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Movement, Variables and Hamblin Alternatives

Marc Novel
Fachbereich Sprachwissenschaft
Universität Konstanz
Marc.Novel@uni-konstanz.de

Maribel Romero
Fachbereich Sprachwissenschaft
Universität Konstanz
Maribel.Romero@uni-konstanz.de

Abstract

Sets of Hamblin alternatives are often used side by side syntactic movement and variable binding. Shan (2004) shows that previous attempts at defining a Predicate Abstraction rule for variable binding while using sets of alternatives face serious problems: they overgenerate alternatives and/or are incapable of handling binding into a *wh*-phrase. This paper provides a solution by assuming Poesio's (1996) general type $\langle\langle a,\tau\rangle,t\rangle$ and by borrowing and extending Rullmann and Beck's (1997) treatment of *wh*-phrases as definites.

1 Introduction

Hamblin (1973) introduced sets of alternatives into Montague Grammar to treat *wh*-phrases in questions. Sets of alternatives have been later used by Rooth (1985) to model focus. Hagstrom (1998) and Shimoyama (2006) use alternatives for quantified expressions in Japanese. Kratzer and Shimoyama (2002) account for German free choice indefinites using Hamblin alternatives, and their approach has been adopted for further languages. In all these analyses, alternatives are employed as a kind of scoping mechanism carried out purely in the semantics.

By introducing sets of alternatives into the grammar, it is generally assumed that Hamblin alternatives operate side by side other scoping devices, such as syntactic movement with subsequent variable binding of movement traces and pronouns. Despite this, the literature dealing with sets of alternatives has struggled to make variables and alternatives work together. The difficulty encountered was to formulate an adequate Predicate Abstraction rule (PA) able to bind variables inside the set of alternatives. Solutions to this problem have been proposed by Poesio (1996), Hagstrom (1998) and Kratzer and Shimoyama (2002). However, Shan (2004) shows that all these solutions are inadequate to deal with sets of alternatives. Hagstrom's (1998) and Kratzer and Shimoyama's (2002) PA-rule generate unwanted readings, while the PA-rule provided by Poesio (1996) is not able to deal with cases where the binder of the variables is intuitively outside the set of alternatives. Shan concludes that it is not possible to formulate an adequate PA-rule for variable binding with alternatives. His proposal is to abandon variables altogether by using Variable Free Semantics (Jacobson, 1999) instead. The goal of the present paper is to present a way to circumvent Shan's problems and thus make sets of alternatives compatible with syntactic movement and variable binding.

2 Two Ways of Scope Taking and their Empirical Motivation

A scoping technique standardly assumed in the syntactic and formal semantic literature (Montague, 1974; May, 1985; Heim and Kratzer, 1998) is overt / covert syntactic movement, by which a constituent is displaced to a higher position in the tree leaving a co-indexed trace in the original position. This is exemplified in (1) for overt *wh*-movement and in (2) for covert Quantifier Raising (QR) at LF. Crucially, the relation between a displaced constituent and its trace is subject to locality constrains (Ross, 1967): *wh*-phrases, for example, cannot overtly move outside syntactic islands such as complex Noun Phrases (NPs) and adjunct clauses, witness (3)-(4):

(1) What$_i$ did Sue eat t$_i$?

(2) a. Alice saw nobody.
b. LF: Nobody$_i$ Alice saw t$_i$.

(3) *Who$_i$ did Taro eat the rice cakes that t$_i$ bought?

(4) *Who$_i$ did Taro leave because t$_i$ came?

A second scoping mechanism seems to be at play in Japanese. In this language, interrogative and quantifier phrases are built using indeterminate phrases like (5) and associating them with particles such as *-ka* or *-mo*. Depending on which particle is associated, a different interpretation is derived: *-mo* gives rise to a universal reading of the indeterminate phrase and *-ka* produces an interrogative or existential interpretation.

(5) a. dare 'who'
b. nani 'what'
c. dore 'which (one)'
d. dono 'which' (Det)

The particle can associate with the indeterminate phrase non-locally. Interestingly, this non-local association can cross an island boundary, as the grammaticality of (6)-(7) shows. But non-local association fails if another *-'ka'/-'mo'* particle intervenes, as shown by the unavailability of reading (8-c) (Shimoyama, 2001). The conditions on non-local association are summarized in (9-b).

(6) Taro-wa [[dare-ga katta] mochi]-o tabemasita ka?
Taro-Top who-NOM bought rice cake-ACC ate Q
'Who$_x$ did Taro eat rice cakes that x bought?'

(7) Taro-wa [[dare-ga kita-kara] kaerimasita ka?
Taro-TOP who-NOM came-because left Q
'Who$_x$ did Taro leave because x came?'

(8) a. Yoko-wa [[Taro-ga nan-nen-ni nani-nituite kaita ronbun]-mo yuu-datta ka]
Yoko-Top [[Taro-Nom what-year-in what-about wrote paper]-MO A-was Q]
siritagatteiru.
want to know
b. **Available reading:** 'Yoko wonders whether for every topic x, every year y, the paper that Taro wrote on x in y got an A.'
c. **Impossible reading:** 'Yoko wonders for which year y, for every topic x, the paper that Taro wrote on x in y got an A.'

(9) a. [. . . [. . . indeterminate . . .] CNP/Adjunct . . .] -ka/mo

association

b. *[. . . [. . . indeterminate . . .] -ka/mo . . .] -ka/mo

association

Kratzer and Shimoyama (2002) and Shimoyama (2006) develop an approach to deal with the Japanese facts. They claim that the association between the indeterminate phrase and its operator is not of syntactic nature, as it is less constrained. They use Hamblin alternatives as a scope taking device instead: indeterminate pronouns induce Hamblin alternatives, which then are passed up the tree until they meet a *-ka* / *-mo* operator. From this point on, all the alternatives are "bound" and a scopal effect is achieved. This scope taking device does not rely on any syntactic movement, as there are no indexed chains involved, and it is therefore not subject to syntactic constraints. This is sketched in (10). However, the alternatives arising from different indeterminate phrases are passed up *together* and become *all* "bound" when they encounter the closest c-commanding operator. This gives rise to a new locality condition that prohibits any other *-ka* / *-mo* operator to intervene: (11).

(10) [Op [wh Island wh]

(11) Op_1 [Op_2 [wh . . . wh]

Thus, (at least) two empirical patterns of scope taking can be found: one is sensitive to syntactic islands[1], whereas the other is immune to them but cannot skip a "binder". The first pattern is usually modeled using syntactic movement and variable binding of the trace; the second is straightforwardly accounted for using Hamblin alternatives. Other constructions for which sets of alternatives have been used as scoping device are in situ *wh*-phrases in English, focus (Rooth, 1985) and free choice indefinites (Kratzer and Shimoyama, 2002). As the two scoping patterns can co-exist in the same language (e.g. QR and focus alternatives in English), the question arises, how the two mechanisms can be combined.

In the rest of the paper, we will use English sentences for semantic derivations, assuming for simplicity that the relevant items are interpreted using the two scoping mechanisms. If some of these assumptions are questionable for English (e.g. a given *wh*-phrase is analysed in situ using alternatives rather than as undergoing syntactic movement, as in (16) below), the reader should feel free to map the structure to some other language and draw the same conclusions. The point of the paper, which is a formal one, remains.

3 Semantics of Quantifer Raising and Hamblin Alternatives

3.1 The semantics of syntactic movement: Quantifier Raising

As we saw, in QR, the quantificational DP is moved into the higher specifier position where it can take proper scope, leaving behind a trace and having its own index of movement rebracketed as λi:

[1]See Richards (1997) for *wh*-movement and islands crosslinguistically.

(12) a. Alice saw nobody   b. Nobody λ_i saw Alice t_i

On the semantic side, the trace will be interpreted as a pronoun. The denotation of the trace $[\![t_i]\!]^{M,g}$ is $g(i)$, as usual: (14-a). The two other expressions *Alice* and *saw* in this sentence are not dependent on the assignment g and are interpreted as in (14-b)-(14-c). The denotation of *saw* is then combined with that of the trace and of *Alice* via function application, giving us (14-d). The PA-rule (13) interpretes the numerical λ-abstract and binds the variable, as in (14-e). Finally, the quantifier applies: (14-f).

(13) Predicate-Abstraction Rule:

$$\lambda x.\ [\![\beta]\!]^{M,g^{x/i}} :: \langle e,\tau\rangle$$

$$\lambda_i \qquad [\![\beta]\!]^{M,g} :: \tau$$

(14) a. $[\![t_i]\!]^{M,g} = g(i)$
b. $[\![saw\ ]\!]^{M,g} = \lambda x \lambda y.y$ saw x
c. $[\![Alice]\!]^{M,g}$ = Alice
d. $[\![Alice\ saw\ t_i]\!]^{M,g}$ = 1 iff Alice saw g(i)
e. $[\![\lambda_i\ Alice\ saw\ t_i]\!]^{M,g} = \lambda x.$ Alice saw $g^{x/i}(i)$
$= \lambda x.$ Alice saw x
f. $[\![Alice\ saw\ nobody]\!]^{M,g}$
= 1 iff $\neg\exists x[$ Alice saw $x]$

3.2 Hamblin Alternatives

In Hamblin (1973), *wh*-expressions denote sets of alternatives. Non-*wh*-words also denote sets, but only singleton sets. So, consequently, proper names now denote sets of individuals, predicates denote sets of relations and sentences denote sets of propositions. This means, following Hamblin's (1973), that every former denotation is enriched to a set of denotations of that type. From a type theoretical point of view, an expression of an arbitrary type τ is enriched to $\langle\tau,t\rangle$.

Additionally, the Functional Application (FA) rule is modified in order to be able to deal with sets. When using Hamblin alternatives, a predicate does not only encounter a single argument, but a set of arguments. The new FA-rule (15) makes every predicate in one set apply to every argument in the other set.

(15) Hamblin Functional Application:

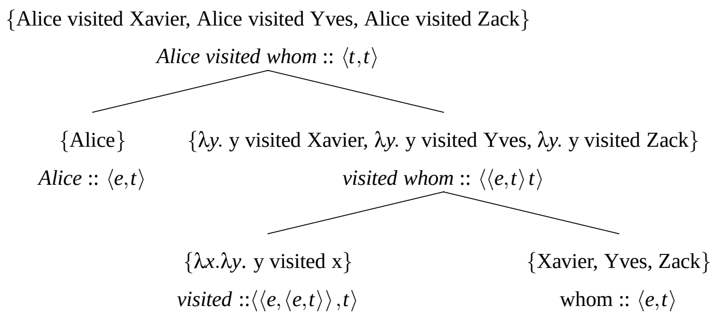
$$\left\{ f(x) : f \in [\![\beta]\!]^{M,g} \ \wedge\ x \in [\![\gamma]\!]^{M,g} \right\}$$
$$\langle\tau,t\rangle$$

$$[\![\beta]\!]^{M,g} \qquad [\![\gamma]\!]^{M,g}$$
$$\langle\langle\sigma,\tau\rangle,t\rangle \qquad \langle\sigma,t\rangle$$

The bottom-up computation of (16) (with the *wh*-phrase interpreted in situ) looks as follows:

(16) Alice visited whom
a. LF: Alice visited whom$_{in-situ}$

b.



4 Shan's Puzzle: Combining Sets of Alternatives with Variables

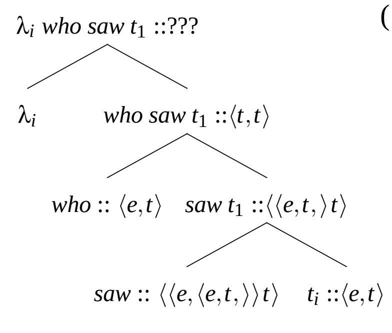
Shan (2004) claims that we end up with a problem as soon as we combine movement and variable binding with sets of alternatives. He argues that it is not possible to provide a PA-rule that is able to deal adequately with sets of alternatives. To localize the problem, it is decidedly the best to demonstrate what happens just up to the point where we need to formulate the PA-rule.

Consider (17), with the *wh*-phrase in base position and *nobody* moved by QR. In the semantics, since we are dealing here with sets of alternatives, every expression of an arbitrary type τ is enriched to the type $\langle \tau, t \rangle$, as shown in (18). The bottom-up composition up to the λ-abstract proceeds as in (19):

(17) a. Who saw nobody

b. LF: nobody λ_i [who$_{\text{in-situ}}$ saw t_i]
QR

(18)



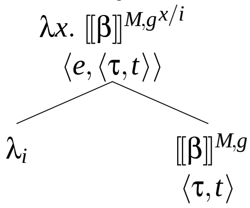
(19) a. $[\![t_i]\!]^{M,g} = \{g(i)\}$
b. $[\![saw]\!]^{M,g} = \{\lambda x.\lambda y.y \text{ saw } x\}$
c. $[\![saw\ t_i]\!]^{M,g} = \{\lambda y.y \text{ saw g(i)}\}$
d. $[\![who]\!]^{M,g} = \{\text{Alice, Barbara, Caroll}\}$
e. $[\![who\ saw\ t_i]\!]^{M,g} =$
$\{\text{Alice saw } g(i), \text{Barbara saw } g(i), \text{Caroll saw } g(i)\}$

f. $[\![\lambda_i\ who\ saw\ t_i]\!]^{M,g} = ???$

The task now is to formulate a PA-rule which takes the set (19-e) of open propositions – due to unbound *i*-variables – and returns an object after the *i*-variables are bound.

A first, naive attempt would be to formulate a PA-rule by abstracting over the set of alternatives. Basically, this PA-rule takes the set of propositions and applies the λ-operator in front of it:

(20) The First Try: A Naive PA-Rule



By applying just the λ-operator in front, we end up with a function into sets, with type $\langle e \langle \tau, t\rangle\rangle$, as in (21). But this is, of course, the wrong type. In order for the quantifier $[\![nobody]\!]^{M,g}$ in (22) to properly combine via Hamblin Functional Application (15), its sister should be a set of $\langle e,t\rangle$-properties. This means that the correct PA-rule should apply the λ-operation to each member of the set of alternatives and produce a set of functions, type $\langle\langle e,\tau\rangle, t\rangle$, as in (23).

(21) $\lambda x. \left\{\text{Alice saw } g^{x/i}(i),\ \text{Barbara saw } g^{x/i}(i),\ \text{Caroll saw } g^{x/i}(i)\right\}$

(22) $[\![nobody]\!]^{M,g} = \left\{\lambda Q_{\langle e,t\rangle}.\neg\exists x[Q(x)]\right\}$

(23) $\left\{\lambda x.\ \text{Alice saw } g^{x/i}(i),\ \ \lambda x.\ \text{Barbara saw } g^{x/i}(i),\ \ \lambda x.\ \text{Caroll saw } g^{x/i}(i)\right\}$

Hence, we end up with a type clash, as the different types do not fit. In such a situtation, a natural solution is to apply a type-shifting rule from type $\langle e \langle \tau, t\rangle\rangle$ into type $\langle\langle e,\tau\rangle, t\rangle$. Such an operation means that we transpose from a function into sets (type $\langle e \langle \tau, t\rangle\rangle$) into a set of functions (type $\langle\langle e,\tau\rangle, t\rangle$). Such a type-shifting rule can be defined, witness (24), but one needs to bear the following caveat in mind. As Shan notes, a function into sets carries less information with respect to ordering compared to a set of functions. As the reader can verify for herself, if we transpose from a function into sets into a set of functions via (24), the resulting set will contain uniform $\langle e,t\rangle$-functions like "to be seen by Alice", "to be seen by Barbara" and "to be seen by Caroll" in (25), but also non-uniform $\langle e,t\rangle$-functions like the ones in (26), which have different values for the subject:

(24) $\lambda Q_{\langle e,\langle \tau,t\rangle\rangle}.\left\{f_{\langle e,\tau\rangle} : \forall x_e.\, f(x) \in Q(x)\right\}$

(25) Uniform properties:

$$\left\{\begin{bmatrix} x_1 \mapsto \text{Alice saw } x_1 \\ x_2 \mapsto \text{Alice saw } x_2 \\ x_3 \mapsto \text{Alice saw } x_3 \end{bmatrix}\begin{bmatrix} x_1 \mapsto \text{Barbara saw } x_1 \\ x_2 \mapsto \text{Barbara saw } x_2 \\ x_3 \mapsto \text{Barbara saw } x_3 \end{bmatrix}\begin{bmatrix} x_1 \mapsto \text{Caroll saw } x_1 \\ x_2 \mapsto \text{Caroll saw } x_2 \\ x_3 \mapsto \text{Caroll saw } x_3 \end{bmatrix}\right\}$$

(26) Non-uniform properties:

$$\left\{\begin{bmatrix} x_1 \mapsto \text{Alice saw } x_1 \\ x_2 \mapsto \text{Caroll saw } x_2 \\ x_3 \mapsto \text{Barbara saw } x_3 \end{bmatrix}\begin{bmatrix} x_1 \mapsto \text{Alice saw } x_1 \\ x_2 \mapsto \text{Barbara saw } x_2 \\ x_3 \mapsto \text{Caroll saw } x_3 \end{bmatrix}\begin{bmatrix} x_1 \mapsto \text{Caroll saw } x_1 \\ x_2 \mapsto \text{Barbara saw } x_2 \\ x_3 \mapsto \text{Alice saw } x_3 \end{bmatrix}\right\}$$

4.1 Hagstrom and Kratzer & Shimoyama

In the literature, a PA-rule where transposing is included can be found in Hagstrom (1998) and Kratzer and Shimoyama (2002):

(27) PA-Rule by Hagstrom and Kratzer & Shimoyama:

$$\left\{ f_{\langle e,\tau\rangle} : \forall x_e.\, f(x) \in [\![\beta]\!]^{M,g^{x/i}} \right\}$$
$$\langle\langle e,\tau\rangle, t\rangle$$

λ_i $\quad$ $[\![\beta]\!]^{M,g}$ $\langle\tau,t\rangle$

This rule is able to apply the λ-operator to each member of the set of alternatives and, as the reader can verify, it produces a set containing uniform functions as well as non-uniform functions. Shan (2004) shows that including non-uniform functions leads to an empirical problem, which we will call Problem 1: non-uniform functions generate unwanted FF and pair-list readings. Consider, for example, (28). If Alice is x_1's mother, Caroll is x_2's mother and Barbara is x_3's mother, then the leftmost function depicted in (26) would predict the functional answer (28-a) to be acceptable, contrary to fact. Similarly, if x_1 is Xavier, x_2 is Yves and x_3 is Zack, then that same function would predict the pair-list answer in (28-b) to be felicitous, contrary to fact.[2]

(28) Who saw nobody$_i$?

a. #His$_i$ mother saw nobody$_i$ / Nobody$_i$ was seen by his$_i$ mother.

b. #Alice didn't see Xavier, Caroll didn't see Yves, and Barbara didn't see Zack.

4.2 Poesio's Approach

So far we have treated the variable assignment g as a parameter on the interpretation function $[\![.]\!]^{M,g}$ It is also possible to treat the assignment as part of the denotation (Groenendijk and Stokhof, 1991; Heim, 1982). Here the denotation of an expression is a function from assignments to the original denotation, so that an expression of type τ when evaluated under g is now treated as $\langle a,\tau\rangle$, where a is the type of variable assignments. A trace t_i denotes the function of type $\langle a,e\rangle$ mapping each assignment g to the individual $g(i)$: (29). A constituent with no unbound index, like the verb *saw* in (30), denotes a constant function.

(29) $t_i :: \langle a,e\rangle$
$$\begin{bmatrix} g_1 \mapsto g_1(i) \\ g_2 \mapsto g_2(i) \\ g_3 \mapsto g_3(i) \end{bmatrix}$$

(30) *saw* $:: \langle a,\langle e,\langle e,t\rangle\rangle\rangle$
$$\begin{bmatrix} g_1 \mapsto \lambda x.\lambda y.\text{y saw x} \\ g_2 \mapsto \lambda x.\lambda y.\text{y saw x} \\ g_3 \mapsto \lambda x.\lambda y.\text{y saw x} \end{bmatrix}$$

Poesio (1996) proposes that, when using set of alternatives, we use assignment-sensitive denotations like the ones above. This way, it is possible to make assignments part of each element of the set of alternatives. That is, it is possible to have the general type $\langle\langle a,\tau\rangle, t\rangle$ with the set layer as the outermost and the assignment layer inside. With this general type template, the Funtional Application rule (31) is used and the PA-rule (32) can be defined:

[2] Kratzer & Shimoyama (2002) are aware that their PA-rule produces a larger set of alternatives than expected, but they do not realize that this problematic.

(31) Assignment-sensitive FA-rule:

$$\{\lambda g. f(g)(x(g)) : f \in [\![\beta]\!]^M \wedge x \in [\![\gamma]\!]^M\}$$
$$\langle\langle a, \tau, \rangle\, t\rangle$$

$[\![\beta]\!]^M$ $\langle\langle a, \langle\sigma, \tau, \rangle\rangle\, t\rangle$ — $[\![\gamma]\!]^M$ $\langle\langle a, \sigma, \rangle\, t\rangle$

(32) PA-rule by Poesio:

$$\{\lambda g.\lambda x. f(g^{x/i}) : f \in [\![\beta]\!]^M\}$$
$$\langle\langle a, \langle e, \tau\rangle\rangle, t\rangle$$

λ_i — $[\![\beta]\!]^M$ $\langle\langle a, \tau, \rangle\, t\rangle$

This PA-rule outputs the correct type $\langle\langle a, \langle e, \tau\rangle\rangle, t\rangle$ and generates a set that contains only uniform properties, as can be seen in the semantic computation in (33):

(33) nobody λ_i [who$_{\text{in-situ}}$ saw t_i]

a. $[\![saw]\!]^M = \{\lambda g.\lambda x.\lambda y. y \text{ saw } x\}$
b. $[\![t_i]\!]^M = \{\lambda g. g(i)\}$
c. $[\![saw\ t_i]\!]^M = \{\lambda g.\lambda y. y \text{ saw } g(i)\}$
d. $[\![who]\!]^M = \{\lambda g. x : x \in D_e\} = \{\lambda g. \text{ Alice},\ \lambda g. \text{ Barbara},\ \lambda g. \text{ Caroll }\}$
e. $[\![\ who\ saw\ t_i]\!]^M = \{\lambda g. \text{ Alice saw } g(i),\ \lambda g. \text{ Barbara saw } g(i),\ \lambda g. \text{ Caroll saw } g(i)\}$
f. $[\![\lambda i\ who\ saw\ t_i]\!]^M$
$= \{\lambda g.\lambda x. \text{ Alice saw } g^{x/i}(i), \lambda g.\lambda x. \text{ Barbara saw } g^{x/i}(i), \lambda g.\lambda x. \text{ Caroll saw } g^{x/i}(i)\}$
$= \{\lambda g.\lambda x. \text{ Alice saw } x,\ \lambda g.\lambda x. \text{ Barbara saw } x,\ \lambda g.\lambda x. \text{ Caroll saw } x\}$
g. $[\![nobody]\!]^M = \{\lambda g.\lambda Q.\neg\exists x[Q(x)]\}$
h. $[\![nobody\ \lambda i \text{ who saw } t_i]\!]^M$
$= \{\lambda g.\neg\exists x[\text{ Alice saw } x],\ \lambda g.\neg\exists x[\text{ Barbara saw } x],\ \lambda g.\neg\exists x[\text{ Caroll saw } x]\}$

While Poesio's (1996) PA-rule circumvents Problem 1, Shan (2004) points out a second problem for Kratzer and Shimoyama's PA-rule which also applies to Poesio's. The problem, which we will call Problem 2, arises when we need to bind a variable that sits inside a *wh*-phrase:

(34) a. Which man$_i$ sold which of his$_i$ paintings?

In this example, for each man, the set of his paintings is different. So, for instance, Picasso's paintings are "Guernica" and "Three Musicians" and Velázquez' paintings are "The Surrender of Breda" and "Las Meninas". This means that, intuitively, the *wh*-phrase has to denote the set of paintings {"Guernica", "Three Musicians"} when *his$_i$* is interpreted as Picasso and the set {"The Surrender of Breda","Las Meninas"} when *his$_i$* is interpreted as Velázquez. More specifically, it seems that the denotation of the constituent headed by the λ-abstract in (35-a) should assign to Picasso the set of propositions {Picasso sold "Guernica', Picasso sold "Three Musicians"} and to Velázquez the set of propositions {Velázquez sold "The Surrender of Breda", Velázquez sold "Las Meninas"}. But this is the function (35-b), which has the problematic type $\langle e\langle\tau, t\rangle\rangle$ again.

(35) a. Which man [λ_i t$_i$ sold which of his$_i$ paintings]
b. λx. $\{x \text{ sold } y : y \text{ is a painting of } x\}$

Additionally, binding into the *wh*-phrase and QRing an NP can take place in the same sentence, as in (36). This means that the type $\langle\langle e, \tau\rangle, t\rangle$ needed for QR and the problematic type $\langle e\langle\tau, t\rangle\rangle$ needed for binding into the *wh*-phrase would have to be interleaved, as sketched in (36):

(36) a. Which man_i told nobody about which of his_i paintings?
b. Which man λ_i nobody [λ_j t_i told t_j about which of his_i paintings $]_{\langle\langle e,\tau\rangle,t\rangle}$
c. $\{\lambda y.\ g(i)$ told y about $z : z$ is a painting of $g(i)\}$
d. Which man [λ_i nobody λ_j t_i told t_j about which of his_i paintings $]_{\langle e\langle \tau,t\rangle\rangle}$
e. λx. $\{x$ told nobody about $z : z$ is a painting of $x\}$

Unfortunately it is not possible with Poesio's (1996) approach to deal with these cases, as his approach tries deliberately to avoid the problematic type $\langle e,\langle\tau,t\rangle\rangle$.

To sum up so far, we need an alternative-friendly Predicate Abstraction rule that will generate a set of functions: type $\langle\langle e,\tau\rangle,t\rangle$. The naive approach produces the wrong type. The PA-rule by Hagstrom and by Kratzer and Shimoyama produces the correct type but overgenerates alternatives and produces ungrammatical readings (Problem 1). The PA-rule by Poesio produces the correct type and avoids Problem 1, but it is not able to deal with examples where the λ-abstract binds into a *wh*-phrase (Problem 2).

In the next section, we develop a solution to Problem 2 within Poesio's approach by treating *wh*-phrases as definite descriptions.

5 Proposal: *Wh*-phrases as definites

Rullmann and Beck (1997) note that *wh*-phrases project existence presuppositions the way definite descriptions do. Consider the definite NP *the unicorn*, which triggers the presupposition that a unicorn exists, and the examples in (37). When the NP *the unicorn* is embedded under a presupposition hole like *know*, as in (37-a), the NP's existence presupposition is projected up. As a result, (37-a) presupposes that a unicorn exists. When the NP is embedded under a presupposition filter like *think*, the presupposition projects up but modified in a particular way: (37-b) presupposes that Bill believes that a unicorn exists. Rullmann and Beck (1997) note that the same pattern is found in *wh*-phrases: (38-a) presupposes that a unicorn exists and (38-b) presupposes that Bill believes that a unicorn exists.[3]

(37) a. Bill $knows_{HOLE}$ he caught the unicorn.
b. Bill $thinks_{PLUG}$ he caught the unicorn.

(38) a. Which unicorn did Bill $know_{HOLE}$ he caught?
b. Which unicorn did Bill $think_{PLUG}$ he caught?

Rullmann and Beck (1997) propose to leave *wh*-phrases in their base position and treat them semantically as definites. This is exemplified in (40), which is parallel to the definite (39). In their approach, the index *i* on the *wh*-phrase is later bound by the question operator in C^0.

(39) $[\![\text{the man Sam}]\!]^{M,g}$ = the (λy. man(w)(y) ∧ y=Sam)

(40) $[\![\text{which man}_i]\!]^{M,g}$ = the (λy. man(w)(y) ∧ $y=x_i$)

[3]Treating *wh*-phrases as definites in base position also allows to generate Groenendijk and Stokhof's (1984) de dicto reading and solves Reinhart's (1992) "Donald Duck" problem. Note that Rullmann & Beck's presuppositionality of *which*-phrases is different from the partitive presupposition in D-linked *which*-phrases (e.g. *which unicorn* as "which unicorn out of a salient set of unicorns"), and, thus, it can in principle be extended to *what*-phrases.

Our proposal is to combine the general type $\langle\langle a,\tau\rangle, t\rangle$ and the PA-rule in Poesio's (1996) approach with Rullmann and Beck's (1997) insight on *wh*-phrases. Instead of denoting a set of assignment-sensitive name-like denotations, as in (41), we propose that a *wh*-phrase denotes a set of assignment-sensitive definite description-like denotations, as in (42).

(41) $[\![who]\!]^M = \{\lambda g.x : x \in D_e\} =_{e.g.} \{\lambda g.\text{ Alice }, \lambda g.\text{ Barbara }, \lambda g.\text{ Caroll }\}$

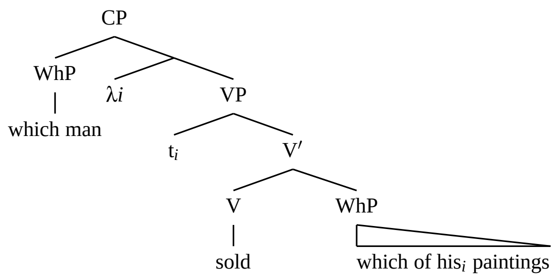
(42) $[\![who]\!]^M = \{\lambda g.\iota x[\text{ person}(x) \wedge x = v] : v \in D_e\}$
$=_{e.g.} \{\lambda g.\iota x[\text{ person}(x) \wedge x = \text{ Alice }], \lambda g.\iota x[\text{ person}(x) \wedge x = \text{ Barbara }],$
$\lambda g.\iota x[\text{ person}(x) \wedge x = \text{ Caroll }]\}$

This move will ensure that, when the *wh*-phrase contains a pronoun bound from the outside, the $\langle a,e\rangle$-functions in the set of alternatives will be partial functions. Consider the denotation of *which of his$_i$ paintings* defined in (43-a) and exemplified in (43-b). Assume, furthermore, that A is the painting "Guernica" and B is the painting "Las Meninas". Then, the $\langle a,e\rangle$-function depicted on the left in (43-b) will map an assignment g to "Guernica" if $g(i)$=Picasso, and it will be undefined otherwise. Similarly, the $\langle a,e\rangle$-function on the right will map an assignment g to "Las Meninas" if $g(i)$=Velázquez, and it will be undefined otherwise. In other words, the Hamblin set will contain as many $\langle a,e\rangle$-functions as there are individuals in D_e. But those functions will be partial and they will output an individual only when that individual is a painting of $g(i)$'s.

(43) $[\![\textit{which of his}_i \textit{ paintings}]\!]^M$
a. $= \{\lambda g.\iota v[\text{ paint-of}(v, g(i)) \wedge v = z] : z \in D_e\}$
b. $=_{e.g.} \left\{ \begin{bmatrix} g_1 \mapsto \iota v[\text{paint-of}(v, g_1(i)) \wedge v = A] \\ g_2 \mapsto \iota v[\text{paint-of}(v, g_2(i)) \wedge v = A] \\ g_3 \mapsto \iota v[\text{paint-of}(v, g_3(i)) \wedge v = A] \end{bmatrix} \begin{bmatrix} g_1 \mapsto \iota v[\text{paint-of}(v, g_1(i)) \wedge v = B] \\ g_2 \mapsto \iota v[\text{paint-of}(v, g_2(i)) \wedge v = B] \\ g_3 \mapsto \iota v[\text{paint-of}(v, g_3(i)) \wedge v = B] \end{bmatrix} \right\}$

The semantic computation of (34) is spelled out below. The last step shows that all Hamblin alternatives arising from *which of his$_i$ paintings* are combined with all Hamblin alternatives arising from *which man*. But, since the final assignment-sensitive propositions are partial functions, the combinations where a painter is not paired with one of his own paintings yield a presupposition failure (marked as #). That is, only answers to (34) that link a painter with one of his own paintings are felicitous (and, hence, true or false). This way, we capture the intuition discussed by Shan that, for a given painter, we can only felicitously choose among that painter's paintings.

(44) Which man λ_i t_i sold which of his$_i$ paintings?



(45) a. $$[\![V]\!]^M = \left\{ \begin{bmatrix} g_1 \mapsto \lambda x.\lambda y.y \text{ sold } x \\ g_2 \mapsto \lambda x.\lambda y.y \text{ sold } x \\ g_3 \mapsto \lambda x.\lambda y.y \text{ sold } x \end{bmatrix} \right\}$$

b. $$[\![V']\!]^M = \left\{ \begin{bmatrix} g_1 \mapsto \lambda y.y \text{ sold } \iota v[\text{paint-of}(v, g_1(i)) \wedge v = A] \\ g_2 \mapsto \lambda y.y \text{ sold } \iota v[\text{paint-of}(v, g_2(i)) \wedge v = A] \\ g_3 \mapsto \lambda y.y \text{ sold } \iota v[\text{paint-of}(v, g_3(i)) \wedge v = A] \end{bmatrix} \begin{bmatrix} g_1 \mapsto \lambda y.y \text{ sold } \iota v[\text{paint-of}(v, g_1(i)) \wedge v = B] \\ g_2 \mapsto \lambda y.y \text{ sold } \iota v[\text{paint-of}(v, g_2(i)) \wedge v = B] \\ g_3 \mapsto \lambda y.y \text{ sold } \iota v[\text{paint-of}(v, g_3(i)) \wedge v = B] \end{bmatrix} \right\}$$

c. $$[\![t_i]\!]^M = \left\{ \begin{bmatrix} g_1 \mapsto g_1(i) \\ g_2 \mapsto g_2(i) \\ g_3 \mapsto g_3(i) \end{bmatrix} \right\}$$

d. $$[\![VP]\!]^M = \left\{ \begin{bmatrix} g_1 \mapsto g_1(i) \text{ sold } \iota v[\text{paint-of}(v, g_1(i)) \wedge v = A] \\ g_2 \mapsto g_2(i) \text{ sold } \iota v[\text{paint-of}(v, g_2(i)) \wedge v = A] \\ g_3 \mapsto g_3(i) \text{ sold } \iota v[\text{paint-of}(v, g_3(i)) \wedge v = A] \end{bmatrix} \begin{bmatrix} g_1 \mapsto g_1(i) \text{ sold } \iota v[\text{paint-of}(v, g_1(i)) \wedge v = B] \\ g_2 \mapsto g_2(i) \text{ sold } \iota v[\text{paint-of}(v, g_2(i)) \wedge v = B] \\ g_3 \mapsto g_3(i) \text{ sold } \iota v[\text{paint-of}(v, g_3(i)) \wedge v = B] \end{bmatrix} \right\}$$

e. $$[\![\lambda_i[VP]]\!]^M = \left\{ \begin{matrix} \begin{bmatrix} g_1 \mapsto \lambda x.g_1^{x/i}(i) \text{ sold } \iota v[\text{paint-of}(v, g_1^{x/i}(i)) \wedge v = A] \\ g_2 \mapsto \lambda x.g_2^{x/i}(i) \text{ sold } \iota v[\text{paint-of}(v, g_2^{x/i}(i)) \wedge v = A] \\ g_3 \mapsto \lambda x.g_3^{x/i}(i) \text{ sold } \iota v[\text{paint-of}(v, g_3^{x/i}(i)) \wedge v = A] \end{bmatrix} \\ \begin{bmatrix} g_1 \mapsto \lambda x.g_1^{x/i}(i) \text{ sold } \iota v[\text{paint-of}(v, g_1^{x/i}(i)) \wedge v = B] \\ g_2 \mapsto \lambda x.g_2^{x/i}(i) \text{ sold } \iota v[\text{paint-of}(v, g_2^{x/i}(i)) \wedge v = B] \\ g_3 \mapsto \lambda x.g_3^{x/i}(i) \text{ sold } \iota v[\text{paint-of}(v, g_3^{x/i}(i)) \wedge v = B] \end{bmatrix} \end{matrix} \right\}$$

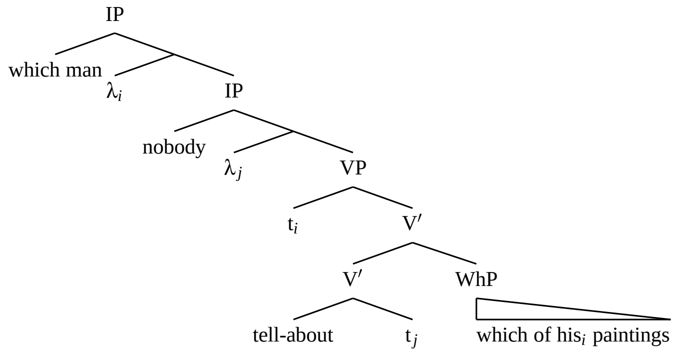
That is: $$\left\{ \begin{bmatrix} g_1 \mapsto \lambda x.x \text{ sold } \iota v[\text{paint-of}(v, x) \wedge v = A] \\ g_2 \mapsto \lambda x.x \text{ sold } \iota v[\text{paint-of}(v, x) \wedge v = A] \\ g_3 \mapsto \lambda x.x \text{ sold } \iota v[\text{paint-of}(v, x) \wedge v = A] \end{bmatrix} \begin{bmatrix} g_1 \mapsto \lambda x.x \text{ sold } \iota v[\text{paint-of}(v, x) \wedge v = B] \\ g_2 \mapsto \lambda x.x \text{ sold } \iota v[\text{paint-of}(v, x) \wedge v = B] \\ g_3 \mapsto \lambda x.x \text{ sold } \iota v[\text{paint-of}(v, x) \wedge v = B] \end{bmatrix} \right\}$$

f. $$[\![WhP]\!]^M = \left\{ \begin{bmatrix} g_1 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \\ g_2 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \\ g_3 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \end{bmatrix} \begin{bmatrix} g_1 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \\ g_2 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \\ g_3 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \end{bmatrix} \right\}$$

g. $$[\![CP]\!]^M = \left\{ \begin{matrix} \begin{bmatrix} g_1 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Picasso}]) \wedge v = A] \\ g_2 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Picasso}]) \wedge v = A] \\ g_3 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Picasso}]) \wedge v = A] \end{bmatrix} \\ \begin{bmatrix} g_1 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Picasso}]) \wedge v = B]\# \\ g_2 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Picasso}]) \wedge v = B]\# \\ g_3 \mapsto \iota z[\text{man}(z) \wedge z = \text{Picasso}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Picasso}]) \wedge v = B]\# \end{bmatrix} \\ \begin{bmatrix} g_1 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Velázquez}]) \wedge v = A]\# \\ g_2 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Velázquez}]) \wedge v = A]\# \\ g_3 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Velázquez}]) \wedge v = A]\# \end{bmatrix} \\ \begin{bmatrix} g_1 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Velázquez}]) \wedge v = B] \\ g_2 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Velázquez}]) \wedge v = B] \\ g_3 \mapsto \iota z[\text{man}(z) \wedge z = \text{Velázquez}] \text{ sold } \iota v[\text{paint-of}(v, \iota z[\text{man}(z) \wedge z = \text{Velázquez}]) \wedge v = B] \end{bmatrix} \end{matrix} \right\}$$

This move also allows us to compute the cases like (36) that Shan (2004) intuitively diagnosed as interleaving types. Poesio's (1996) general type $\langle\langle a, \tau\rangle, t\rangle$ is kept throughout the derivation (47), and both λ-abstracts –λ_j under *nobody* and λ_i under *which man*– give rise to denotations of type $\langle\langle a, \langle e, t\rangle\rangle, t\rangle$. We do not need the problematic type $\langle e, \langle \tau, t\rangle\rangle$ and types are not interleaved.

(46) Which man$_i$ told nobody$_j$ about which of his$_i$ paintings?



(47) a. $[\![t_i \text{ tell } t_j \text{ about which of his}_i \text{ paintings}]\!]^M$
$= \{\lambda g.g(i) \text{ tells } g(j) \text{ about } \iota x[\text{ paint-of}(x, g(i)) \wedge x = v] : v \in D_e\}$

b. $[\![\lambda_j\ t_i \text{ tell } t_j \text{ about which of his}_i \text{ paintings}]\!]^M$
$= \left\{\lambda g.\lambda u_e.g^{u/j}(i) \text{ tells } g^{u/j}(j) \text{ about } \iota x[\text{ paint-of}(x, g^{u/j}(i)) \wedge x = v] : v \in D_e\right\}$
$= \left\{\lambda g.\lambda u_e.g^{u/j}(i) \text{ tells u about } \iota x[\text{ paint-of } (x, g^{u/j}(i)) \wedge x = v] : v \in D_e\right\}$

c. $[\![\textit{nobody}]\!]^M = \{\lambda g.\lambda Q.\neg\exists[Q(u)]\}$

d. $[\![\text{nobody } \lambda_j\ t_i \text{ tell } t_j \text{ about which of his}_i \text{ paintings}]\!]^M$
$= \left\{\lambda g.\neg\exists u[g^{u/j}(i) \text{ tells } u \text{ about } \iota x[\text{ paint-of}(x, g^{u/j}(i)) \wedge x = v]] : v \in D_e\right\}$

e. $[\![\lambda_i \text{ nobody } \lambda_j\ t_i \text{ tell } t_j \text{ about which of his}_i \text{ paintings}]\!]^M$
$= \left\{\lambda g.\lambda w_e.\neg\exists u[g^{w/i\,u/j}(i) \text{ tells u about } \iota x[\text{paint-of}(x, g^{w/i\,u/j}(i)) \wedge x = v]] : v \in D_e\right\}$
$= \{\lambda g.\lambda w_e.\neg\exists u[\text{w tells u about } \iota x[\text{paint-of}(x, w) \wedge x = v]] : v \in D_e\}$

f. $[\![\text{which man}]\!]^M = \{\lambda g.\iota y[\text{mans}(y) \wedge y = z] : z \in D_e\}$

g. $[\![\text{which man } \lambda_i \text{ nobody } \lambda_j\ t_i \text{ tell } t_j \text{ about which of his}_i \text{ paintings}]\!]^M$
$=\{\lambda g.\neg\exists u[\iota y[\text{ man}(y) \wedge y = z] \text{ tells u about } \iota x[\text{paint-of}(x, \iota y[\text{man}(y) \wedge y = z]) \wedge x = v]]$
$: v \in D_e \wedge z \in D_e\}$

In sum, using the Poesio's (1996) general type $\langle\langle a,\tau\rangle, t\rangle$ (as opposed to Shan's (2004) type $\langle a, \langle\tau, t\rangle\rangle$), we can use an alternative-friendly PA-rule that generates the correct set of alternatives. No spurious functional or pair-list readings are produced, hence circumventing Problem 1.[4] To this, we add Rullmann and Beck's (1997) treatment of *wh*-phrases as underlying definites. This allows us to bind into a *wh*-phrase while keeping the same general type throughout the derivation, thus avoiding Problem 2.

6 Extensions: Free Choice and Focus

As mentioned above, Hamblin sets of alternatives have been also used to model the behaviour of free choice indefinites and focus. In this section, we briefly consider how the analysis pursued in the present paper applies to these two phenomena.

Kratzer and Shimoyama (2002) propose that free choice NPs like German *irgendeinen Studenten* in (48) are interpreted as introducing a (widened) set of students, as in (49). The semantic computation proceeds as usual until the relevant operator is encountered, e.g. the modal *kann*

[4]For genuine functional and pair-list readings, see the appendix.

'can' in (48). We note that there exist examples where we need to bind into a free choice indefinite, that is, examples with the problematic configuration described in Problem 2: e.g., in (50), the set of professors intuitively varies with the students. To circumvent the problem, one would need to treat free choice indefinites as underlying *definites*, as in (51).

(48) Hans kann irgendeinen Studenten besuchen.
Hans can anyone student visit.
'Hans can visit any student.'

(49) $[\![\text{irgendein Student}]\!]^{M,g} = \{x : x \text{ is a student in } w\}$

(50) a. John can introduce any student$_i$ to any professor of his$_i$.
b. LF: Can [any student λ_i John introduces t_i to any professor of his$_i$]

(51) $[\![\text{any professor of his}_i]\!]^{M,g} = \{\lambda g.\iota y[\text{professor-of}(y, g(i)) \wedge y = v] : v \in D_e\}$

As for focus, Rooth (1985) proposes that a focused element (marked in capitals) of type τ has as its focus semantic value the set D_τ, as exemplified in (52)-(53). Can we find examples of binding into a focused XP? Jacobson (2004) gives examples like (54) and argues that, intuitively, they seem to involve functions into sets of alternatives, i.e. the problematic type $\langle e, \langle \tau, t\rangle\rangle$.

(52) John only introduced MARY to Sue.

(53) $[\![\text{MARY}]\!]^f = \{\lambda g.x : x \in D_e\}$

(54) a. Every third grade boy loves Mary$_j$/her$_j$ and every FOURTH grade boy loves himSELF
b. Every third grade boy loves himself and every FOURTH grade boy loves HIMself.

These examples can be captured in the approach pursued in the present paper without resorting to the problematic type. Consider first (54-a). To capture the intended contrast between *Mary*$_j$ / *her*$_j$ and *himSELF*$_i$, we propose the LF in (55), with focus on the entire pronoun including its index. This would give us the ordinary semantic value in (56-a) and the focus semantic value in (56-b). A member of this focus semantic value is the proposition expressed by the first conjunct *Every third grade boy loves her*$_j$. Thus, Rooth's (1985) focus felicity condition is satisfied.

(55) LF: ... [every FOURTH grade boy λ_i t$_i$ loves [himSELF$_i$]$_{Focus}$].

(56) a. $\lambda g.\forall x[\text{ 4-gr-boy}(x) \rightarrow [\![t_i]\!]^M(g^{x/i}) \text{ loves } [\![t_i]\!]^M(g^{x/i})]$
b. $\{\lambda g.\forall x[\text{ 4-gr-boy}(x) \rightarrow [\![t_i]\!]^M(g^{x/i}) \text{ loves } h(g^{x/i})] : h \in D_{\langle a,e\rangle}\}$
E.g. : $\{\lambda g.\forall x[\text{ 4-gr-boy}(x) \rightarrow [\![t_i]\!]^M(g^{x/i}) \text{ loves } \lambda g'.g'(i)(g^{x/i})]$,
$\lambda g.\forall x[\text{ 4-gr-boy}(x) \rightarrow [\![t_i]\!]^M(g^{x/i}) \text{ loves } \lambda g'.g'(j)(g^{x/i})]$,
$\lambda g.\forall x[\text{ 4-gr-boy}(x) \rightarrow [\![t_i]\!]^M(g^{x/i}) \text{ loves } \lambda g'.g'(k)(g^{x/i})]\}$

As for (54-b), Sauerland (2000) analyzes *HIMself* underlyingly as a definite description with focus on part of the descriptive content, as in (57). In the framework used in the present paper, this would give us the focus semantic value in (58), one of whose members is the proposition expressed by the first conjunct *Every third grade boy loves himself.*

(57) LF: ... [every FOURTH grade boy λ_i t_i loves the $[\text{FOURTH}]_{Focus}$ year grade boy pro_i]

(58) $\{\lambda g.\forall x[\text{ 4-gr-boy}(x) \rightarrow x \text{ loves the [Adj year grade] boy } x] : \text{ Adj } \in D_{\langle g,\langle e,t\rangle\rangle}\}$
E.g. $\{\lambda g.\forall x[\text{ 4-gr-boy }(x) \rightarrow x \text{ loves the [third year grade] boy } x],$
$\lambda g.\forall x[\text{ 4-gr-boy }(x) \rightarrow x \text{ loves the [fourth year grade] boy } x],$
$\lambda g.\forall x[\text{ 4-gr-boy}(x) \rightarrow x \text{ loves the [fifth year grade] boy } x], \ldots\}$

In sum, Hamblin alternatives arising from free choice indefinites and focus which (appear to) bind into the set of alternatives can be handled in the present account without resource to the problematic type $\langle e, \langle \tau, t\rangle\rangle$.

7 Conclusion

We have seen that it is not trivial to combine syntactic movement and variable binding with Hamblin alternatives. A naive Predicate Abstraction (PA) rule produces the wrong type ($\langle a, \langle \tau, t\rangle\rangle$). Hagstrom's (1998) and Kratzer and Shimoyama's (2002) PA-rule deliver the correct type but at the expense of overgenerating alternatives (Problem 1 from Shan (2004)). And Poesio's (1996) PA-rule cannot handle cases where a pronoun inside the *wh*-phrase needs to be bound from the outside (Problem 2 from Shan (2004)).

To circumvent the first problem, we follow Poesio (1996) and use the general type $\langle\langle a, \tau\rangle, t\rangle$ throughout the derivation, as opposed to Shan's (2004) type $\langle a, \langle \tau, t\rangle\rangle$. The new PA-rule outputs the correct type $\langle\langle a, \langle e, \tau\rangle\rangle, t\rangle$ without overgenerating alternatives. To solve the second problem, we borrow an insight from Rullmann and Beck's (1997) and treat *wh*-phrases, free choice indefinites and potentially other constructions giving rise to Hamblin alternatives as underlying definite descriptions. This allows us to maintain Poesio's (1996) general type while producing sets of alternatives whose felicity is relativized to the binder.

Thus, if we commit ourselves to combining movement and variable binding with Hamblin alternatives, we can do it, but we need to do it with caution.

A Genuine functional and pair-list readings

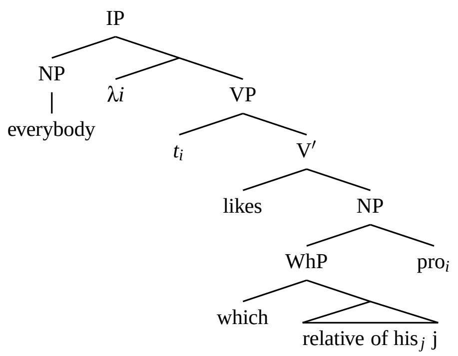
For functional readings like (59-a), we incorporate Engdahl's (1986) skolem functions into our analysis below and assume Chierchia's (1993) constraints. For pair-list readings like (59-b), we assume that an absorption mechanism turns the functional reading into a pair-list reading in the appropriate configurations (Chierchia, 1993), but we will not spell it out in this paper.

(59) Which relative of his_i does everybody_i like the best?
 a. Functional answer: His_i mother.
 b. Pair-list answer: Johnny likes his aunt Lilly the best, Paul likes his father Martin the best and Timmy likes his cousin Matt the best.

With Engdahl (1986), we make the following assumptions. First, a predicate like *relative of* his_i can be applied to a skolem function $f_{\langle e,e\rangle}$ using the semantic rule (60). Second, next to the trace left by a moved functional *wh*-phrase, a second index is fed as the argument of the function. In our case, since we interpret *wh*-phrases in base position, the extra index is the sister of the entire *wh*-phase, as in (61). The abrigded semantic computation is given in (62).

(60) Functional N′-rule: $[\![\text{relative of his}_2\ 2]\!]^{M,g}$(f)(w)=1
iff $\forall x \in Dom(f)$ $[\![\text{relative of his}_2\ 2]\!]^{M,g}$ (f(x))(w) = 1
iff $\forall x \in Dom(f)[f(x)$ is a relative of x in w$]$

(61)



(62) a. $[\![\text{which relative of his}_j\ \text{j}]\!]^M$
$= \{\lambda g.\iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h] : h \in D_{\langle e,e\rangle} \wedge h \text{ is a natural function}\}$
$= \{\lambda g.\iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{mother}}],$
$\lambda g.\iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{father}}],$
$\lambda g.\iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{aunt}}]\}$

b. $[\![\text{pro}_i]\!]^M = \{\lambda g.g(i)\}$

c. $[\![[\text{which relative of his}_j\ j]\text{pro}_i\ ]\!]^M$
$= \{\lambda g.\iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{mother}}](g(i)),$
$\lambda g.\iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{father}}](g(i)),$
$\lambda g.\iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{aunt}}](g(i))\}$

d. $[\![t_i]\!]^M = \{\lambda g.g(i)\}$

e. $[\![\ \text{t}_i \text{ likes [which relative of his}_j \text{ j] pro}_i\ ]\!]^M$
$= \{\lambda g.g(i) \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{mother}}](g(i)),$
$\lambda g.g(i) \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{father}}](g(i)),$
$\lambda g.g(i) \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{aunt}}](g(i))\}$

f. $[\![\lambda i\ \text{t}_i \text{ likes [which relative of his}_j \text{ j] pro}_i\ ]\!]^M$
$= \{\lambda g.\lambda u_e.g^{u/i}(i) \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{mother}}](g^{u/i}(i))$
$\lambda g.\lambda u_e.g^{u/i}(i) \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{father}}](g^{u/i}(i))$
$\lambda g.\lambda u_e.g^{u/i}(i) \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{aunt}}](g^{u/i}(i))\}$
$= \{\lambda g.\lambda u_e.u \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{mother}}](u)$
$\lambda g.\lambda u_e.u \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{father}}](u)$
$\lambda g.\lambda u_e.u \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{aunt}}](u)\}$

g. $[\![\textit{everybody}]\!]^M = \{\lambda g.\lambda Q.\forall u[Q(u)]\}$

h. $[\![\ \text{everybody } \lambda i\ \text{t}_i \text{ likes [which relative of his}_j \text{ j] pro}_i\ ]\!]^M$
$= \{\lambda g.\forall u[u \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{mother}}](u)]$
$\lambda g.\forall u[u \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{father}}](u)]$
$\lambda g.\forall u[u \text{ likes } \iota f[\forall x \in Dom(f)[f(x) \text{ is a relative of } x] \wedge f = h_{\text{aunt}}](u)]\}$

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