Vincent HOMER/ *Ling 207*/ Friday June 16th
Term Paper: Nested Choice Functions

Nested choice functions

0▣ Introduction: Why choice functions?

0.1 Indefinites *an X* and *some X* sometimes have a 'referential' or 'specific' reading. Modifiers like *certain* favor these specific indefinites. So do certain intonational contours.

(1) I've just found out that Lisa and my ex-girlfriend will come the party. I wish some guest could stay home.

Under the traditional view of scope by c-command, one expects the specific indefinite *some guest* to scope over the whole sentence through Quantifier Raising.

0.2 Specific indefinites are found within syntactic islands: this is a case where QR cannot be invoked, unless we claim that existentially quantified NPs are not subject to subjacency.

(2) Everyone is convinced that [if *a friend of mine* comes to the party], it will be a disaster. (G. Chierchia)

In (2), *a friend of mine* can clearly take scope over the matrix clause when it denotes my friend Saddam Hussein. But *a friend of mine* is embedded in an *if*-clause, i.e. a scopal island.

0.3 We assume that specific indefinites denote *choice functions*. A choice function is a function that applies to a non-empty set and returns an element of that set. For instance, the function *f* picks an element out of the set of my friends:

(3) $f([\![\text{friend}]\!](\text{I}))=[\![\text{Saddam Hussein}]\!]$

So (2) can be paraphrased as (4) below:

(4) a. There is a friend of mine such that everyone is convinced that, if he comes to the party, it will be a disaster.
b. Everyone is convinced that if the *f*(friend of mine) comes to the party, it will be a disaster.
c. Everyone is convinced that if the friend of mine that is selected by the contextually provided choice function *f* comes to the party, it will be a disaster.

0.4 A choice function has the effect that the indefinite that denotes it takes maximal scope. But it is not always the case that a specific indefinite takes widest scope. It has been argued (Reinhart (1997)) that 'intermediate scopes' exist.

(5) a. Every professor rejoices if a student cheats on the exam.
b. IS: For every professor *x*, there is a student *y* such that if *y* cheats on the exam, *x* rejoices.

(5) can also be understood as meaning that there is one particular student for whom every professor will rejoice (widest scope of the indefinite), or that every professor will rejoice provided that any student cheats on the exam (narrowest scope). We display the various readings of (5).

(6) a. Every professor rejoices if a student cheats on the exam.
b. NS: $\forall x[[\![\text{professor}]\!](x) \rightarrow [\exists y[[\![\text{student}]\!](y) \wedge [\![\text{cheat}]\!](y)] \rightarrow [\![\text{rejoice}]\!](x)]]$
c. IS: $\forall x[[\![\text{professor}]\!](x) \rightarrow \exists y[[\![\text{student}]\!](y) \wedge [[\![\text{cheat}]\!](y)] \rightarrow [\![\text{rejoice}]\!](x)]]]$
d. WS: $\exists y[[\![\text{student}]\!](y) \wedge \forall x[[\![\text{professor}]\!](x) \rightarrow [[\![\text{cheat}]\!](y)] \rightarrow [\![\text{rejoice}]\!](x)]]]$

What (6c) shows is the *intermediate scope* of the sentence: the students vary with the professors (so *a student* is in the scope of *every professor*), and it is understood that the indefinite does not scope in the antecedent of the conditional. In other words, *a student* escapes an island while remaining within the scope of the higher universal quantifier. To achieve this intermediate scope, one has to resort to a choice function and restrain its scope. To this end, Reinhart proposes that choice functions are *variables* that can be *existentially* bound at any level (not necessarily at the topmost level). So the intermediate scope can be rendered as:

(7) a. Every professor rejoices if a student cheats on the exam.
b. For each professor *x*, there is a way *f* of choosing among the students such that *x* will rejoice if *f*(student) cheats on the exam.

(8) and (9) below are further examples in the same connection.

(8) a. Every linguist studied every solution that could solve a certain problem.
b. For every linguist *x*, there is a way *f* of choosing among the problems such that *x* studied every solution *z* that could solve *f*(problem).

(9) a. Every director is happy to direct every film that features some actor.
b. For every director *x*, there is a way *f* of choosing among the actors such that *x* is happy to direct every movie *z* that features *f*(actor).

In (8) and (9), it is quite clear that the indefinite must scope over the lower universally quantified NP, because the narrowest scope is overly strong (one cannot expect a linguist to have studied every solution that could solve any problem whatsoever).

0.5 But Kratzer (1998) takes these sentences with a grain of salt. She claims that existential closure is not necessary, and that the so-called intermediate scope readings are the artifact of a **parameterized** or **skolemized choice function**, henceforth SF, that is, a function which takes a set and an individual as its arguments and returns a member of the set. The variable denoting the individual can be bound, so it is expected that students will vary with professors in (5a), due to this bound variable.

So the question arises: what evidence do we have that non-parameterized functions are necessary? It is claimed (Chierchia (2001)) that no SF can handle 'professor' sentences placed in a downward-entailing context. But is this sufficient to show that an indefinite in a 'professor' sentence outside of a DE context really denotes a bare CF? It could well be that a DE context is an exceptional case which imposes an existential closure (and no existential closure is ever licensed, apart from these very cases). Our claim is that there exists a set of sentences which manifest an intermediate existential closure outside of a DE environment, and for which no SF can be invoked: these sentences contain a specific indefinite with *two existential closures* (for *two functions*), one maximal and the other intermediate.

1 Skolemized versus non-skolemized CFs

1.1 Kratzer (1998) argues that 'professor' sentences are no evidence for an existential closure. Block the binding of the individual variable, and no intermediate scope emerges.

(10) Every professor will rejoice if a student of *mine* cheats on the exam.
(11) Every professor rewarded every student who read some book *Mary* has recommended.

So the representation she proposes for 'linguist' sentences with alleged intermediate scope is given in (12b). Compare with the alternative (bare CF) given in (12c):

(12) a. Every linguist studied every solution that could solve a (certain) problem.
b. SF: $\forall x[[\![\text{linguist}]\!](x) \rightarrow \forall y[[\![\text{solution to}]\!](y, f(x, [\![\text{problem}]\!])) \rightarrow [\![\text{studied}]\!](x, y)]]$ (*skolemized choice function*)
c. CF: $\forall x[[\![\text{linguist}]\!](x) \rightarrow \exists f(CH(f) \wedge \forall y[[\![\text{solution to}]\!](y, f([\![\text{problem}]\!])) \rightarrow [\![\text{studied}]\!](x, y)]]$ (*choice function, intermediate existential closure*)

A test seems to show that (12a) contains an existential closure, though: as Chierchia (2001) shows, it suffices to negate (12a) to manifest the superiority of CFs over SFs.

(13) Not every linguist studied every solution that could solve a (certain) problem.

Consider *Situation 1*: it makes (12a) true and its negation (13) false. On the other hand, *Situation 2* makes (12a) false and its negation (13) true.

(14)

Situation 1	*Situation 2*
3 linguists: A, B, C. A studied every solution to WCO. B studied every solution to donkey sentences. C studied every solution to Parasitic Gap.	3 linguists: A, B, C. A studied every solution to WCO. B studied every solution to donkey sentences. There is no problem for which C studied every solution.
There are problems for which A, B and C did not study any solution.	There are problems for which A, B and C did not study any solution.

Below are the two competing representations (CF and SF) for (13) repeated as (15):

(15) Not every linguist studied every solution that could solve a certain problem.

CF $\neg\forall x[[\![\text{linguist}]\!](x) \rightarrow \exists f(CH(f) \wedge \forall z[[\![\text{solution to}]\!](z, f([\![\text{problem}]\!])) \rightarrow [\![\text{studied}]\!](x, z))]]]$

It is not the case that for every linguist *x* there is a way *f* of choosing a problem such that *x* studied every solution to *f*(problem). ➢ **True** in *Sit. 2* and **False** in *Sit. 1*.

SF $\neg\forall x[[\![\text{linguist}]\!](x) \rightarrow \forall z[[\![\text{solution to}]\!](z, f([\![x, \text{problem}]\!])) \rightarrow [\![\text{studied}]\!](x, z)]]$

It is not the case that for every linguist *x f* selects a problem such that *x* studied every solution to *f*(*x*, problem). ➢ **True** in *Sit. 2* and **True** in *Sit. 1!*

The CF representation of (15) is true in *Situation 2* and false in *Situation 1*. And such are intuitively the truth values of (15). On the other hand, the SF representation is true in both models: *f* can select a problem that A (or B or C) didn't study, and there are many. So the SF representation seems to be inadequate. In fact, all DE contexts (such as the restriction of a universal quantifier) make the SF account stumble[1].

1.2 But DE contexts do not toll the knell of SFs. In fact, there are cases that clearly defeat non-parameterized CFs. The one proposed in Schlenker (1998) is a case in point. Consider the following model: *John, Peter and Mary are students about to take a syntax exam. John hasn't understood what wh-movement is; Peter is unfamiliar with WCO, and Mary with Principle C. In order for the exam to be a success, each of them should study the topic he is unfamiliar with.*

(16) If every student studies a certain topic, the exam will be a success.

Uttered against the aforementioned background, (16) means:

(17) If every student studies a (certain) topic, namely the one he is unfamiliar with, the exam will be a success.

An SF representation is adequate in this case:

(18) $[[\![\text{every student}]\!](\lambda x.[\![\text{study}]\!](x, f(\text{topic}, x)) \rightarrow [\![\text{exam will be a success}]\!]]$

1.3 How about bare CFs? It all depends on the site of the existential closure. If the function is bound by a quantifier located in the matrix clause, then the topic will be the same for every student (this is not desired). Now, if it is located in the *if*-clause, again, the topic will not vary with students. And, third option, if the quantifier is below *every student* (narrowest scope), then any topic will do, and this is not what the sentence means in the model. There is no other option. Hence the CF account fails.

In fact, SFs fare better in all contexts, apart from the DE ones: Chierchia (2001) shows that intermediate scope vanishes when a 'linguist' sentence is passivized. This is a puzzle from the bare-CF viewpoint. But it is natural under the alternative view, for skolemized choice functions contain a hidden parameter, which creates a WCO effect when one tries to raise a universally quantified NP past a coindexed pronoun:

[1] Here it bears saying that the DE context in question is not the one the specific indefinite itself is placed in (as a matter of fact, specific indefinites in 'linguist' sentences are in a DE context, namely the restriction of a universally quantified NP). The DE context Chierchia (2001) talks about is the one under which the whole sentence is placed.

(19) Every analysis that solves some_i problem has been looked at by every linguist_i.

(*wide scope only*)

In view of this, Chierchia (2001) proposes:

(20) a. Indefinites, when interpreted as choice functions, always have a hidden parameter.

b. Existential closure of a function *f* is restricted to the (top and the) immediate scope of the quantifier that binds the argument of *f*.

This means that 'linguist' sentences do not make the case for non-parameterized CFs: a closure is only necessitated when the sentence is placed in a DE context (for no clear reason, it should be said). Chierchia's verdict is that a comprehensive, albeit not unified, theory must accommodate both varieties of choice functions, CFs and SFs.

2. Introducing nested (bare) choice functions

Our claim is (i) that recursion of (bare) choice functions is possible, and (ii) that this shows that bound CFs can be found outside of DE contexts. The argument proceeds as follows: first, we show that recursion is possible (and spell out the conditions that make nested CFs the only option, leaving no room for skolemization), and second, we analyze the consequences of this finding.

2.1 Consider the following sentence (in a situation in which, as is the case in the actual world, a passport must be shown by every visitor).

(21) a. To enter the US, every visitor had to show a (certain) photo ID. (*a passport*)

b. $\exists f[CF(f) \wedge [\![\text{every visitor}]\!](\lambda x.[\![\text{must}]\!](\exists f'(CF(f') \wedge [\![\text{show}]\!](f'(f([\![\text{photo ID}]\!](x)))(x)))))]$

In (21), a first selection out of the set of photo IDs of *x* yields the set of passports of *x* (a *type* of IDs). For those citizens who have more than one passport, a second selection is in order, to ensure that what is shown at the customs is a specific *token*. Put differently, the *type* of photo IDs is required, but the token is not. Even though no restriction weighs on the token, a selection will have to made anyway: so two selections take place, one imposed, the other free. This can be represented using two choice functions *f* and *f'* bound at a different level as shown in (21b).

Notice that, for there to be two choice functions, it is not sufficient that two selections be performed. For it is conceivable that the choice of the token (the second one) be imposed as well: in that case, there would be no need for two CFs, only one (with topmost closure) would do the job. Conversely, if the two choices were left free, then the indefinite would be bound at the lowest level, and a second *choice function* would be superfluous (a unique *f* applying to the set of *tokens* of photo IDs of every visitor would suffice). This case shows then that intermediate closure is possible. Does it show that is necessary?

A skolemized choice function will let the photo IDs vary with the visitors (because the matrix subject binds the individual variable): an SF denotes a function that associates an individual with the member of a set. But in our world (where passports are specifically required), this is notoriously not possible. So it is important (because the law says so) that the *type* of ID does not vary with visitors. In a sense, an SF does half the job: it accounts for the individual variation of tokens, not for the absence of variation of the legal prescription.

2.2 Now, we have anticipated a little bit the victory of CFs. For do we need *f'* in (21)? If we do, then choice functions would be used as denotations of non-specific indefinites, that is, we would invoke CFs for the narrowest scope (it doesn't matter which passport is selected by every visitor who holds two citizenships). In fact, (22) can do the job just as well (there is no island that shows the need for a CF).

(22) c. $\exists f[CF(f) \wedge [\![\text{every visitor}]\!](\lambda x.[\![\text{must}]\!](\exists y(y \in (f([\![\text{photo ID}]\!](x)) \wedge [\![\text{show}]\!](x, y))))]$

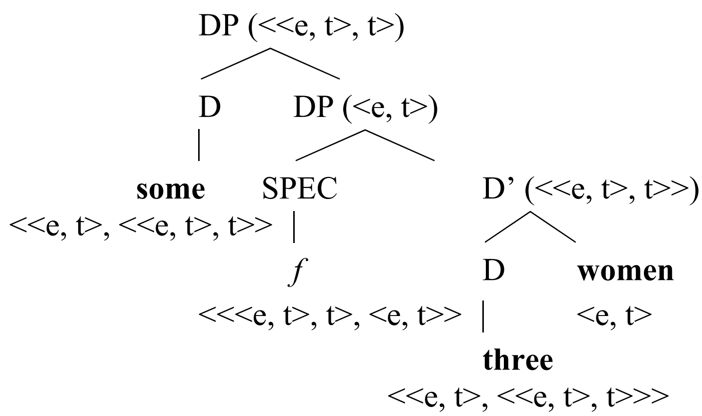
What does it mean to bind the variable *y*, in syntactic terms? After *f* applies, the outcome is a set of photo ID. But where is the variable *y* to be found in the syntax? Without using a second CF, it is possible to postulate a silent quantifier (*some*), as this is the intuitive meaning of the DP *a photo ID* (what gets shown is not a *type*, i.e. a set, but a *token*).

A CF is a function from a set to an entity, we said. Now, it is more accurate to say that a CF is a function that maps a set of sets to a set (type <<e,t>, t>, <e, t>>). When a visitor has only one passport, the final pick will be that very passport (the singleton set whose sole member is its unique passport): so we can raise the type of *f* without loss of generality. This is consonant with Reinhart (1997) about plural indefinites:

(23) a. three women
b. $f(\{X|\text{women}(X) \wedge |X| = 3\})$
c. Type of *f*: <<<e, t>, t>, <e, t>>

Applying the silent quantifier *some* (emphasis should be given to the partitive meaning of this determiner in the case at hand) we obtain the following representation with stacked DPs (the syntactic representation is just a tentative one; it does not prejudge the question of the position of *f* inside DP, it simply illustrates function application; the fact that D takes a DP complement needs to be further discussed):

(24)



And we give the (categorematic) lexical entry for *some*:

(25) $[\![\text{some}]\!]^M = \lambda f_{<e,t>}.\ \lambda g_{<e,t>}.\ \{x \in D: f(x) = 1\} \cap \{x \in D: g(x) = 1\} \neq \varnothing$[2]

So recursive choice functions are not clearly necessary in this particular instance.

2.3 The following criteria must be met if we want to establish the necessity of nested choice functions:

(26) a. A syntactic island, to make QR impossible (a relative clause for instance because it is not possible to extract out of it).
b. Two universal quantifiers: the existential quantifiers will scope over one universally quantified NP each. The second CF will not be replaceable by a silent quantifier.
c. The modal *must* will unambiguously force the higher closure to be located in the matrix clause.

Hence the general template of a sentence containing nested choice functions:

(27)

General type		Modal	Subtype		Island boundary	Specific indefinite
↓		↓	↓		↓	↓
$\exists f$	Every x…	*must*	$\exists f'$	every y…	[	$f'(f(\ldots\ldots))$

The three sentences below conform to the template[3]:

(28) a. To place an order on line, every customer must enter every digit that is printed on a (certain) card.
(*only credit cards will do, but a customer may have more than one*)
b. $\exists f[CF(f) \wedge [\![\text{every customer}]\!](\lambda x.\ [\![\text{must}]\!](\exists f'(CF(f') \wedge [\![\text{enter}]\!]([\![\text{every digit printed on}]\!](f'(f([\![\text{card}]\!](x))))(x))))]$

(29) a. In this traditional Finnish village, every family must make every piece of tinsel that decorates a (certain) tree near the fireplace.
(*only fir trees will do as Christmas trees, and the one that each family will fell and decorate is usually chosen out of several*)
b. $\exists f[CF(f) \wedge [\![\text{every family}]\!](\lambda x.\ [\![\text{must}]\!](\exists f'(CF(f') \wedge [\![\text{make}]\!]([\![\text{every piece of tinsel on}]\!](f'(f([\![\text{tree}]\!](x))))(x))))]$

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[2] It is not clear whether there is some uniqueness involved in the photo ID example (the law does not say that exactly one photo ID be shown). But if there is one, then maybe a simple determiner like *some* is not the right candidate. Then we should resort to a partitive quantifier like *exactly one of* which is not head-like and would thus sit in Spec,DP, giving rise to a different representation. This is then the correct entry:
(1) $[\![\text{exactly one of}]\!]^M = \lambda f_{<e,t>}.\ \lambda g_{<e,t>}.\ |\{x \in D: f(x) = 1\} \cap \{x \in D: g(x) = 1\}| = 1$

[3] In all these sentences the first CF *f* applies to a set relativized to an individual (or a group of individuals, as in the Finnish example). It is not crucial that the set be so relativized. Anyway this does not change the type of this first *f*, which can remain <<e, t>, t>, <e, t>>, since even though *card* is taken to be a relational noun (<e, <e, t>>), *card of* x is not (it is of type <e, t>).

(30) a. IRS says that every taxpayer must answer every relevant question that is asked on a (certain) form.

(*only the 1040 form is valid, but you usually fill out two, and send one*)

b. $\exists f[CF(f) \wedge [\![\text{every taxpayer}]\!](\lambda x.\ [\![\text{must}]\!](\exists f'(CF(f') \wedge [\![\text{answer}]\!]([\![\text{every relevant question asked on}]\!](f'(f([\![\text{form}]\!](x))))(x))))]$

Why can't the lower CF *f'* be replaced by a silent quantifier? It has to scope over the lower universally quantified NP (which is not possible through QR, due to the island). And the choice of the card token cannot be left to vary with digits (the digits have to be all on the same card).

Why is *must* decisive? Suppose we dispense of it, then the following ensues:

(31) a. *(The day after the glorious bullfight, when the newspapers came out…)*
Every *torero* was proud of every photograph that showed him in some outfit.

b. $\exists f(CF(f) \wedge \forall x[[\![\text{torero}]\!](x) \rightarrow \exists f'(CF(f') \wedge \forall z[[\![\text{photograph of } x]\!](z) \wedge [\![\text{show}]\!](x \text{ in } f'(f([\![\text{outfit}]\!](x))))(z) \rightarrow [\![\text{was proud of}]\!](x, z)))]]$

On the face of it, this sentence justifies the use of two CFs. For each *torero* (bullfighter), there is one kind of outfit that arouses pride (*el traje de luces*); each *torero* has several copies of it (he wears only one at a time). But an SF could very well capture the same fact: for each *torero* *x*, *x* is proud of every photo showing him in *f*(*x*, outfit). It is only accidentally that all the outfits that arouse pride on that glorious morning are of the type *traje de luces*.

This does not happen when the modal *must* comes in. For the legal or moral prescription cannot be accidentally met by all individuals. In other words, it is crucial that the indefinite *a card* in (28) scopes over the deontic modal. On the other hand, the choice of the token is not legally or morally prescribed, so it would be improper to let the indefinite scope over the modal *entirely*. This can only be achieved through nested choice functions.

Importantly, no skolemized CF can achieve the same result (they do not lend any freedom to the scope of the indefinite): for even though card tokens vary with customers, the *type* of the card is not a matter of individual variation. And even though the association of customers with types of cards is prescribed, the selection of the token is not.

3▣ Consequences

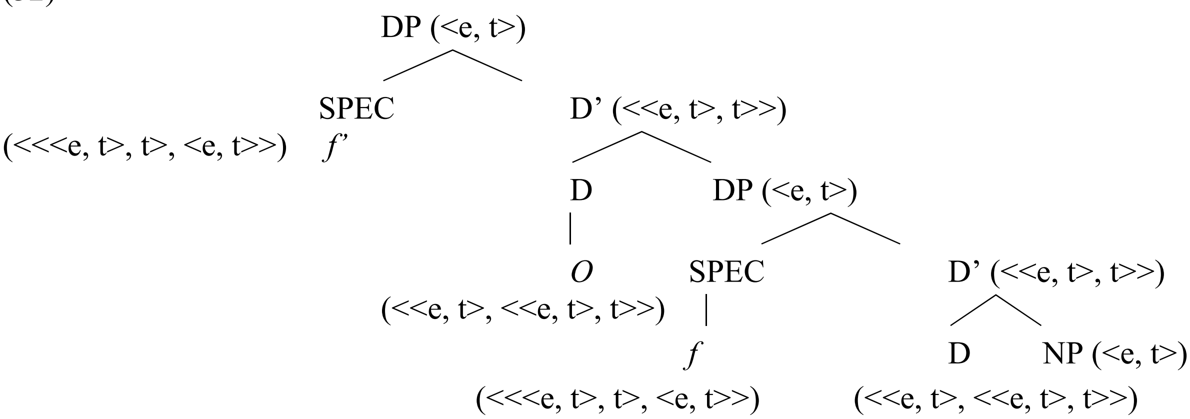
3.1 The first consequence is that a choice function is used for an indefinite with intermediate scope: this is now established, *outside of a DE context*. So the view of the field on which Chierchia (2001) bases its generalization (given in (20)) has to be revised: it may still be true that all specific indefinites have a hidden parameter, but the existential closure is called for in a non DE context. Besides, degrees of specificity emerge: the card type in (28) is maximally specific or referential, whereas the card token is less specific, as it were (true, it is not specific, but *a card* must scope over *every digit*). This lends support to Reinhart's claim to the effect that CFs are freely bound.

3.2 Second, CFs apply to sets of sets and return sets (a singleton set when e.g. a customer has only one credit card) and are thus of type $\langle\langle\langle e, t\rangle, t\rangle, \langle e, t\rangle\rangle$. This is just a confirmation of what we claimed earlier.

But now we know that they are recursive. We would then like the type of the output to be the same as the type of the input. Let's revise the type of CFs: <<e, t>, <e, t>>. This unfortunately is impossible, since we defined choice functions as functions that take a set and return an element of that set. So the type of the input and the output must differ, unless we redefine CFs (a move that we won't take here).

So what can be done, if we are to maintain that a CF applies to the outcome of another CF, *inside DP*? We maintain the original type (<<<e, t>, t>, <e, t>>) and propose that the type of the output of the first CF is raised in order to feed the second CF. Furthermore, the type of the verbal predicate must also be raised in order to apply to the set argument (of type <e, t>). In order to raise the type of the outcome of the first function, we hypothesize an operator *O*:

(32)

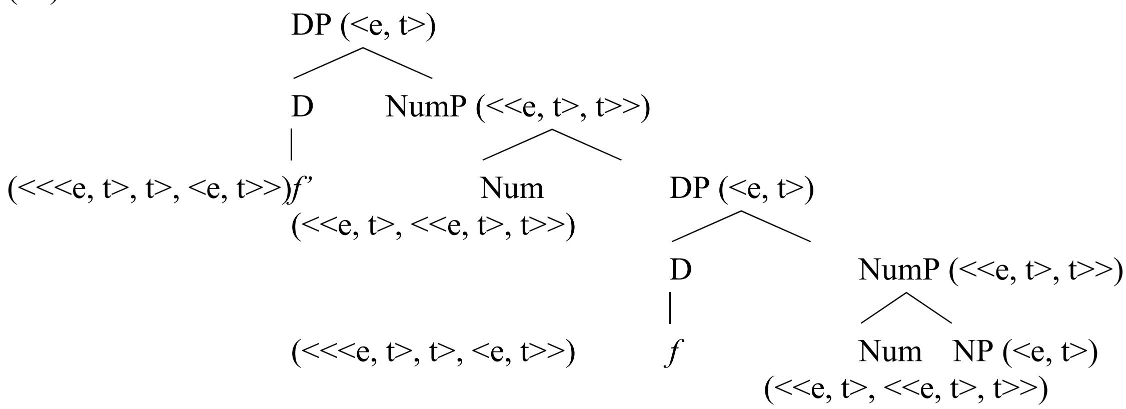


Here the lower *f* is spelled out as *some* or *a* (they are probably heads, but can just as well project and therefore sit in Spec,DP). And the determiner is silent. Our *O* acts as a quantifier: it is thus very akin to a determiner. We are led to say that *O* takes a DP complement (our raising operator makes it impossible to use the theory of multiple specifiers). So Determiners have DP complements. We seem to fall back on the representation we gave for the 'photo ID' sentence: but in fact this is not so, because here it is crucial that a second CF be in the structure, due to the scope(s) we want the indefinite to take. Now in (32) we have DPs that are of the same type as NPs, which seems a bit odd, though hopefully not lethal to our proposal.

Maybe we would rather have *f* sitting in D (and spelled out either as *a*, *some* or ∅[4]). But we would still need a second DP layer (*f'* cannot be in Spec,DP if *f* is in D, otherwise there would be a strange asymmetry). Under this scenario, it is necessary to have an intermediate projection between *f* and NP: syntax affords us one, namely NumP (in fairness, we could have a DP instead, unless we want to disallow Ds taking DP complements).

[4] ∅ before a bare plural.

(33)



Num takes either an NP or a DP as complement (which again is an odd consequence of the recursion). It seems harder to have *f* applying directly to an NP (because NPs are of type <e, t>, unless we are willing to drop this assumption, which might make our proposal more costly than necessary). The two syntactic representations are in fact deeply similar. But do they make the same predictions? Reinhart (1997) convincingly shows that the collective meaning of indefinite is to be ascribed to choice functions (distributive meanings must be ascribed to GQs). And she argues that those DPs that have distributive meanings and cannot take free scope are those that have a modified numeral in them (therefore, those that have their specifier filled by a modified numeral). Only the DPs which don't contain a modified numeral can take free scope. From this, Reinhart concludes that *f* sits in Spec,DP (her reasoning is thus based on a complementary distribution). Winter (2004) links meaning and structure: the D' layer has collective meaning and wide scope, and is ambiguously quantificational; the DP level is unambiguously quantificational, and lacks collective meaning and wide scope; the NP layer is not quantificational, does not have collective meaning, nor wide scope. Under this latter view, a D' with a filled D position is quantificational.

So (32) is more in keeping with Reinhart (*f* is in Spec,DP), while (33) fits well with neither: Winter would probably rejects (33) on the grounds that our DPs are not quantificational, being of type <e, t> (but it seems after all that Winter would not agree on the type we give to *f* in the first place). (32) has the merit that it predicts why the indefinites with modified numerals do not denote choice functions (because Spec,DP cannot be filled twice).

3. Conclusion

We have found evidence that nested choice functions exist: our *credit card* sentences cannot be handled by SFs nor by QR. Strikingly, a non-DE environment lends support to existential closure. Granted, some syntactic assumptions are in order to make nested choice functions get off the ground. These assumptions need to be further explored (as a matter of fact, the structure of DPs is a hugely debated issue). Likewise, more thought must be given to bare choice functions: the set of contexts in which they are necessary no longer is a natural class (at least, DE environments were a natural class). This in turn just makes the riddle of existential closure deeper.

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