :: p(w,x)]]\!]^g_{I,S} = 1$ iff for all $a \in D$: $[\![p(w,x)]\!]^{g+\langle x,a\rangle}_{I,S} = 1$, where D is as in (13).

As for existential quantification, we now have to account for the scope independent construals. As above, we consider two cases: (a) the case where R is interpreted in situ, which is usually assaciated with the opaque reading of R, and (b) the one where R is value loaded. Both cases work the way as we already discussed in section 4:

(28) $[\![(\exists x\backslash\alpha)[R :: p(w,x)]]\!]^{g,C}_{I,S} = 1$ iff $S(x, g\backslash\alpha) \in D$, $[\![p(w,x)]\!]^{g+\langle x,S(x,g\backslash\alpha)\rangle,C}_{I,S} = 1$, where either

a. (opaque, default:) $D = [\![R]\!]^{g,C}_{I,w}$ or
b. (transparent, value loaded:) for some $C_i \in C$, the proposition $\{w : [\![R(x)]\!]^{g(x/S(x,g\backslash\alpha)),C}_{I,w}\}$ is in C_i.

(28) implies that we not only take into account the "referential beliefs" of a subject; examples like (29-a) (with stress on *witch*) might have a specific reading with *witch* being transparent with respect to Mary and opaque with respect to *doubt*; the reading is paraphrased in (29-b):

[9] This of course corresponds to the new variable restriction for indefinites in a Heimean file semantics, cf. Heim (1982).

(29) a. John doubts that Mary believes that a witch is after him
b. John doubts that it is a witch that Mary believes is after him.

6. Discussion

6.1 Scope Interaction

Consider:

(30) Everyone$_y$ believes$_{w_0}$ that$_w$ a$_x$ witch blighted their mares
…and if they ever find out who she is, they'll try to catch her (Ioup (1977))

The continuation with *she* is meant to guatantee that the reading is specific in that a$_x$ has wide scope over *believe*. But it still seems to be possible to get both wide and narrow scope for $\exists$ w.r.t. $\forall$, even if *witch* is interpreted as opaque, ie. in the scope of *that*$_w$.

A disambiguated simplified representation of these readings in Ty2 is (31):

(31) a. $(\forall y)\textbf{believe}(w_0, y, (\lambda w)(\exists x\backslash w)[\textbf{witch}_{default} :: \textbf{btm}(w, x)])$
b. $(\forall y)\textbf{believe}(w_0, y, (\lambda w)(\exists x\backslash y)[\textbf{witch}_{default} :: \textbf{btm}(w, x)])$

(31-a) says that every believer has a specific but possibly different person in mind that is supposed to be a witch haunting him, whereas (31-b) implies that this person is the same for any believer. Note that scope independence from y automatically induces independence from w, a matter to which we return immediately. That the formulas in (31), together with the conditions in (28), correctly yield specific opaque readings should be obvious.[10]

6.2 Percus' Problem

Theories that represent the loaded interpretation in Ty2 by simply chosing a different variable for the restriction seem to overgenerate if the choice of variables is totally free. For example, one can allow for (32-a) and (32-b), but (32-c) must be blocked:

(32) a. $(\lambda w)((\exists x)(\textbf{witch}(w, x) \wedge \textbf{iah}(w, x))$
b. $(\lambda w)((\exists x)(\textbf{witch}(w', x) \wedge \textbf{iah}(w, x))$
c. $(\lambda w)((\exists x)(\textbf{witch}(w, x) \wedge \textbf{iah}(w', x))$

[10] Ioup (1977) discusses a similar interaction, claiming that the reading she has in mind cannot be represented in first order logic. Unfortunately, I was not able to pin down what exactly her intuitions are, so there might be more involved here than can be captured by (31).

This problem, discussed in Percus (2000) and Romoli and Sudo (2008) does not come up in the present framework: loading is limited to the restriction of a quantifier, and this is directly implemented in the interpretation of the tripartite structure. No free choice of variables is permitted.

6.3 The Linear Scope Restriction

Next consider a ditransitive structure and the scope possibilities for *a book*:

(33) every$_x$ man bought every$_y$ girl a$_z$ book

a. Wide scope: $(\exists z\backslash x)(\textbf{book} :: \textbf{buy-for}(x, z, y))$
There is a certain book such that every man bought it for every girl

b. Intermediate scope: $(\exists z\backslash y)(\textbf{book} :: \textbf{buy-for}(x, z, y))$
For every man there is a book and he bought it for every girl

c. Narrow scope: $(\exists z)(\textbf{book} :: \textbf{buy-for}(x, z, y))$
For every man and girl there is a book he bought for her

d. "Mixed" scope:
For every girl there is a book such that every man bought it for her

The mixed scope can be generated by QR (May 1977) or by scope reversal in Categorial Grammar (Barker 2002). However, such a reading seems extremely difficult to construct; I therefore assume, contrary to the predictions of the theories mentioned above, that the mixed scope reading does not really exist and should therefore be excluded. This indeed follows from our theory: The mixed reading would result from leaving z scope-dependent on y but making it scope-independent from x. In the format chosen above, however, making z scope independent from x implies scope independence from y because y follows x in g and is therefore cut away by cutting away x. This built-in feature of the theory I dub the Linear Scope Restriction. The LSR blocks "mixed" readings.

The mixed reading could nonetheless be expressed by modifying the mechanism of "cutting away" in the obvious way. However, such a move would be questionable for independent reasons: A more liberal mechanism not obeying the LSR would also allow for so-called branching constructions. Branching, however, seems to me a logician's invention; following others, most recently Szymanik (2009), I claim that branching is non-existent in the grammar of natural language.

6.4 Reinhart's problem

As noted by Reinhart (1997) the specific reading of (34)

(34) If we invite a (certain) professor, John will be upset

cannot be expressed by simply giving wide scope to the existential quantifier:

(35) $\#(\exists x)((\textbf{invite}(\text{we}, x_0) \wedge \textbf{prof}(x)) \rightarrow \textbf{Jwbu})$

These truth conditions are too weak: as soon as a non-professor (Reinhart's Donald Duck) is invited, the sentence comes out true. In our own analysis, the specific reading could only be expressed by (36):

(36) $((\exists x \backslash w_0)(\textbf{Prof} :: \textbf{invite}(w_0, \text{we}, x)) \rightarrow \textbf{Jwbu}(w_0))$

It seems that we get the wrong result in case we interpret D as the default. On the other hand, S would now have to choose an individual for x and the empty assignment. The quesion then arises whether this should be admissible at all. If so, one might still impose the special condition that in this case the presuppositionally loaded interpretation (with respect to the speaker) is the only available reading. If not, the analysis of the conditional cannot be based on material implication. Material implication should indeed be replaced by a modal analysis. But in that case, scope independence is no problem, as the usual truth conditions make us evaluate the antecedent with respect to the closest possible worlds that render the antecendent *true*; so there is no way to get the implication true by looking at a false antecendent.

Unfortunately, however, Reinhart's problem rears its ugly head again in other downward entailing contexts:

(37) every woman who loves a (certain) professor will be unhappy

Again, a specific opaque reading yields the wrong truth conditions. We therefore need a revision of the above truth conditions, to the effect that every specific reading is in a sense presuppositional. This amounts to saying that formally there is no in situ interpretation of the restriction.

6.5 Specific Readings are Presuppositional

We must conclude, therefore, that the specific reading is always one that does not allow for a simple in situ interpretation of the restriction. What does this imply for the bona fide cases of opaque readings? Consider:

(38) John doubts that a witch is after him.

Let us assume the reading is specific, and the restriction is not interpreted by the speaker. Then it is John who might have doubts concerning the witchhood of the person he thinks is after him. But now consider:

(39) John doubts that every man who met a (certain) witch will be unhappy

This approximately translates as:

(40) John doubts $\lambda w(\forall x)[(\lambda z)(\mathbf{man}(w,z) \wedge (\exists y\backslash x)[\mathbf{witch} :: \mathbf{met}(w,z,y)]) :: \mathbf{unhappy}(w,x)]$

The predicate *witch* in (40) seems to allow for the following disambiguations:

(41) a. John believes that there is a witch and he doubts that every man who met her will be unhappy
b. John believes that there is a certain entity of which he doubts that it is a witch and he doubts that every man who met her will be unhappy

(41-b) seems a little bit strange, but doubts concerning the witchcraft of a certain person are of course possible when considering yet another reading of (39):

(42) John believes that there is a certain entity of which he doubts that it is a witch but he does not doubt that every man who met her will be unhappy

All these readings have in common that the restriction is interpreted in a way already proposed in (28) where the individual chosen by S is a witch either in John's belief worlds as in (41-a) or in the worlds compatible with what he doubts, as in (41-b) and (42). That is, the individual chosen by S must in fact be one that is a witch in any of the C_i's that disambiguate the sentence. In other words, the reading called transparent in (28-b) is not necessarily "transparent" (I apologize for this terminological hardship), since the attitude verb we consider might be the one that immediately embeds the indefinite. In case of upward entailing contexts, the value loading is almost equivalent to the opaque reading, but here it is not: in the peculiar kind of "reading" (which is generated as one of the combinatory options the system allows for), it is presupposed that John doubts that a certain individual is a witch, and in (41-b) it is asserted that John doubts that every man who met her will be unhappy.

The more natural reading (42) should also be accounted for, but here the problem is orthogonal to the one at hand. In order to grasp the difference between this reading and the ones discussed hitherto, compare (42) with the reading of (43) with heavy stress on *him*:

(43) John doubts that a witch is after HIM

The preferred reading of (43) is one in which John does not doubt that a witch is after someone else, he only doubts that he himself is chased. The additional problem is that attitudes are focus sensitive—a topic beyond the scope of the present article.

In general, then, we propose that the specific reading is always value loaded. Strictly speaking there is no normal (opaque in situ) interpretation of the restriction, as already evidenced by Reinhart's Donald Duck example. Formally, this observation leads to the following update:

(44) *Revision of (28):*
Clause (28-a) must be dropped from the definition of $(\exists x \backslash \alpha)$ in (28).

Summarizing so far, I think that specific readings always imply some pragmatically determined variation for the interpretation of the restriction; this can depend either on the speaker's referential beliefs or the subject's beliefs or their attitudes under consideration. As the same variability for interpreting the restriction was observed for the in situ interpretations of quantifiers, the general pattern is that the interpretations of the quantifiers and the restrictions are in fact logically independent, thus corroborating the thesis that the Theory of Generalized Quantifiers is on the wrong track.

7. Further Applications

Note that the format of tripartite quantification in (1) is asymmetric: The quantifier does not relate two properties, but rather binds a variable in an open proposition. This asymmetry is not accidental; it reflects my general conviction that quantifiers in NL correspond to real quantifiers in logic, and that the scope of a quantifier is an open proposition. As discussed in extenso in Sternefeld (2006) Vol. 2, I assume that NL-predicates correspond to open propositions rather than to complicated "Curried" functions. Such predicates contain "pointers" (the free variables) that link to a position in the syntactic tree where the respective variable must be bound. The pointers correspond to occurrences of theta roles; they form theta grids that are projected and "discharged" in the syntactic tree. Moreover, the system can be implemented compositionally by making variable assignments (or pointers) part of the ontology, as discussed in Sternefeld (2001). As a result, binding does not rely on QR, and there is no reason to resort to otherwise unmotivated syntactic operations. This works because NL quantifiers are real quantifiers, rather than relations between sets. That the latter is false has just been demonstrated: there's no way in such a theory to get wide scope for the quantifier without also getting wide scope for the restriction.

Another property of the system is that S-functions, although they could be built up incrementally (as is the case with value assignments g), are still global in that the information encoded in S is available at any stage of the computation. This makes it possible to evaluate pronouns quasi dynamically, as in (45):

(45) Every$_x$ man loves a$_{y\backslash x}$ woman. She$_y$ is pretty

When encountering *she*$_y$, S provides a unique value for y so that the pronoun can be interpreted properly. If *a woman* is interpreted scope dependently, no unique value exists, and anaphora is ungrammatical. This is of course as one would expect.

A more interesting application would be so called Hob-Nob-anaphora discussed extensively in Haas-Spohn (1995):

(46) Hob believes that$_w$ a witch is after him and Nob suspects that$_w$ she might kill him

In our previous definitions, we used the global function S only for interpreting scope independent construals. If we extend the use of S also to certain cases of "ordinary" (scope-dependent) quantification, we might overrule the above restrictions on the use of new variables and choose the same variable w for both intensional contexts **believe**$(w_0, h, \lambda w \ldots)$ and **suspect**$(w_0, n, \lambda w \ldots)$. This implies that S interprets *she* across intensional contexts so that the individuals chosen in the believe contexts are the same as that in the suspect context. Whether this line of thought is feasible is left to further research; one of the reasons I did not interpret ordinary quantification via S is that I wanted to avoid technical complications that arise with existentials having narrow scope with respect to negation. Specific readings as discussed here always scope over negation, and that's what the function S also does.

8. Summary

We finally summarize the motivation for designing the structure of quantification as we did by embedding the present approach into a broader program that comprises the following thesis:

- There is no QR for quantifiers in object position (quantifiers bind variables in open propositions)
- There is no QR for binding pronouns (quantifiers are quantifiers rather than second order relations)
- Since all verbs have the same logical type, namely that of open propositions, operators like verb negation, which tends to occur as close to

the verb as possible in German, can retain their simple proposition-negating semantics (without enforcing otherwise unmotivated “pseudo-scrambing” operations)
- There is no need for choice functions à la Reinhart (1997)
- There is no movement of the restriction or of the quantifier, everything is interpreted in situ
- There are no special locality restrictions that block mixed readings
- There are no further syntactic constraints for the use of world variables, as have been proposed in Percus (2000).

Hence, the picture developed here differs in many details from that described in Romoli and Sudo (2008), and it was precisely this difference that prompted the present paper.

Apart from that, however, the general program outlined above has nothing to say about an in situ interpretation of the surface form $\exists\forall$ when the universal quantifier seemingly gains wide scope over the existential quantifier. I claim that at least in German such a reading is available only in certain contexts that allow the indefinite to be “located” in some way, preferably in time and space as is normally the case with inversed linking. For me, such an inverted reading is impossible in simple sentences like *a man loves every woman* (ie. its German equivalent). It might come into reach only when $\forall$ can quantify (post festum) over contexts like place and time. An in situ treatment of such constructions is left to future research.

References

Barker, C. (2002). Continuations and the Nature of Quantification. *Natural Language Semantics* 10. 211–242.

Bäuerle, R. (1983). Pragmatisch-Semantische Aspekte der NP-Interpretation. In: M. Faust (ed.) *Allgemeine Sprachwissenschaft, Sprachtypologie und Textlinguistik: Festschrift für Peter Hartmann*. Tübingen: Narr. 121–131.

Bennett, M. (1979). Questions in Montague Grammar. Mimeo. Indiana University Linguistics Club.

Cresti, D. (1995). Extraction and Reconstruction. *Natural Language Semantics* 3. 79–122.

Fodor, J. (1979). *The Linguistic Description of Opaque Contexts*. Ph.D. thesis. MIT, Cambridge.

Gallin, D. (1975). *Intensional and Higher-Order Modal Logic*. Amsterdam: North-Holland.

Haas-Spohn, U. (1995). *Versteckte Indexikalität und subjektive Bedeutung*. Berlin: Akademie Verlag.

Heim, I. (1982). *The Semantics of Definite and Indefinite Noun Phrases*. Ph.D. thesis. University of Massachusetts, Amherst. Published by Garland, New York.

Heim, I. & A. Kratzer (1998). *Semantics in Generative Grammar*. Malden, Mass.: Blackwell.

Hintikka, J. & E. Saarinen (1979). *Game Theoretical Semantics*. Dordrecht: Reidel.

Ioup, G. (1977). Specificity and the Interpretation of Quantifiers. *Linguistics and Philosopy* 1. 233–245.

May, R. (1977). *The Grammar of Quantification*. Ph.D. thesis. MIT, Cambridge, Mass.

Montague, R. (1973). The Proper Treatment of Quantification in Ordinary English. In: J. Hintikka & P. Suppes (eds.) *Approaches to Natural Language: Proceedings of the 1970 Stanford Workshop on Grammar and Semantics*. Dordrecht: Reidel. 221–242.

Percus, O. (2000). Constraints on Some Other Variables in Syntax. *Natural Language Semantics* 8. 173–229.

Reinhart, T. (1997). Quantifier Scope: How Labor is Divided Between QR and Choice Functions. *Linguistics & Philosophy* 20. 335–397.

Romoli, J. & Y. Sudo (2008). De Re/De Dicto Ambiguity and Presupposition Projection. Sinn und Bedeutung, September 30, 2008.

Saarinen, E. (1979). *Essays in Honour of Jaakko Hintikka*. Dordrecht: Reidel.

Schwager, M. (t.a.). Speaking of Qualities. In: *Proceedings from Semantics and Linguistic Theory (SALT) 19*. Ithaca, NY: CLC Publications.

Sternefeld, W. (2001). Semantic vs. Syntactic Reconstruction. In: C. Rohrer, A. Roßdeutscher, & H. Kamp (eds.) *Linguistic Form and its Computation*. Stanford, CA: CSLI Publications. 145–182.

Sternefeld, W. (2006). *Syntax. Eine morphologisch motivierte generative Beschreibung des Deutschen. Band 2*. Tübingen: Stauffenburg Verlag.

Szabó, Z. (t.a.). Specific, Yet Opaque. In: *Proceedings of The 17th Amsterdam Colloqium*. Berlin: Springer. (Lecture Notes in Computer Science).

Szymanik, J. (2009). *Quantifiers in Time and Space*. Amsterdam: ILLC Publications.

Tarski, A. & R. L. Vaught (1957). Arithmetical Extensions of Relational Systems. *Compositio Mathematica* 12. 81–102.