Quantifying over Individual Concepts

by

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Abstract

Since Montague (1973), it has been assumed that quantificational DPs must, at least sometimes, be analyzed as quantifiers over individual concepts (i.e., functions from indices of evaluation to individuals). Because the domain of individual concepts is significantly greater than that of individuals, the challenge has always been how to properly constrain quantification over these objects. This dissertation proposes a solution to this problem by developing a novel theory as to how NPs are shifted from predicates of individual into predicates of individual concepts. The idea is that, since NPs are interpreted as restrictors, the nature of this shifting mechanism will constrain quantification. The proposal bears a strong resemblance to the analysis of interrogative clauses of Karttunen (1977): suitable predicates of individual concepts are built from the interaction of a type-shifting operation and existential quantifiers. In three cases studies, I show how this theory can solve old and new puzzles: (i) the different interpretations of sentences of the form '[Det NP] *changed*' (Nathan 2006); (ii) two ambiguities in the interpretation of concealed questions (Heim 1979); and (iii) question intruders, a novel puzzle concerning the interpretation of both embedded interrogative clauses and concealed questions.

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Contents

Chapter 1

Why quantify over individual concepts

This dissertation investigates sentences in which DPs are interpreted as quantifiers over so-called **individual concepts** (ICs), i.e., functions from indices of evaluation to individuals. The major challenge for this treatment of DPs has always been how to determine their domain of quantification: because the set of ICs is considerably larger than that of individuals, it is easy to over-generate readings for sentences containing these DPs if their domain is not properly restricted.

For example, under the proposal of Montague (1973), sentence (1a) would be translated into the formula (1b), which is true at *i* when an IC is a price and is rising at *i*.

(1) a. A price is rising.

b. $\exists u_{\mathsf{se}}.\ \mathbf{price}(u)(i) \wedge \mathbf{rise}(u)(i)$

But when is an IC ever a price? The IC represented in (2) — i.e. the function that maps any *i* to the price of the thing that Ann sees at *i* — is a natural candidate, after all, it always maps an index to something that is a price at that index. However, if that were the case, it would be possible for (1a) to be true in a context in which no price has actually changed: contra our intuitions, all that is needed for (1b) to be satisfied is that Ann changes her gaze to something more expensive.

(2) $\lambda i.\ \iota x[\mathsf{price}(\iota y[\mathsf{see}(y)(\mathsf{ann})(i)])(x)(i)]$

In this dissertation, I propose a solution to this challenge by developing an explicit theory of how NPs can be shifted from predicates of individuals into predicates of ICs that can serve as suitable restrictors for quantifiers. In this theory, the NP *price* will never be true of the IC in (2), for example. The proposal is, in a sense, an extension of the analysis of interrogatives of Karttunen (1977) to NPs: suitable predicates of ICs will be built from the interaction of a type-shifting operator and existential quantifiers. The LFs I propose for NPs interpreted as predicates of individual concepts will in fact bear a strong similarity to the LFs of interrogative clauses. In three case studies, I show how this proposal can naturally account for old and new puzzles.

In this introductory chapter, I first present the motivations that led Montague (1973) to treat DPs as quantifiers over ICs (§1.1). I then discuss in more detail the over-generation issues that his proposal faces (§1.2). Finally, I give a brief overview of what's to come in the remaining chapters of this dissertation (§1.3).

1.1 Motivations

1.1.1 Irreducible predicates of individual concepts

The invalid argument in (3), due to Barbara Partee, is a well-known example of substitution failure. Its invalidity is surprising: the second premise, an identity statement between *the temperature* and *ninety*, should guarantee that truth would be preserved when substituting the first DP for the second – yet the conclusion doesn't follow. This puzzle is often referred to as **the temperature paradox**.

(3) The temperature rises.
The temperature is ninety.
$\not\therefore$ Ninety rises.

The standard solution to failures of substitution of this kind is to claim that the DPs involved are under the scope of an intensional operator. Montague (1973) famously proposed a solution to (3) in which *rise* was treated as such – not as a predicate of individuals[1] but rather as a predicate of functions from indices of evaluation to individuals, i.e., a predicate of ICs:

[1] Here, I take indices of evaluation to be world-time pairs, where times are understood as time intervals (my ontological assumptions concerning time are fairly standard, see von Stechow 2009 for a review). However, it will often be convenient to talk about time-intensionality and world-intensionality separately (for example, the predicate *rise* is only a time-intensional operator — it cares about the values of ICs across times, not worlds). Thus, throughout the dissertation, I sometimes take indices of evaluation to be times, sometimes worlds and sometimes world-time pairs. Because indices are treated the same regardless of what they are, this will not lead to any confusion. I use different variables for each of these: i, j are reserved to world-time pairs, $t, t', \ldots$ to times, and $w, w', \ldots$ to worlds.

(4) $[\![\text{rise}]\!]^t \coloneqq \lambda u_{\text{se}}.\ \textbf{rise}(u)(t)$

This contrasts with the identity copula *be*, which was proposed to be purely extensional: as defined in (5), it simply involves identity between individuals.[2]

(5) $[\![\text{is}]\!]^t \coloneqq \lambda x_{\text{e}}.\lambda y_{\text{e}}.\ y = x$

The lexical entries above are all we need to solve Partee's puzzle – the only thing missing is a compositional analysis of the sentences in (3). The framework I adopt is that of Heim and Kratzer (1998), which has two rules for interpreting complex nodes via function-argument application – the first applies the extension of a node to its sister's **extension**, and the second applies it to its sister's **intension**:

(6) a. **Functional Application** (FA)
$[\![\phi\ \psi]\!]^i = [\![\psi\ \phi]\!]^i = [\![\phi]\!]^i([\![\psi]\!]^i)$ if $[\![\phi]\!]^i :: \sigma\tau$ and $[\![\psi]\!]^i :: \sigma$

b. **Intensional Functional Application** (IFA)
$[\![\phi\ \psi]\!]^i = [\![\psi\ \phi]\!]^i = [\![\phi]\!]^i([\![\psi]\!]_{¢})$ if $[\![\phi]\!]^i :: \text{s}\sigma,\tau$ and $[\![\psi]\!]^i :: \sigma$
where $[\![\phi]\!]_{¢} \coloneqq \lambda j.\ [\![\phi]\!]^j$

Thus, while *rise* composes with its subject via IFA, the identity copula composes with its arguments via regular FA:

(7) $[\![\text{the temperature rises}]\!]^t$
$= [\![\text{rise}]\!]^t([\![\text{the temperature}]\!]_{¢})$ by IFA
$= \textbf{rise}(\lambda t'.\ \iota x[\text{temperature}(t')(x)])(t)$ by lexical entries

(8) $[\![\text{the temperature is ninety}]\!]^t$
$= [\![\text{is}]\!]^t([\![\text{ninety}]\!]^t)([\![\text{the temperature}]\!]^t)$ by FA (x2)
$= (\iota x[\text{temperature}(x)(t)]) = \text{ninety}$ by lexical entries

With the rules in (6), we can translate the sentences in (3) into the formulas in (9). The paradox is resolved: although *the temperature* and *ninety* have identical extensions, truth-preserving substitution is not possible because *rise* combines with their intensions, which are not guaranteed to be identical by the premises.[3]

(9) a. $\textbf{rise}(\lambda t'.\ \iota x[\text{temperature}(x)(t')])(t)$

[2]For ease of exposition, I simplify many aspects of Montague's proposal – because of his commitment to the idea that there is a one-to-one mapping between syntactic categories and semantic types, his lexical entries had to be very complex. My simplifications, however, keep the core of his insights intact.

[3]The intension of *ninety* is a function that maps any index to ninety — this IC can never "rise", as its value is always the same. This is a good result: the sentence *Ninety is rising* is odd to begin with.

b. $(\iota x[\mathsf{temperature}(x)(t)]) = \mathsf{ninety}$

c. $\mathbf{rise}(\lambda t'.\ \mathsf{ninety})(t)$

There are many other predicates which, like *rise*, will give rise to invalid arguments of the form of (3). For example, substituting *rise* for *fall*, *stabilize*, *grow*, *be different*, *remain the same* won't turn Partee's sentences into a valid argument, which suggests that these VPs also denote predicates of ICs. However, the nature of the NPs in these sentences also matters. We still have substitution failure if instead of *temperature* we use other nouns related to numerical values like *price* and *weight*, as well as NPs headed by *number* or *amount*, as shown in (10).

(10) The number of students in my class will grow.
The number of students in my class is ten.
$\not\therefore$ Ten will grow.

However, if the NP is *girl*, the argument is valid:

(11) The girl will grow.
The girl is Ann.
∴ Ann will grow.

This is due to the fact that all the VPs we discussed so far have two different uses: an "extensional" use and an "intensional" one. For example, when the subject of *grow* is a concrete object, as in (11), the VP is interpreted extensionally and the sentence conveys that the size of that object is bigger than it used to.[4] When its subject is a numerical value, as in (10), then the VP is interpreted intensionally and the sentence conveys that the subject picks out a numerical value that is greater than the one it used to pick out. As it is standardly done, I will treat this ambiguity as homophony between two different lexical entries. For example, I take there to be two homonyms *grow* in English, one that is a predicate of individuals (translated into $\mathsf{grow} :: \mathsf{est}$), and another that is a predicate of ICs (translated into $\mathbf{grow} :: \mathsf{se}, \mathsf{st}$):

(12) a. $[\![\text{grow}_{ext}]\!]^t \coloneqq \lambda x_{\mathsf{e}}.\ \mathsf{grow}(x)(t)$

b. $[\![\text{grow}_{int}]\!]^t \coloneqq \lambda u_{\mathsf{se}}.\ \mathbf{grow}(u)(t)$

There was some initial suspicion surrounding Montague's solution to the temperature paradox because the puzzle appeared to be too tied to numbers and measures (e.g., Bennett 1974, Jackendoff 1979). Subsequent work, however, showed that the

[4]Assuming an ontology in which the same individual may inhabit two different time intervals.

phenomenon was much more general, as well summarized in Janssen 1984 (see also Löbner 2020 for a recent overview). For example, the following argument is invalid in the same way as (3) if the first sentence is interpreted as conveying that the table will be replaced by a different table.

(13) The table in the center of the room will change.
The table in the center of the room is the table I made.
$\not\therefore$ The table I made will change.

Again, it is important to point out that the VP *change* also has an extensional use. Under this interpretation, *the table in the center of the room will change* actually implies that there will be some physical property of the table that will change. Throughout this paper, I only take into consideration the intensional use of *change*.

I call VPs like *rise* and *change*, in their intensional uses, **irreducible predicates of ICs**, as it does not seem possible to offer a working analysis of these verbs where they are translated into predicates of individuals. So far, we've been analyzing them by appealing to non-logical constants:

(14) a. $[\![\text{rise}]\!]^t \coloneqq \lambda u_{se}.\ \textbf{rise}(t)(u)$
b. $[\![\text{change}]\!]^t \coloneqq \lambda u_{se}.\ \textbf{change}(t)(u)$

However, their meanings seem to have a logical structure that can be further decomposed: a concept u rises if its value in the beginning of t ($= t_{\text{beg}}$) is smaller than its value at the end of t ($= t_{\text{end}}$), whereas it changes at t if its extension at t_{beg} is different from its extension at t_{end}. I thus define **rise** and **change** as follows:[5]

(15) a. $\textbf{rise} \coloneqq \lambda u.\lambda t.\ u(t_{\text{beg}}) < u(t_{\text{end}})$
b. $\textbf{change} \coloneqq \lambda u.\lambda t.\ u(t_{\text{beg}}) \neq u(t_{\text{end}})$

Implicit in this rendition of the meanings of *change* and *rise* is that they presuppose that their argument is defined at the beginning and at the end of the time of evaluation. This seems accurate: sentence (16) suggests that there was an emperor both before and after the changing event took place on November 15, 1889 — it could not be felicitously uttered when what happened on that date was that the emperor was deposed and Brazil became a republic.

(16) The emperor of Brazil changed on November 15, 1889

[5] In the present chapter, I take indices of evaluation to be intervals of time.

Thus, the following would be a more explicit rendition of **rise** and **change**, where I adopt the notation for presuppositions from Heim and Kratzer (1998):

(17) a. $\textsf{\textbf{rise}} \coloneqq \lambda t.\lambda u : t_{\mathsf{beg}}, t_{\mathsf{end}} \in \mathsf{dom}(u).\ u(t_{\mathsf{beg}}) < u(t_{\mathsf{end}})$

b. $\textsf{\textbf{change}} \coloneqq \lambda t.\lambda u : t_{\mathsf{beg}}, t_{\mathsf{end}} \in \mathsf{dom}(u).\ u(t_{\mathsf{beg}}) \neq u(t_{\mathsf{end}})$

What we can conclude from Partee's puzzle, then, is that not all VPs can be analyzed as predicates of individuals – some of them are intensional with respect to their subject position and need therefore to be analyzed as predicates of ICs.

1.1.2 Enter quantificational DPs

The solution to the temperature paradox we just sketched was fairly simple: all we really needed was to assume that *rise* was a predicate of ICs. However, the puzzle posed by irreducible predicates of ICs goes beyond the basic sentences from Partee's paradox. Once we consider data with quantificational DPs, we see that many other parts of the grammar will have to be fine-tuned.

Montague (1973) illustrated the issue by presenting the following argument, which is analogous to Partee's but differs from it in that it involves unambiguously quantificational DPs instead of definite descriptions:

(18) A price rises.
Every price is a number.
$\not\therefore$ A number is rises.

Like Partee's original example, the above argument has the form of a valid argument, yet the conclusion doesn't follow.

Our assumptions so far do not permit us to even properly interpret the first premise of (18): if *a price* is translated into the function in (19), it cannot directly compose *rise*, as its argument must be a function of type et.

(19) $[\![\text{a price}]\!]^t = \lambda f_{\mathsf{et}}.\ \exists x_{\mathsf{e}}.\ \mathsf{price}(x)(t) \wedge f(x)$

It is still possible to generate an interpretable LF for the sentence *a price rises*, however. To show how this can be done, I first review how movement chains are interpreted in Heim and Kratzer 1998. As shown in (20), when an XP within a YP moves to the edge of the structure, two operations apply: (i) a trace $t_{n,\alpha}$ is left behind, where n is an index and α is the trace's semantic type; and (ii) an operator λ_n is merged to YP before XP is. The rule for interpreting traces (and pronouns) and the one for interpreting constituents of the form '$\lambda_n\ \phi$' are shown in (21).

(20) $[_{\text{YP}} \ldots \text{XP} \ldots] \rightarrow [\text{XP}\ [\lambda_1\ [_{\text{YP}} \ldots t_{1,\alpha} \ldots]]]$

(21) a. **Pronoun and traces**
$[\![t_{n,\alpha}]\!]^{g,i} := [\![pro_{n,\alpha}]\!]^{g,i} := g_n$ where $g_n :: \alpha$

b. **Predicate abstraction** (PA)
$[\![\lambda_n\ \phi]\!]^{g,i} := \lambda x.\ [\![\phi]\!]^{g^{[n \mapsto x]},i}$

The first premise of (18) could thus be interpreted as follows: if *a price* QRs and leaves behind a trace of type e, then its trace may compose with *rise* via IFA and PA interprets sister node of *a price* as a predicate of individuals. This is illustrated below:

(22) $[\![\text{a price}\ \lambda_1[t_{1,\text{e}}\ \text{rises}]]\!]^t$
$= [\![\text{a price}]\!]^t(\lambda x.\ [\![t_{1,\text{e}}\ \text{rise}]\!]^{t,g^{[1 \mapsto x]}})$ by FA & PA
$= [\![\text{a price}]\!]^t(\lambda x.\ [\![\text{rise}]\!]^t(\lambda t'.\ [\![t_{1,\text{e}}]\!]^{t',g^{[1 \mapsto x]}}))$ by IFA
$= [\![\text{a price}]\!]^t(\lambda x.\ \textbf{rise}(\lambda t'.\ x)(t))$ by lexical entries
$= \exists x.\ \text{price}(x)(t) \wedge \textbf{rise}(\lambda t'.\ x)(t)$ by lexical entries
$= \exists x.\ \text{price}(x)(t) \wedge x < x$ by def. of **rise**

The issue, of course, is that these are not the correct truth conditions of the sentence. Given our definition of **rise**, the formula above can never be true: **rise**(t) can only be true an IC u when $u(t_{\text{beg}})$ and $u(t_{\text{end}})$ are different individuals, but in the formula above **rise**(t) is applied to an IC that has the same value across all indices. This follows from the fact that traces are rigid designators.[6]

A possible solution could be to re-analyze *rise* as a predicate of intensions of generalized quantifiers, as shown in (23). Suppose, for the sake of argument, that RISE is a non-logical constant.

(23) $[\![\text{rise}_Q]\!]^t := \lambda Q_{\text{s,ett}}.\ \text{RISE}(Q)(t)$

This would allow us to account for (18) like we accounted for Partee's original example: the sentences would be translated into the formulas in (24), and substitution wouldn't be truth preserving since the intensions of *a price* and *a number* are not guaranteed by any of the premises to be identical.

(24) a. $\text{RISE}(t)(\lambda t'.\lambda f_{\text{et}}.\ \exists x_{\text{e}}.\ \text{price}(x)(t') \wedge f(x))$

b. $\forall x.\ \text{price}(x)(t) \rightarrow \exists y.\ \text{number}(y)(t) \wedge x = y$

c. $\text{RISE}(t)(\lambda t'.\lambda f_{\text{et}}.\ \exists x_{\text{e}}.\ \text{number}(x)(t') \wedge f(x))$

[6] The same issue would arise even under certain theories in which traces are more complex syntactic objects, such as Fox 2002, since traces are treated as "partial" rigid designators.

Nonetheless, this analysis is untenable: sentence (25) has a reading in which *every* scopes over the disjunction of VPs, as it can be true when half of the prices is rising and the other half is dropping. The analysis of *rise* as a predicate of intensions of generalized quantifiers would not be able to account for this reading, since it would force semantic reconstruction of the quantificational DP under disjunction, as shown in (26).

(25) Every price is either rising or dropping.

(26) $[\![\text{rise}_Q]\!]^t \sqcup [\![\text{drop}_Q]\!]^t(\lambda i.\ [\![\text{every price}]\!]^i)$
$= \mathsf{RISE}(\lambda i.\ [\![\text{every price}]\!]^i)(t) \vee \mathsf{DROP}(\lambda i.\ [\![\text{every price}]\!]^i)(t)$

Rather than changing the meaning of *rise*, Montague's solution was to analyze DPs as quantifiers over ICs. His proposal has two key features: (i) quantificational determiners are treated as relations between predicates of ICs; and (ii) NPs are also translated into predicates of ICs.

(27) $[\![\text{a}]\!]^t \coloneqq \lambda U_{\mathsf{se,t}}.\lambda V_{\mathsf{se,t}}.\ \exists u_{\mathsf{se}}.\ U(u) \wedge V(u)$

(28) $[\![\text{price}]\!]^t \coloneqq \lambda u_{\mathsf{se}}.\ \textbf{price}(u)(t)$

The sentences in (18) can then be straightforwardly translated into the formulas in (29). The argument is correctly predicted to be invalid: the conclusion doesn't follow because, even if every price IC is co-extensional with a number IC, we cannot conclude that any price IC is also a number IC – all the formulas in (29) can be true when there is no IC that both $[\![\text{price}]\!]^t$ and $[\![\text{number}]\!]^t$ are true of.

(29) a. $\exists u.\ \textbf{price}(u)(t) \wedge \textbf{rise}(t)(u)$
b. $\forall u.\ \textbf{price}(u)(t) \wedge \exists v.\ \textbf{number}(v)(t) \wedge u(t) = v(t)$
c. $\exists u.\ \textbf{number}(u)(t) \wedge \textbf{rise}(t)(u)$

In sum, to fully capture the truth conditions of sentences with VPs like *rise* and *change*, it is not enough to analyze them as predicates of ICs – we must also fine-tune our treatment of quantificational DPs as well as NPs so they can smoothly compose with those VPs.

One could to call into question the need to treat NP as predicates of ICs. All we needed to account for the invalidity of (18) was to treat quantificational DPs as generalized quantifiers ranging over ICs – Montague's compositional proposal is just one of many ways of arriving at this result. For example, we could have treated quantificational determiners as functions from predicates of individuals to generalized quantifiers ranging over ICs:

(30) $[\![\text{a price rises}]\!]^t = [\![\text{a}]\!]^t(\lambda x_{\text{e}}.\ [\![\text{price}]\!]^t(x))(\lambda u_{\text{se}}.\ [\![\text{rises}]\!]^t(u))$

Frana (2017), however, provides independent evidence for the analysis of NPs as predicates of ICs. The evidence comes from sentences in which irreducible predicates of ICs are inside a relative clause:

(31) A price that changed rose.

Assuming that the relative clause in (31) is translated as in (32), it is not clear how the NP *price that changed* would be interpreted if *price* wasn't also a predicate of individual concepts.

(32) $[\![\text{that changed}]\!]^t = [\![\text{change}]\!]^t = \lambda u_{\text{se}}.\ \textbf{change}(u)(t)$

(33) $$\begin{aligned}[\![\text{price that changed}]\!]^t &= [\![\text{price}]\!]^t \sqcap [\![\text{change}]\!]^t \\ &= \lambda u_{\text{se}}.\ \textbf{price}(u)(t) \wedge \textbf{change}(u)(t)\end{aligned}$$

On the other hand, as shown in (33), under Montague's analysis, we can just intersect the relative clause with its head, as it is standardly assumed.

1.2 Problems

The fragment of Montague 1973 is able to correctly invalidate the temperature paradox as well as other analogous invalid arguments with quantificational DPs. However, in many ways the proposal seems incomplete: *a governor* is translated into the generalized quantifier in (34), but the proposal is not explicit about what ICs are in its domain – after all, nothing is said about which ICs *governor* should be true of.

(34) $[\![\text{a governor}]\!]^t = \lambda V_{\text{se,t}}.\ \exists u_{\text{se}}.\ \textbf{governor}(u)(t) \wedge V(u)$

Consider the two arguments in (35) and (36): while the first is valid, the second isn't. The premise of (36) can be true when no state changed its governor but the person who used to be the richest governor lost all its fortune and became the poorest governor. Under these circumstances, the premise would be true but the conclusion would still be judged as false (contrast (36) with the valid argument *The richest governor hates clam chowder* ∴ *A governor hastes clam chowder*).

(35) The governor of Rio de Janeiro changed.
∴ A governor changed.

(36) The richest governor changed.
$\not\therefore$ A governor changed.

The difference between (35) and (36) seems to follow from the fact that the IC *the governor of Rio de Janeiro*, but not the IC *the richest governor*, is in the domain of the quantifier *a governor*. Therefore, to the extent we want to explain the contrast between these two arguments, is not enough to simply translate *a govenor* into (34) without an explicit proposal as to which ICs this quantifier ranges over and/or which ICs the noun *governor* is true of.

Nathan (2006) makes the same point with an example similar to the following. Table 1.1 displays the New England governors — i.e., the governors of the US states of Connecticut (Conn.), Maine (Me.), Massachusetts (Mass.), New Hampshire (N.H.), Rhode Island (R.I.), and Vermont (Vt.) — ranked by height in 2022 and 2023. Crucially, the governor of Conn. changed from 2022 to 2023, which resulted in a change in the ranking. Sentence (37) is not judged to be true under these circumstances: the intuition is that only **one** governor changed, yet it is true that the tallest New England governor changed, and that the second tallest New England governor changed, etc.

	1	2	3	4	5	6
2022	Ann Conn.	Beth Me.	Cleo Mass.	Deb N.H.	Ella R.I.	Flo Vt
2023	Beth Me.	Cleo Mass.	Deb N.H.	Ella R.I.	Flo Vt	Gia Conn

Table 1.1: New England governors ranked by height, 2022 & 2023

(37) Every New England governor changed.

Again, this points towards the conclusion that while an IC like *the governor of Conn.* are in the domain of a quantifier like *every New England governor*, the IC *the tallest New England governor* is not.

The discussion is this section is meant to show that Montague's analysis of DPs as quantifiers over ICs needs to be complemented with a proposal as to how the domain of these quantifiers is determined. It could be that Montague's proposal is exactly what the grammar delivers, and that the data discussed above is to be accounted for by a pragmatic theory of how quantifier domain are contextually determined. In this dissertation, however, I pursue the hypothesis that the grammar itself heavily restricts the kinds of ICs a DP can range over. In the following chapters, I go through three different case studies which all point toward the conclusion that linguistic form — specifically, the form of NPs — play a crucial role in determining a DP's domain of quantification.

1.3 Overview of the dissertation

In the following chapters, I develop a proposal concerning the interpretation of DPs where the basic meaning of an NP is taken to be a predicate of individuals and that a very restrictive mechanism is able to shift NPs into predicates of ICs. The goal is to devise a shifting operation through which *governor* can be true of the IC *the governor of Rio de Janeiro* but false of the IC *the richest governor*. The resulting theory draws inspiration from the analysis of the semantics of interrogative clauses of Karttunen (1977): just like propositions can be turned into suitable question denotations (i.e., sets of propositions) through the interaction of a type-shifting operation and existential quantifiers, so can NPs be turned into predicates of ICs.

This dissertation is organized as follows. Chapter 2 is devoted to providing an account of an observation due to Nathan 2006 concerning the interpretations of sentences of the form '[D NP] *change*.' His observation is that such sentences will have different interpretations depending on formal properties of the NP. In that chapter, I present my theory of how NPs are shifted into predicates of ICs, and show how it can naturally the facts observed by Nathan. In chapter 3, I focus on so-called **concealed questions**, i.e., DPs that can be paraphrased as embedded questions, and provide a novel account of two ambiguities identified by Heim 1979. Although the analysis builds on previous proposals by Frana (2017) and Romero (2005), I show how we can use the theory developed in chapter 2 to account for these ambiguities in a way that is not only simpler but also more empirically adequate than these previous proposals. Finally, in chapter 4, I discuss a novel puzzle concerning the interpretation of embedded interrogative clauses and concealed questions: **question intruders**. Intruders are parts of a question that are simply not interpreted within the scope of the question-embedding predicate. Because, in my proposal, NPs in concealed questions and interrogative clauses have a similar structure, it is possible to provide a unified analysis of intruders.

The chapters were initially written as independent papers, and therefore they can be read in any order. Because of this, some redundancy was unavoidable.

Chapter 2

From NPs to predicates of individual concepts

Sentences such as (1) led Montague (1973) to analyze quantificational DPs as quantifiers over individual concepts (ICs), i.e., functions from indices (times, in this chapter) to individuals. Under one of its readings, (1) doesn't convey that every person who is a governor has the property of having changed — rather, the intuition is that this sentence is true whenever the extension *the governor of* α is different than what it was before, for every α that denotes some contextually relevant state.

(1) Every governor changed.
$\rightsquigarrow$ *for every z, the governor of z changed*

Under Montague's proposal, (1) would be translated into the formula in (2), which involves quantification over ICs. The main issue with this proposal is that, because the NP *governor* is mapped to a non-logical constant of type se, st (i.e., **governor**), it is unclear whether it truly capture our intuitions concerning the meaning of this sentence — after all, we are never told which ICs should count as a governor.

(2) $\forall u_{\mathsf{se}}.\ \textbf{governor}(u)(t) \rightarrow \textbf{change}(u)(t)$

One could argue Montague's analysis is in fact sufficient — that's all that the semantics should deliver, and what we're lacking is a theory of the pragmatic constraints on quantification domains. Nathan (2006), however, observed certain properties concerning the meaning of sentences with DPs interpreted as quantifiers over ICs that challenge this line of argumentation. His observation, which I dub **Nathan's observation**, points toward the conclusion that not only must quantification over ICs be severely constrained, but also that the nature of most of these constraints must be grammatical rather than pragmatic.

Nathan's observation is that sentences of the form '[Det NP] *change*' may have two kinds of interpretations depending on formal properties of the NP. Sentence (1), for example, can be true if uttered in a situation in which the set of governors remains constant throughout time but the governors all swap positions in such a way that no state has the same governor that it used to have. Following Schwager (2007), I call this the **pointwise-change** interpretation. To judge the next sentence, suppose it is taken for granted (i.e., contextually entailed) that there is such a thing as the council of governors, a group composed of all governors and no one else. With that in mind, observe that sentence (3) differs from (1): it cannot be true in the scenario in which the governors just swap positions — it requires all governors to be replaced by someone who wasn't a governor before (i.e., the set of governors has to be completely different). Following Schwager (2007), I call this the **set-change** interpretation.

(3) Every member of the council of governors changed.
$\rightsquigarrow$ *every member of council of governors was replaced by someone who wasn't a member of the council of governors*

It is quite puzzling that sentences (1) and (3) should have different truth conditions, especially since the NPs *governor* and *member of the council of governors* are meant to be contextually equivalent. Nathan (2006) observed that the crucial difference here is that *governor* is a relational noun without an overt internal argument. Although I will show that there are other properties that an NP may have that will allow a sentence to get a pointwise change interpretation, Nathan's assessment generalizes beyond the sentences in (1) and (3): there is indeed a correlation between pointwise change and whether the head noun is relational. Thus, under the hypothesis that the DPs in these sentences are translated into generalized quantifiers over ICs, Nathan's observation shows us that formal properties of NPs determine the kinds of ICs that are in a DP's domain of quantification.

The main goal of the present chapter is to develop a constrained theory of quantification over ICs that can account for Nathan's observation. I identify the source of these constraints in the interpretation of the NPs: like Nathan (2006), I depart from Montague (1973) in that I take the basic meaning of NPs to be predicates of individuals, but they can be turned into predicates of ICs via the restricted application of type-shifting operations performed by a phonologically null operator.

Differently from Nathan (2006), I propose a single mechanism for turning NPs into predicates of ICs. The differences between (1) and (3) will follow naturally from the different internal structures of the NPs involved. The proposal, in a nutshell is as follows. NPs are turned into predicates of ICs through the phonologically null operator $\uparrow_{\mathsf{se}}$, whose building blocks are type-shifting operations from Partee 1986, iota and ident. In (4), I show the result of applying $\uparrow_{\mathrm{IC}}$ to the NP *price of milk*.

(4) $[\![\uparrow_{\mathsf{se}}]\!]^{t}(\lambda t'.\, [\![\text{price of milk}]\!]^{t'}) = \lambda u_{\mathsf{se}}.\, u = (\lambda t'.\, \iota x[\mathsf{price\text{-}of\text{-}milk}(x)(t')])$

Pointwise change interpretations arise when the internal argument of a relational noun is existentially closed from above $\uparrow_{\mathsf{se}}$, as shown in (5): the NP is interpreted as the predicate true of ICs of the form *the governor of* α, for some α.

(5) EX λ_1 [$\uparrow_{\mathsf{se}}$ [$t_{1,\mathsf{e}}$ governor]]
$\rightsquigarrow \lambda u_{\mathsf{se}}.\, \exists z_{\mathsf{e}}.\, u = (\lambda t'.\, \iota x[\mathsf{governor}(z)(x)(t')])$

Because non-relational nouns do not have an internal argument to be existentially bound, the above strategy for creating predicates of ICs will not work for them. I argue that set readings are derived instead via the interaction of the shifting operation and existential closure of an NP modifier[1]:

(6) EX λ_1 [$\uparrow_{\mathsf{se}}$ [$t_{1,\mathsf{et}}$ member of the council of governors]]
$\rightsquigarrow \lambda u_{\mathsf{se}}.\, \exists A_{\mathsf{et}}.\, u = (\lambda t'.\, \iota x[\mathsf{member\text{-}of\text{-}council\text{-}of\text{-}governors}(x)(t') \wedge A(x)])$

Although it may not immediately obvious why, I show that assuming that the NPs *governor* and *member of the council of governors* are interpreted as above correctly captures these sentences' truth conditions.

The proposal I advance bears strong resemblance to the theory of the semantics of interrogative clauses in Karttunen (1977), in that suitable predicates of ICs, just like suitable meanings for *wh*-interrogatives, are created via the interaction of a type-shifting operation and existential quantifiers.

The chapter is structured as follows:§2.1 presents Nathan's observation and offers a new perspective on the puzzles it raises; §2.2 lays out the main proposal and shows how it can account for Nathan's observation; §2.3 advances some necessary further enrichments of the proposal; §2.4 discusses previous attempts to account of Nathan's observation; §2.5 concludes.

[1]Not to be confused with the quantifier's silent domain restriction. As discussed later in the chapter, I follow von Fintel (1994) in taking silent domain restriction to be an argument of the determiner rather than a sister to the noun as in Stanley and Szabó 2000.

2.1 A new perspective on Nathan's observation

In this section, I discuss observations made by Nathan (2006) concerning the truth conditions of sentences of the form 'DP *change*,' which make an even stronger case for the need of constraining quantification over IC. Furthermore, these observations point toward the conclusion that these constraints are imposed by grammar itself rather than pragmatics: they show that the kinds of ICs a DP quantifies over are determined by the linguistic form.

What I call **Nathan's observation** is the finding that sentences of the form 'DP *change*' may have two kinds of interpretations. After formalizing what these are and discussing their distribution, I translate them into constraints on predicates of ICs that can restrict quantificational DPs. The discussion will allow us to see Nathan's observation under a new perspective: (i) I propose two constraints on suitable predicates of ICs and (ii) I suggest that the two different interpretations Nathan identified are follow from where in the NP these constraints are evaluated.

2.1.1 Nathan's observation

The key contrast identified by Nathan (2006), which was demonstrated above by contrasting (1) and (3), can also be illustrated by comparing sentences (7) and (8). Suppose that, at our university, the academic council is the composed of the deans of all schools. Now, consider the scenario illustrated in Figure 2.1: next year, the current deans will all swap positions, but, crucially, the set of school deans/members of the academic council will remain the same. Under such a scenario, sentence (7) is judged to be true, but sentence (8) isn't.

	this year	next year
dean of school of humanities	Ann	Beth
dean of school of science	Beth	Cleo
dean of school of engineering	Cleo	Deb
dean of school of architecture	Deb	Ann

Figure 2.1: Academic council scenario

(7) Every school dean will change.

(8) Every member of the academic council will change.

While (7) is true as long as no school dean remains the dean of the same school, sentence (8) requires the entire extension of the NP *member of the academic council* to be different. These truth conditions are rendered in (9). Under the terminology of Schwager (2007), (7) allows for a **pointwise change** (PC) interpretation, while (8) only has a **set change** (SC) interpretation.

(9) a. **Truth conditions of (7)**
$\forall z.\ \mathsf{school}(z)(t) \rightarrow \iota x[\mathsf{dean}(z)(x)(t_{\mathsf{beg}})] \neq \iota y[\mathsf{dean}(z)(y)(t_{\mathsf{end}})]$
"the dean of every school will change"

b. **Truth conditions of (8)**
$\forall z.\ \mathsf{member.of.ac}(z)(t_{\mathsf{beg}}) \rightarrow \neg\mathsf{member.of.ac}(z)(t_{\mathsf{end}})$
$\wedge\ |\{\ x \mid \mathsf{member.of.ac}(x)(t_{\mathsf{beg}})\}| \leq |\{\ x \mid \mathsf{member.of.ac}(x)(t_{\mathsf{end}})\ \}|$
"every member of the a.c. will be replaced by someone who isn't one"[2]

Under Montague's proposal, these two sentences would be translated into the formulas in (10). Given that these formulas have the same logical structure, the differences between (7) and (8) would have to be explained in terms of the differences in the constants **school.dean** and **member.of.ac**. Since no constraints are imposed on their possible values, the distinction is left unaccounted for.

(10) a. $\forall u_{\mathsf{se}}.\ \mathbf{school.dean}(u)(t) \rightarrow \mathbf{change}(u)(t)$

b. $\forall u_{\mathsf{se}}.\ \mathbf{member.of.ac}(u)(t) \rightarrow \mathbf{change}(u)(t)$

The distribution of PC and SC readings can only be explained by properties of the NPs involved — after all, the only difference between (7) and (8) is in their NPs, which, in our context, are even co-extensional. Nathan (2006) proposed that the distribution of these interpretations is determined by the nature of the head noun: the PC interpretation arises with relational nouns whose internal argument is not pronounced, and, if these conditions aren't met, we get the SC interpretation. This characterization correctly predicts the distribution of these readings in (7) and (8): *dean* is a relational noun without a pronounced internal argument, whereas *member* is a relational noun with an internal argument. In §2.2, I discuss other circumstances under which PC interpretations become available, but for now I will assume that Nathan's characterization is fully correct.

The PC *vs* SC distinction cuts across all kinds of quantificational determiners, not just *every*. It is simple to schematize these readings given any determiner, though. For the PC reading, we can rely on the paraphrase alluded above: '[Det NP] *change*' will

[2]The second conjunct of the formula in (9b) guarantees that the sentence won't be true if certain members are removed and not replaced by anyone new (but note that the sentence can still be true if all members are replaced and some extra ones are added).

have the same truth conditions as '[the NP [of Det NP′]] *change*', e.g. *most school deans changed* can be paraphrased as *the deans of most schools changed*. The SC readings, in turn, can be paraphrased as follows: '[Det NP] *change*' is roughly the same as '[Det NP] ceased to be NP' (+ a cardinality condition, see fn.2), e.g., *most members of the academic council changed* is roughly the same as *most member of the academic council ceased to be members of the academic council*. The following is a formal rendition of this systematization:

(11) a. **Pointwise Change**
$$[\![\text{Det NP change}]\!]^t = [\![\text{Det}]\!]^t(\lambda z.\ \exists x.\ [\![\text{NP}]\!]^t(z)(x))$$
$$(\lambda z.\ \iota x[[\![\text{NP}]\!]^{t_{\text{beg}}}(z)(x)] \neq \iota y[[\![\text{NP}]\!]^{t_{\text{end}}}(z)(x)])$$

b. **Set Change**
$$[\![\text{Det NP change}]\!]^t = [\![\text{Det}]\!]^t([\![\text{NP}]\!]^{t_{\text{beg}}})(\lambda x.\ \neg[\![\text{NP}]\!]^{t_{\text{end}}}(x))$$
$$\wedge\ |[\![\text{NP}]\!]^{t_{\text{beg}}}| \leq |[\![\text{NP}]\!]^{t_{\text{end}}}|$$

It should be noted that sentences that most naturally get a PC reading may also have an SC reading. For instance, both of the following sentences could be truthfully uttered in the given scenario:

(12) **Scenario**. The current school deans are Ann, Beth, Cleo and Deb, but we don't know which person is the dean of which school. Next year, Ann and Beth will switch positions and Cleo will replaced by someone new.

a. Exactly one school dean will change next year.

b. Three school deans will change next year.

Sentence (12a) is can be judged as true because there is exactly one person who is a school dean now who but won´t be next year (SC interpretation). Sentence (12b) can be judged as true because there are three schools who will have a different dean next year (PC interpretation). Given that both of these are true, we must conclude that NPs that give rise to PC readings may also give rise to the SC readings.[3]

This doesn't mean we have to change the schema in (11), however. As it is well known, relational nouns can easily be detransitivized and most compositional treatments of the phenomenon resort to an operation that existentially binds their internal argument (Barker 2011). I propose that this operation is performed by a phonologically null operator EX, defined below in (13), which is defined in terms of the polymorphic

[3]In §2.2.5 I show that, if the context is rich enough, NPs that appear to only give rise to the SC reading may also give rise to the PC reading.

function **Ex** which existentially binds the first argument of any function of boolean type.

(13) $[\![\text{EX}]\!]^t \coloneqq \lambda f_{\alpha\beta}.\ \textbf{Ex}(f)$

(14) $$\textbf{Ex}(f_{\alpha\beta}) \coloneqq \begin{cases} \exists x_\alpha.\ f(x) & \text{if } \beta = \mathsf{t} \\ \lambda y_\alpha.\ \textbf{Ex}(\lambda x_\sigma.\ f(x)(y)) & \text{if } \beta = \sigma\tau \end{cases}$$

We can thus keep the schema in (11) for now: (12a) can have an SC interpretation because *school dean* was destransitivized by EX, as shown in (15).

(15) $[\![\text{EX school dean}]\!]^t = \lambda x_{\mathsf{e}}.\ \exists z.\ \mathsf{school\text{-}dean}(z)(x)(t)$

2.1.2 Set Change via Identity Preservation

In the previous section, I presented arguments in favor of the claim that sentences of the form '[Det NP] changed' involve quantification over ICs. Therefore, the PC *vs* SC distinction must be stated in terms of a distinction between different kinds of ICs that DPs may quantify over. In this subsection, I propose two constraints on the domains of quantification of DPs that will derive SC interpretations.

First, consider the scenario in Figure 2.2, which illustrates changes in the decoration of a wall: from 2022 to 2023, the flag of Italy was replaced by the flag of Tanzania, the flag of Brazil just changed places, and the flag of Japan was replaced by the flag of Korea. Given these circumstances, (16a) is false, but (16b) isn't:

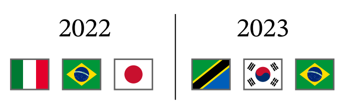


Figure 2.2: Flag scenario

(16) a. Every$_U$ flag on the wall changed.

b. Exactly$_U$ two flags on the wall changed.

The sentences above have the SC interpretation: (16a) would only be true if every single flag had been replaced, but only two flags were.[4]

We can investigate constraints on quantification over ICs by considering the (im)possible values for the silent domain restriction U in the sentences in (16). The set in (17)

[4] Since *flag* is a relational noun, the sentences in (16) also have a PC reading. This interpretation would call for the unlikely situation in which flags are changing the country they are the flag of.

is a suitable value for *U*, as *change* is true of exactly two of its members: the IC *the flag of Italy or Tanzania on the wall* (i.e., the IC that maps any interval *t* to the unique flag that is on the wall at *t* and is the flag of Italy or the flag of Tanzania at *t*), and the IC *the flag of Japan or South Korean on the wall* – these are the two ICs in (17) that have different values in 2022 and in 2023. Therefore, if *U* is (17), sentences (16a) and (16b) have their predicted truth value.

(17) **Suitable value for *U***

{ [2022 ↦ , 2023 ↦ ] (*the flag of Italy or Tanzania on the wall*)
[2022 ↦ , 2023 ↦ ] (*the flag of Brazil*)
[2022 ↦ , 2023 ↦ ] (*the flag of Japan or S.K. on the wall*) }

The set in (18), in contrast, is an unsuitable value for *U*, even though identification by position is a fairly salient method of identification. If it was a potential value for *U*, we'd predict the opposite judgments for the sentences in (16), since *change* is true of all its members.

(18) **Unsuitable value for *U* I**

{ [2022 ↦ , 2023 ↦ ] (*the leftmost flag on the wall*)
[2022 ↦ , 2023 ↦ ] (*the middle flag on the wall*)
[2022 ↦ , 2023 ↦ ] (*the rightmost flag on the wall*) }

The key difference between (18) and (19) is that, in the unsuitable set of ICs, two different ICs pick out the flag of Brazil in 2022 and in 2023, respectively. But why would the same IC have to pick out the Brazilian flag at both indices?

The set in (19) is another unsuitable value for *U*, as it predicts both sentences in (16) to be false: only one of its members changed. The relevant contrast between (19) and our good set (17) is that one and the same IC picks out the flag of Japan in both 2022 and 2023. The question then is why is it required on the one hand for one and the same IC to pick out the Brazilian flag but it is not allowed for one and the same IC pick out the Japanese flag.

(19) **Unsuitable value for *U* II**

{ [2022 ↦ , 2023 ↦ ] (*the flag of Italy or Tanzania on the wall*)
[2022 ↦ , 2023 ↦ ] (*the flag of Brazil*)
[2022 ↦ , 2023 ↦ ] (*the flag of Japan*) }

If we just look at the sets in (17), (18), and (19) on their own, it is impossible to make sense of these facts. A pattern emerges only when we take into consideration the NP *flag on the wall*. The different statuses that the Brazilian flag and the Japanese flag have can then be understood: only the Brazilian flag is in the extension of the NP at both indices. I thus identify two properties that are jointly satisfied in (17) and only (17): (i) the values of all its ICs are always flags on the wall, and (ii) for every x that is a possible flag on the wall, there's a unique member of the set that ever picks out x. The unsuitable set (18) satisfies (i) but not (ii), while the unsuitable set in (19) satisfies (ii) but not (i).

I thus formalize two constraints that an IC in the domain of quantification of a DP must have **given the intension of an NP**. The first one is called **Property Preservation**: u is property preserving relative to an NP intension iff $u(t)$ is in the extension of NP at every index t for which u is defined.[5] The second one is called **Identity Preservation**: u is identity preserving relative to an NP intension iff for every x that is a possible extension of u, if x is in the extension of NP at some interval t, then the value of u at t is x. These constraints are defined below:

(20) **Property Preservation**
$\mathbf{p.pres}(N_{\mathsf{set}})(u_{\mathsf{se}}) \coloneqq \forall t \in \mathsf{dom}(u).\ u(t) \in N(t)$

(21) **Identity Preservation**
$\mathbf{id.pres}(N_{\mathsf{set}})(u_{\mathsf{se}}) \coloneqq \forall t_1, t_2 \in \mathsf{dom}(u).\ u(t_1) \in N(t_2) \to u(t_1) = u(t_2)$

The IC *the flag of Japan* in (19) is not property preserving relative to *flag on the wall*: in 2023, this IC is mapped to the Japanese flag despite not being on the wall at that time. Both of the ICs *the middle flag on the wall* and *the rightmost flag on the wall* in (18) are not identity preserving relative to *flag on the wall*: each of them fails to pick out the Brazilian flag at an interval in which it is still a flag on the wall.

I make the following proposal: an NP may also be interpreted as the predicate true of those ICs that are both property and identity preserving relative to the intension of NP. This is formalized via the metalanguage operator **ic**, defined below:

(22) $\mathbf{IC}(N_{\mathsf{set}}) \coloneqq \lambda u_{\mathsf{se}}.\ \mathbf{p.pres}(N)(u) \wedge \mathbf{id.pres}(N)(u)$

Together, these two constraints give us the SC reading.[6] Sentence (16a) would be translated into the formula in (23):

(23) $\forall u_{\mathsf{se}} \in U.\ \mathbf{IC}([\![\text{flag otw}]\!]_{¢})(u) \to u(t_{\mathsf{beg}}) \neq u(t_{\mathsf{end}})$

For the above formula to be defined, all the ICs in U must be at least defined at t_{beg} and t_{end}. To unpack the above formula, let's assume that the domain of each element of U

[5] Property preservation is contemplated in Nathan 2006 as a sufficient constraint on quantificational domains, but is shown to not be enough.

[6] Almost: (23) is wrongly predicted to be true if some flags are just removed. I address this at §2.3.

only contains t_{beg} and t_{end}. Property Preservation guarantees that all elements of U are flags on the wall at both times, so we can rewrite (23) as:

(24) $$\forall u_{se} \in U.\ [\![\text{flag otw}]\!]^{t_{\text{beg}}}(u_{t_{\text{beg}}}) \land [\![\text{flag otw}]\!]^{t_{\text{end}}}(u_{t_{\text{end}}}) \land \textbf{id.pres}([\![\text{flag otw}_{¢}]\!])(u) \rightarrow u(t_{\text{beg}}) \neq u(t_{\text{end}})$$

Identity Preservation, on the other hand, requires that any IC in U must pick the same entity at both the beginning and the end of the interval of evaluation if that entity is a flag on the wall at both intervals. We can thus rewrite (24) as:

(25) $$\forall u_{se} \in U.\ [\![\text{flag otw}]\!]^{t_{\text{beg}}}(u_{t_{\text{beg}}}) \land [\![\text{flag otw}]\!]^{t_{\text{end}}}(u_{t_{\text{end}}}) \land ([\![\text{flag otw}]\!]^{t_{\text{beg}}}(u_{t_{\text{end}}}) \lor [\![\text{flag otw}]\!]^{t_{\text{end}}}(u_{t_{\text{beg}}})) \rightarrow u(t_{\text{end}}) = u(t_{\text{beg}})) \rightarrow u(t_{\text{beg}}) \neq u(t_{\text{end}})$$

This is the SC reading: an IC can only change values if its value at t_{beg} is no longer a flag on the wall at t_{end}.

2.1.3 Pointwise Change via local Identity Preservation

The requirement that ICs in the domain of a quantifier [Det NP] be identity preserving relative to NP is the main driving force of the SC reading. Effectively, it only allows for an IC to "change" its extension from t_1 to t_2 if its extension at t_1 is no longer in the extension of the NP at t_2. But what about PC interpretations? As we will see now, the ICs involved in this readings seem to violate identity preservation. However, I will argue that this violation is merely apparent – we can still detect Identity Preservation in action even in PC readings.

Consider the following scenario:

	CT	ME	MA	NH	RI	VT
2022	A	B	C	D	E	F
2023	B	C	D	E	F	A

Figure 2.3: Governor scenario

New England is a region in the United States composed of six states: Connecticut (CT), Maine (ME), Massachusetts (MA), New Hampshire (NH), Rhode Island (RI) and Vermont (VT). Now, supposed that from 2022 to 2023, the set of governors of New England remained the same, but they all switched positions, as illustrated in Figure 2.3. Under such circumstances, the following sentence is true:

(26) Every (New England) governor changed.

Given that the above sentence is true, a natural assumption is that the domain of *every governor* is comprised of those ICs expressed by descriptions of the form *the governor of z*, where z is some New England state. These IC are all property preserving relative to EX(*governor*) (detransitivized *governor*), but, crucially, they are **not** identity preserving. Take the IC *the governor of Massachusetts*, for example: in 2022 it picks out C, but its value is different in 2023 even though C is still the governor of some state. If the NP in (26) were interpreted as (27), the sentence would only have an SC interpretation and would therefore be incorrectly predicted to be false in the scenario illustrated in Figure 2.3.

(27) $\mathbf{IC}(\lambda t.\ \mathbf{Ex}([\![\text{governor}]\!]^t))$

Rather than giving up on Identity Preservation as a general constraint on domains of quantification, I pursue a different route. Crucially, *the governor of Massachusetts* **is** identity preserving relative to the NP *governor of Massachusetts*: whenever an individual x is the governor of Massachusetts, the IC *the governor of Massachusetts* will have x as its extension – this IC will never not pick out someone who is not a governor of Massachusetts. In fact, for every IC of the form *the governor of x*, it is the case that it is identity preserving relative to the NP *governor of x*. I thus propose that the NP in (26), under the relevant reading, is not interpreted as (27) but rather as (28), with EX scoping **over** the predicate to which **IC** is applied to.

(28)
$$\begin{aligned}
&\lambda u_{se}.\ \mathbf{Ex}(\lambda z.\ \mathbf{IC}(\lambda t.\ [\![\text{governor}]\!]^t(z)))\\
&= \lambda u_{se}.\ \exists z.\ \mathbf{IC}(\lambda t.\ [\![\text{governor}]\!]^t(z))\\
&= \lambda u_{se}.\ \exists z.\ \mathbf{p.pres}(\lambda t.\ [\![\text{governor}]\!]^t(z)) \wedge \mathbf{id.pres}(\lambda t.\ [\![\text{governor}]\!]^t(z))\\
&= \lambda u_{se}.\ \exists z.\ \forall t_1 \in \mathsf{dom}(u).\ u_1 \in [\![\text{governor}]\!]^{t_1}(z)\\
&\qquad\qquad \wedge \forall t_2 \in \mathsf{dom}(u).\ u_1 \in [\![\text{governor}]\!]^{t_2}(z) \rightarrow u(t_1) = u(t_2)
\end{aligned}$$

The requirement, then, is not that the IC *the governor of Massachusetts* be property and identity preserving relative to the NP EX(*governor*) but rather to the NP *governor of z*, given some z.

The idea I like to advance, then, is that Identity Preservation is active in both SC and PC interpretations. However, it is more locally evaluated in PC interpretations: it must apply to an NP before EX applies to it. Evidence in favor of this proposal can be found once we look at relational nouns that, unlike *governor*, are not "functional" (a relational noun N is functional iff $\forall x_e.\ \exists! y_e.\ [\![\text{N}]\!]^t(x)(y)$).

Consider the following scenario. In the US, each state has two senators – the one who has held the senator seat the longest is called the senior senator, while the other is known as the junior senator. Suppose that from 2022 to 2023, every senior senator of a New Englad state became the junior senator of another New England state. As a consequence, everyone who was a junior senator of a New England state in 2022 became, in 2023, the senior senator of that state. These changes are illustrated in Figure 2.3, where the senior senator of each state appears to the left of the junior senator of that same state. Crucially, the set of New England senators remains the same from 2022 and 2023. Yet, it is possible to truthfully utter sentence (29a) but not sentence (29b).

	CT	ME	MA	NH	RI	VT
2022	A1,A2	B1,B2	C1,C2	D1,D2	E1,E2	F1,F2
2023	A2,B1	B2,C1	C2,D1	D2,E1	E2,F1	F2,A1

Figure 2.4: Senator scenario

(29) a. Half of the (New England) senators changed.

b. Every (New England) senator changed.

The fact that (29b) is judged as false tells us that the ICs *the junior senator of z* or *the senior senator of z*, given some New England state z, are not suitable for the domain of *every New England senator*. This is predicted if the NP in (29b) is interpreted as the predicate in (30). For example, the IC *the junior senator of Massachusetts* is not identity preserving relative to the NP *senator of Massachusetts*: in 2022 it picks out C2 but in 2023 it picks out someone else even though C2 is still a senator of Massachusetts. Thus, the idea that Identity Preservation is still active even in PC interpretations seems to be correct.

(30) $\lambda u_{\mathrm{e}}.\ \exists z.\ \mathbf{IC}(\lambda t.\ [\![\text{senator}]\!]^{t}(z))$

What the discussion in this section has show is that Nathan's observation mostly follows from a single constraint, Identity Preservation. Cases in which it is obviated are shown to be just apparent — the constraint is just evaluated relative to a different predicate. This suggest that there is an operator that takes scope within the DP and imposes the Property and Identity Preservation constraints. This is what I will spell out in the next section.

2.2 From NPs to predicates of individual concepts

In this section, I advance my proposal as to how NPs are shifted into predicates of ICs. The goal is to devise a simple system which pairs sentences to explicit truth conditions and that can furthermore account for Nathan's observation. Given the discussion in the previous section, we can achieve this goal if: (i) this type-shifting operation turns NPs into predicates true of ICs that are property and identity preserving relative to the intensions of these NPs, and (ii) it can take scope at different nodes of an NP.

Differently from Montague (1973), I will neither assume that DPs are always translated into generalized quantifiers over ICs or that NPs are always translated into predicates of ICs. I take natural language determiners to be systematically ambiguous in that they may either involve quantification over individuals or ICs:

(31) a. $[\![\text{the}_\alpha]\!]^t = \lambda f_{\alpha t}.\ \iota a_\alpha[f(a)]$

b. $[\![\text{every}_\alpha]\!]^t = \lambda f_{\alpha t}.\lambda g_{\alpha t}.\ \forall a_\alpha \in f.\ g(a)$

c. $[\![\text{a}_\alpha]\!]^t = \lambda f_{\alpha t}.\lambda g_{\alpha t}.\ \exists a_\alpha \in f.\ g(a)$ where $\alpha = \mathsf{e}$ or $\alpha = \mathsf{se}$

2.2.1 The basic ingredients: iota and ident

I propose that NPs are turned into predicates of ICs via the interaction of (the polymorphic versions of) two type shifting operations from Partee 1986, iota and ident:

(32) a. $\mathsf{iota}_\alpha \coloneqq \lambda f_{\alpha t}.\ \iota x_\alpha[f(x)]$

b. $\mathsf{ident}_\alpha \coloneqq \lambda x_\alpha.\ \lambda y_\alpha.\ y = x$

These two operations are inverses of each other: iota takes a function f and returns the unique object f is true of; while ident takes an object a and returns the function that is only true of a. Thus, $\mathsf{iota}_\alpha(\mathsf{ident}_\alpha(x_\alpha)) = x$ and $\mathsf{ident}_\alpha(\mathsf{iota}_\alpha(f_{\alpha t})) = f$, whenever f is true of only one object.

In (33), I show how these operations can turn an NP like *price of milk* into a predicate of ICs. First, we use iota_e to turn this NP into an IC, namely, the IC that will map any world w to the unique price of milk at w. Then, $\mathsf{ident}_\mathsf{se}$ can apply to this IC and give us a predicate true of any ICs identical to it.

(33) $\mathsf{ident}_\mathsf{se}(\lambda i.\ \mathsf{iota}_\mathsf{e}([\![\text{price of milk}]\!]^i))$
$= \lambda u.\ u = (\lambda i.\ \iota x_\mathsf{e}[[\![\text{price of milk}]\!]^i(x)])$

I take these operations to be performed a single phonologically null operator, $\uparrow_\mathsf{se}$, which may apply to any property-denoting node within a DP:

(34)
$$[\![\uparrow_{\text{IC}}]\!]^t(N_\mathsf{set}) \coloneqq \mathsf{ident}_\mathsf{se}(\lambda t'.\ \mathsf{iota}_\mathsf{e}(N(t'))) = \lambda u_\mathsf{se}.\ u = (\lambda t'.\ \iota x[N(t')(x)])$$

From now on, I make use of the function **the** to simplify the formulas in the remaining of this paper. We can then rewrite (33) as simply as (36). The important thing to keep in mind is that $\textbf{the}(f)$ is not an individual but an IC.

(35) $\textbf{the}(f_{\text{est}}) \coloneqq \lambda i.\ \iota x[f(x)(i)]$

(36) $\lambda u.\ u = \textbf{the}(\text{price-of-milk})$

A consequence of the present proposal is that we now have two possible analyses of a description like *the price of cheese*. We can either combine the NP directly with *the*$_{\text{e}}$, or we can first shift the NP into a predicate of ICs and then combine it with *the*$_{\text{se}}$, as shown in (37). Observe that the extension of *the*$_{\text{se}}$ *price of cheese* is the same as the intension of *the*$_{\text{e}}$ *price of cheese*.

(37) a. $[\![\text{the}_{\text{e}} \text{ [price of cheese]}]\!]^{t} = \iota x_{\text{e}}[\text{price.of.cheese}(t)(x)]$

b. $[\![\text{the}_{\text{se}} \text{ [}\!\uparrow_{\text{se}} \text{ price of cheese]}]\!]^{t}$
$= \iota u_{\text{se}}[u = \textbf{the}(\text{price-of-cheese})]$
$= \textbf{the}(\text{price-of-cheese})$
$= [\![\text{the}_{\text{e}} \text{ [price of cheese]}]\!]_{¢}$

The simple sentence *the price of cheese changed*, then, has two possible LFs: in one of them, *changed* composes with *the*$_{\text{e}}$ *price of cheese* via IFA; in the other, it composes with *the*$_{\text{se}}$ *price of cheese* via FA. They have, however, equivalent translations.

(38) a. [the$_{\text{e}}$ price of cheese] changed

b. $\textbf{change}(t)(\textbf{the}(\text{price-of-cheese}))$

(39) a. [the$_{\text{se}}$ [$\uparrow_{\text{se}}$ price of cheese]] changed

b. $\textbf{change}(t)(\iota u_{\text{se}}[u = \textbf{the}(\text{price-of-cheese})])$
$= \textbf{change}(t)(\textbf{the}(\text{price-of-cheese}))$

Creating predicates of ICs via $\uparrow_{\text{se}}$ only ever creates predicates that are true of a single IC. This is perhaps a welcome result for NPs that, like *price of cheese*, are only ever true of a single individual, but it definitely leads to unsatisfying results when we try to apply it to NPs like *flag on the wall*:

(40) $[\![\uparrow_{\text{se}} \text{ flag on the wall}]\!]^{t} = \lambda u.\ u = (\lambda t'.\ \iota x[\text{flag-otw}(x)(t')])$

If this were the only possible translation of *flag on the wall* as a predicate of ICs, the sentence *every flag on the wall changed* would be incorrectly predicted to only be felicitously uttered, if at all, when there was a single flag on the wall.

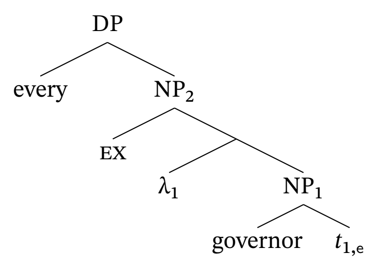


Figure 2.5: interpretable LF for *every governor*

The proposal, then, seems lacking: it only yields the correct analysis of sentences like *the price of cheese changed*, which are sentences that could already be accounted for anyways. In the following subsections, however, I show that the present proposal can in fact cover all the relevant data involving quantification over ICs: all we need is to take into account other quantificational operators that may be present within the NP.

2.2.2 First pass: functional relational nouns

I now show how, under the present proposal, we can in fact easily account for the truth conditions of sentences like (41a), where the head noun of the quantificational DP is a functional relational noun. As discussed in the previous section, these are the kind of sentences which may have PC readings – the truth conditions of (41a) can be simply stated as (41b).

(41) a. Every governor changed.

b. $\forall z.\ \textbf{change}(t)(\textbf{the}(\mathsf{governor}(z)))$

The proposal I laid out in the previous subsection is that NPs are turned into predicates of ICs via the application of null operators. Crucially, these operators may take scope at different positions within the NP. We therefore predict that $\uparrow_{se}$ may scopally interact with other operators within the NP. When interpreted as a generalized quantifier over individuals, the structure of the DP *every governor* is as shown in Figure 2.5. There are thus two possible scope sites for $\uparrow_{se}$ in this structure: NP_1 and NP_2, the two nodes whose extension is a predicate of individuals.

Suppose we apply it to NP_2. Then we face the same problem as we did before when we tried to apply it to *flag on the wall*: as shown in (42), the result is a predicate that is true of a single IC, and, furthermore, that IC has undesired uniqueness presuppositions (after all, we're mostly concerned with contexts in which there exists more than one governor).

(42) $[\![\uparrow_{\mathsf{se}}\ \mathrm{NP}_2]\!]^{t} = \lambda u.\ u = (\lambda t'.\ \iota x[\exists z.\ \mathsf{governor}(z)(x)(t')])$

Now, suppose instead we apply it to NP_1. Indeed, the result is still a predicate true of a single IC:

(43) $[\![\uparrow_{\mathsf{se}}\ \mathrm{NP}_1]]\!]^{t,g} = \lambda u.\ u = \mathbf{the}(\mathsf{governor}(g_1))$

However, once we compose this predicate of ICs with EX, we not only get a predicate that is true of more than one IC, but we get exactly the predicate of ICs we want: the one that is true of all ICs expressed by *the governor of z*, given some *z*.

(44) $[\![\mathrm{EX}\ [\uparrow_{\mathsf{se}}\ \mathrm{NP}_1]]\!]^{t} = \lambda u.\ \exists z.\ u = \mathbf{the}(\mathsf{governor}(z))$

If we interpret the restrictor of *every* in (41a) as the predicate of ICs given in (44), the result is the following:

(45) $\forall u.\ (\exists z.\ u = \mathbf{the}(\mathsf{governor}(z))) \rightarrow \mathbf{change}(t)(u)$

These are exactly the truth conditions we set out to derive: the formula above is equivalent to the one given in (41b), as can be seen by using the equivalencies in (46):

(46) a. $(\exists x.\ \phi) \rightarrow \psi \Leftrightarrow \forall x.\ \phi \rightarrow \psi$, unless x is free in ψ

b. $(\forall x.\ x = y \rightarrow \psi) \Leftrightarrow \psi[y/x]$, when y is free in ψ

(47) $\forall u.\ (\exists z.\ u = \mathbf{the}(\mathsf{governor}(z))) \rightarrow \mathbf{change}(t)(u)$
$= \forall u.\ \forall z.\ u = \mathbf{the}(\mathsf{governor}(z)) \rightarrow \mathbf{change}(t)(u)$
$= \forall z.\ \mathbf{change}(t)(\mathbf{the}(\mathsf{governor}(z)))$

We thus capture the equivalence between (41a) and (48). Importantly, the sentence is correctly predicted to be true in a situation in which the set of governors remains the same after the change – all that is needed is that for each state, its current governor is different from before.

(48) The governor of every state changed.

My proposal as to how NPs are turned into predicates of ICs bears many similarities to the semantic analysis of interrogatives proposed in Karttunen 1977. Karttunen proposed that propositions are turned into sets of propositions (i.e., questions) via the interaction of an operation he called the proto-question rule and the meaning of *wh*-phrases. The proto-question rule is nothing but an instantiation of ID_{α}, namely $\mathrm{ID}_{\mathsf{st}}$,[7]

[7]This is not completely accurate, as Karttunen took interrogatives to denote sets of **true** propositions. In my exposition of Karttunen 1977, then, I actually follow Hamblin 1973 with respect to what the meaning of questions actually is, like much subsequent literature on questions. This does not bear on the present discussion, however.

and, as such, it always yields singleton sets of propositions if used by itself. Multiple alternatives can be generated, however, once an existential quantifier – the *wh*-phrase – binds a variable within the scope of $\textsc{Id}_{\mathsf{st}}$ from outside:

(49) $[_{\text{CP}}$ who λ_2 $[_{\text{C}'}$ $\textsc{Id}_{\mathsf{st}}$ $[t_{2,\mathsf{e}}$ came$]]]$

(50) a. $[\![\text{C}']\!]^{g,t} = \lambda p.\ p = \mathsf{came}(g_2)$

b. $[\![\text{CP}]\!]^{g,t} = \lambda p.\ \exists x.\ \mathsf{human}(x)(t) \wedge p = \mathsf{change}(x)$

This generalization of Karttunen's proposal to creates sets of objects other than propositions is also done in Charlow 2019, for different purposes. In particular, Demirok (2019) applies the theory of alternatives of Charlow to interpret DPs containing *wh*-phrases such as *whose dog*, and his LF for such DPs is bears strong similarities to the one I proposed above for NPs like *governor*.

In §2.1.1, I pointed out that Nathan (2006) claimed that PC interpretations were only available if the noun within the quantificational DP was a relational noun without an overt internal argument. A problem for this characterization of the distribution of PC readings is that the following two sentences are equivalent in that they both can get a PC interpretation:[8]

(51) a. Every New England governor changed.

b. Every governor of a New England state changed.

This is completely expected under the current proposal. In Figure 2.6 I lay out the interpretable LF of the DP *every governor of a New England state* when interpreted as a standard generalized quantifier ranging over individuals. I follow the analysis of nested quantifiers that is laid out in Heim and Kratzer 1998, where I resort to null operator movement to create nodes within NPs that quantificational DPs can take scope over. Again, there are two nodes, NP_1 and NP_2, that $\uparrow_{\mathsf{se}}$ could in principle apply to. We get the PC reading if it applies to NP_1, since the restrictor of *every* would end up denoting the following predicate:

(52) $\lambda u.\ \exists z.\ \mathsf{ne.state}(z)(t) \wedge u = \mathbf{the}(\mathsf{governor}(z))$

[8]Nathan (2006) reports that sentences like (51b) are odd, but I have been unable to find speakers that agree with this assessment – speakers I consulted with report that the above sentence has the exact same status as (51a), which Nathan claims to be good . It is possible that Nathan's judgments are due to some preference of interpreting the indefinite outside of its hots DP (Danny Fox, p.c.).

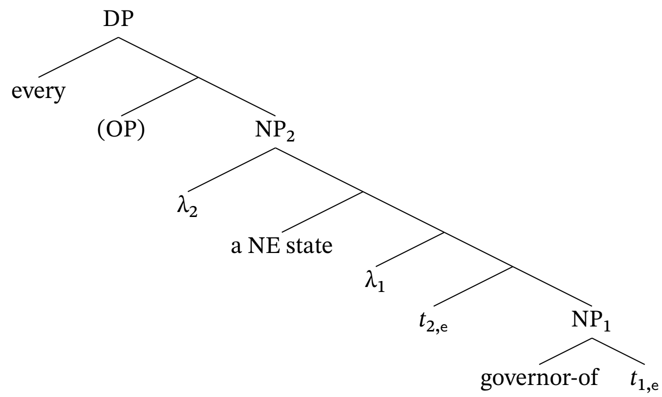


Figure 2.6: interpretable LF of *every governor of a New England state*

2.2.3 Non-relational nouns: deriving identity preservation

In the previous subsection, we have seen how our system can generate the correct predicate of ICs for NPs headed by functional relational nouns. The crucial part of the analysis was a particular interaction between $\uparrow_{\text{se}}$ and EX, the latter being an independently motivated operator that existentially closes the internal argument of relational nouns. We still need to account for sentences like (53), where the noun that heads the NP is non-relational. The task has two parts: not only must we explain how we can generate a predicate of ICs that is true of more than one IC, but also why these ICs must be identity preserving relative to the NP.

(53) Every flag on the wall changed.

My proposal will be to, as in the previous subsection, rely on EX: I propose that it is base generated under the scope of $\uparrow_{\text{se}}$ and that it subsequently QRs over it. As shown in Figure 2.7, if EX leaves behind a trace of type e, the structure is not interpretable: after the traces composes with the NP, it creates a note of type t, which cannot be combined with $\uparrow_{\text{se}}$. The solution, also shown in Figure 2.7, is to allow EX to leave a trace of type et. The trace and the NP will then be able to compose via the rule of **Predicate Modification** (PM) from Heim and Kratzer 1998, which is defined below in (54).

(54) $[\![\phi\ \psi]\!]^t = \lambda x_\alpha.\ [\![\phi]\!]^t(x) \wedge [\![\psi]\!]^t(x)$ when $[\![\phi]\!]^t :: \alpha\text{t}$ and $[\![\psi]\!]^t :: \alpha\text{t}$

The NP *flag on the wall* can then be interpreted as a predicate of ICs as follows:

(55) $[\![\text{EX}\ \lambda_1\ \ \uparrow_{\text{se}} [\text{flag.on.the.wall}\ t_{1,\text{et}}]]\!]^t$

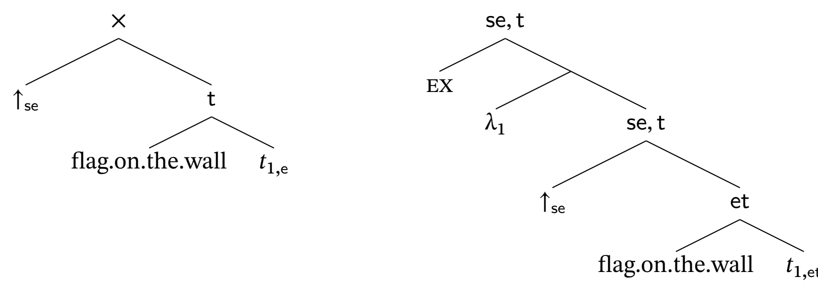


Figure 2.7: *flag on the wall* as an IC-predicate

$$= [\![\text{EX}]\!]^t(\lambda A_{\text{et}}.\lambda u_{\text{se}}.\ u = (\lambda t'.\ \iota x[\text{flag-otw}(x)(t') \wedge A(x)]))$$
$$= \lambda u_{\text{se}}.\ \exists A_{\text{et}}.\ u = (\lambda t'.\ \iota x[\text{flag-otw}(x)(t') \wedge A(x)])$$

In (56), I introduce another way to simplify incoming formulas. This allows us to rewrite (55) as (57), when convenient.

(56) $\textbf{the}_{A_{\text{et}}}(f_{\text{est}}) := \lambda t'.\iota x[f(x)(t') \wedge A(x)]$

(57) $\lambda u_{\text{se}}.\ \exists A_{\text{se}}.\ u = \textbf{the}_A(\text{flag-otw})$

A couple of examples of ICs that would be in this set are given below in (58). The first IC, (58a), is only defined at intervals in which Flag 1 is a flag on the wall, and, when defined, it will map that interval to Flag 1. The second IC, (58b), is only defined when exactly one of Flag 1 and Flag 2 is a flag on the wall, and, when defined, it will map that interval to the one among Flag 1 and Flag 2 that is a flag on the wall at that interval.

(58) a. $\lambda t'.\ \iota x[\text{flag.otw}(t')(x) \wedge x \in \{\ \text{flag1}\ \}]$

b. $\lambda t'.\ \iota x[\text{flag.otw}(t')(x) \wedge x \in \{\ \text{flag1}, \text{flag2}\ \}]$

Crucially, all the ICs that (55) is true of are all identity preserving relative to NP *flag on the wall*. This can be proven in the following way. Take an arbitrary IC u and assume that (55) is true of u but that u is not identity preserving relative to *flag on the wall*. If u is not identity preserving, then there are two indices t_1 and t_2 in the domain of u such that the following holds:

(59) a. $u(t_1) \in [\![\text{flag on the wall}]\!]^{t_2}$

b. $u(t_2) \in [\![\text{flag on the wall}]\!]^{t_1}$

c. $u(t_1) \neq u(t_2)$

If u is in (55), then there is some A such that the statement in (60) is true. From this, the statements in (61) all follow.

(60) $u = (\lambda t.\ \iota x[\text{flag-otw}(x)(t) \wedge A(x)])$

(61) a. $\forall x.\ \text{flag-otw}(x)(t_1) \wedge A(x) \leftrightarrow u(t_1) = x$

b. $\forall x.\ \text{flag-otw}(x)(t_2) \wedge A(x) \leftrightarrow u(t_2) = x$

From (61b), we conclude that $u(t_2)$ is an element of A. Since (59b) states that $u(t_2)$ is a flag on the wall at t_1, (61a) can only be true if the following holds:

(62) $u(t_1) = u(t_2)$

But this contradicts (59c). Because u was arbitrary, this proves that there can't be an element of (55) that is not identity preserving relative to *flag on the wall*.

The method for deriving IC that was just devised, therefore, is able to create a non-trivial predicate of ICs that furthermore can be proven to be all identity preserving. The only issue left to address, then, is whether the ICs the current system generates can actually be used to capture the readings that are indeed attested.

Let's go back to our flag scenario in Figure 2.2, where from 2022 to 2023 the following changes took place: (i) the flag of Italy was replaced with that of Tanzania, (ii) the flag of Japan was replaced with that of South Korean, and (iii) the flag of Brazil just switched places. In such a scenario, (63a) is false, but (63b) is not.

(63) a. Every flag on the wall changed.

b. Exactly two flags on the wall changed.

We correctly predict this state of affairs if the domain of *every flag on the wall* is the set in (64), since *change* is only true of two out of the three ICs in it.

(64) $\{\ \mathbf{the}_{\{\text{it,tz}\}}(\text{flag-otw}), \mathbf{the}_{\{\text{br}\}}(\text{flag-otw}), \mathbf{the}_{\{\text{jp,sk}\}}(\text{flag-otw})\ \}$

In §2.1.1 I showed that sentences of the form '[Det NP] *change*' in which the NP is headed by a relational noun are in fact ambiguous between PC and SC readings. In the previous section, I showed how their PC reading is derived. Now we can also account for their SC reading: we just need to assume a structure with two occurrences of EX, as shown in Figure 2.8 — the first EX detransitivizes the relational noun, and then things proceed as they do in Figure 2.7. The translation of this structure is shown below:

(65) $\lambda u_{\text{se}}.\ \exists A_{\text{et}}.\ u = (\lambda t.\ \iota x[\mathbf{Ex}(\text{governor})(t)(x) \wedge A])$

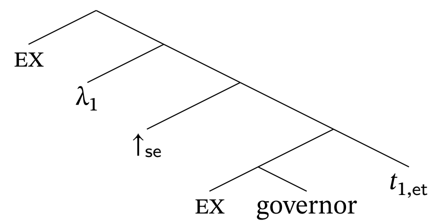


Figure 2.8: SC reading for *governor*

2.2.4 Non-functional relational nouns

We've seen how to generate predicates of ICs from NPs headed by both functional relational nouns as well as non-relational nouns. The only remaining class of nouns to account for are the non-functional relational nouns such as *senator*. If we try to shift them as we did *governor*, we will have a predicate that is indeed true of more than a single IC, but all the ICs will have the undesired presupposition that each state has a single senator:

(66) a. EX λ_1 [$\uparrow_{\text{se}}$ [senator $t_{1,\text{e}}$]]

b. $\lambda u.\ \exists z.\ u = \textbf{the}(\textsf{senator}(z))$

The solution is straightforward: we just need to combine our analyses of *governor* and *flag on the wall*. That is, we need two occurrences of EX outscoping $\uparrow_{\text{se}}$: one that binds the internal argument of *senator*, and another that binds a modifier. This is shown below:

(67) a. EX λ_2 EX λ_1 [$\uparrow_{\text{se}}$ [[senator $t_{1,\text{e}}$] $t_{2,\text{et}}$]]

b. $\lambda u.\ \exists A.\ \exists z.\ u = \textbf{the}_A(\textsf{senator}(z))$

The ICs that this predicate could be true of are, for example, *the senator of Massachusetts that is either Ann or Beth* or *the senator of Vermont that is Cleo*.

The proposal accounts for the mixed behavior of *senator* with respect to identity preservation. As desired, the ICs only need to be identity preserving relative to a given predicate of the form *senator of z*, given some *z*. Consider the scenario in Figure 2.9: in 2022, the senators of Massachusetts were Ann and Beth and the senators of Vermont were Cleo and Deb; in 2023, Ann and Cleo swapped positions and nothing else changed. Under these circumstances, (68a) but not (68b) is true:

(68) a. Exactly two New England senators changed.

b. Exactly four New England senators changed.

	2022	2023
Senators of MA	Ann, Beth	Cleo, Deb
Senators of VT	Beth, Cleo	Deb, Ann

Figure 2.9: Senator scenario II

These judgments are accounted for if the domain of these quantifiers is the following set, since *change* is only true of two ICs in it — namely, $\textbf{the}_{\{ann,cleo\}}(\text{senator}(\text{ma}))$ and $\textbf{the}_{\{ann,cleo\}}(\text{senator}(\text{vt}))$.

(69)

$$\left\{\begin{array}{c} \textbf{the}_{\{ann,cleo\}}(\text{senator}(\text{ma})) \\ \textbf{the}_{\{beth\}}(\text{senator}(\text{ma})) \\ \textbf{the}_{\{ann,cleo\}}(\text{senator}(\text{vt})) \\ \textbf{the}_{\{deb\}}(\text{senator}(\text{vt})) \end{array}\right\}$$

The predicate in (67b) is true of all members of (69). On the other hand, its impossible to come up with a set of ICs where both *change* and (67b) would be true of four of its members. For example, suppose we wanted an IC that picked out Ann in 2022 and Beth in 2023 as senators of Massachusetts (e.g., *the senior senator of Massachusetts*). The only IC that in (67b) that comes closest of doing so (70), but it would be undefined in 2022, since both Ann and Beth are senators of Massachusetts in that year.

(70) $\textbf{the}_{\{ann,beth\}}(\text{senator}(\text{ma}))$

2.2.5 Obviation of identity preservation

Sometimes, even NPs headed by non-relational nouns will be turned into predicates of ICs that do not seem to be identity preserving. The cases I discuss in this section fall into two categories: (i) obviation via the interaction with other operators within the NP, and (ii) obviation via contextual enrichment.

In my proposal, there is nothing particularly special about relational nouns: the only reason that NPs headed by these nouns are able to obviate identity preservation is because EX can bind an argument — not a modifier — within the scope of $\uparrow_{se}$. Thus, a prediction of the current proposal is that the presence of an indefinite within an NP alone could give rise to PC interpretations, even if the noun in question is non-relational. This prediction is borne out.

Suppose that we have ten professors in our department and each one of them has a different armchair in their office. One day, they decide to swap around the armchairs in their offices and they do in such a way that (i) no office has the armchair that it used to, and (ii) the set of office armchairs remains the same after the swapping. In such a scenario, (71) is, unsurprisingly, false. However, contra Nathan's original statement of his own observation, (72) could be true.

(71) Every armchair changed.

(72) Every armchair in a professor's office changed.

My proposal predicts (72) to be ambiguous between a true and a false reading, depending on where the indefinite *a professor* is interpreted relative to $\uparrow_{\mathsf{se}}$. If it is interpreted within the scope of the shift, the sentence will be false. However, if it outscopes it, the NP will be interpreted as follows:

(73) $\lambda u.\ \exists z.\ \mathsf{prof}(z)(t) \wedge u = \mathbf{the}(\mathsf{armchair} \sqcap \mathsf{in\text{-}office\text{-}of}(z))$

The above predicate is true of ICs of the form *the armchair in z's office* for some z that is a professor. If the NP in (72) is interpreted in this way, then the sentence should be true, as the ICs are not expect to be identity preserving relative to the NP *armchair in a professor's office*:

(74) $\forall u.\ (\exists z.\ \mathsf{prof}(z)(t) \wedge u = \mathbf{the}(\mathsf{armchair} \sqcap \mathsf{in\text{-}office\text{-}of}(z))) \rightarrow \mathbf{change}(u)(t)$
$= \forall z.\ \mathsf{prof}(z)(t) \rightarrow \mathbf{change}(\mathbf{the}(\mathsf{armchair} \sqcap \mathsf{in\text{-}office\text{-}of}(z)))(t)$

Sentence (72) is thus predicted to have an interpretation that can be paraphrased by the sentence *the armchair in every professor's office changed*.

The other case we should consider is one in which the context enrichment is enough to obviate identity preservation. The following example was suggested to me by Danny Fox (p.c.). Suppose that a linguistic department's lounge has three paintings. Each of these paintings is chosen by a special committee: the leftmost painting is chosen by the syntacticians in the department, the middle one is chosen by the semanticists in the department, and the rightmost one is chosen by the phonologists in the department. Each of these committee makes their choice independently. Suppose that things are as described in Figure 2.10. Some speakers I consulted with agree that the following is true:

(75) This year, every painting on the lounge's wall changed.

I propose the following solution to cases like this one. It is well known that non-relational nouns can be type-shifted into relational nouns (Barker 2011). Here, I assume that this is done by the silent operator π which introduces a contextually salient relation R:

	last year	this year
Painting chosen by syntacticians	A	B
Painting chosen by semanticists	B	D
Painting chosen by phonologists	C	A

Figure 2.10: Lounge paintings scenario

(76) $[\![\pi_R]\!]^t \coloneqq \lambda x.\lambda y.\, R(x)(y)(t)$

The idea, then, is that in cases like the above, contextual enrichment allows a non-relational noun to be interpreted relationally. Under these circumstances, PC readings may be derived as they are for lexically relational nouns:

(77) EX λ_1 $\uparrow_{\text{se}}$ [[picture on the lounge's wall] π_R $t_{1,\text{e}}$]

It should be clear how this will allow identity preservation to be obviated: the above LF will be interpreted as that predicate true of ICs of the form *the picture on the lounge's wall chosen by x*, for some *x*.

2.3 Further developments

In the present section, I address some potential issues with the theory as laid out in §2.1. After discussing what these issues are, I show that they can all be overcome by slightly enriching the basic proposal.

2.3.1 The ban on non-overlapping individual concepts

In §2.1.2, I proposed to derive SC readings via the constraints Property and Identity Preservation. However, these two constraints are not enough — the proposal as it currently stands massively over-generates readings. This can be clearly apparent when we look at quantifiers that involve counting.

Suppose that the paintings on Ann's wall change from Monday to Friday as describe in Figure 2.11. The following sentence could potentially be a true description of this state of affairs:

	Monday	Friday
Paintings on Ann's wall	A B C	D C

Figure 2.11: Ann's wall scenario

(78) One painting on Ann's wall changed, another was removed.

Interestingly, people may have different opinions concerning which of the paintings changed and which was removed. For example, if D occupies the same place on the wall as A did, then one might be inclined to say that D was replaced by A. But, if someone actually saw picture A be removed first, then they could be inclined to say that D was in fact replaced by B. It's even possible that one may judge (78) as true even if they have no strong opinions concerning which painting changed. It thus seems that we'd want to allow both sets U_1 and U_2 to be the silent domain restrictor of the quantificational determiner in (78):

(79) $$U_1 = \left\{ \begin{array}{c} \textbf{the}_{\{a,d\}}(\text{painting-on-anns-wall}) \\ \textbf{the}_{\{b\}}(\text{painting-on-anns-wall}) \\ \textbf{the}_{\{c\}}(\text{painting-on-anns-wall}) \end{array} \right\}$$

(80) $$U_2 = \left\{ \begin{array}{c} \textbf{the}_{\{a\}}(\text{painting-on-anns-wall}) \\ \textbf{the}_{\{b,d\}}(\text{painting-on-anns-wall}) \\ \textbf{the}_{\{c\}}(\text{painting-on-anns-wall}) \end{array} \right\}$$

Crucially, what we cannot allow is for U_3 to be a suitable quantificational domain, as it would allow for sentence (82) to be true in the given scenario, contra the intuitions of any speaker of English.

(81) $$U_3 = \left\{ \begin{array}{c} \textbf{the}_{\{a,d\}}(\text{painting-on-anns-wall}) \\ \textbf{the}_{\{b,d\}}(\text{painting-on-anns-wall}) \\ \textbf{the}_{\{c\}}(\text{painting-on-anns-wall}) \end{array} \right\}$$

(82) Two paintings on Ann's wall changed.

The set U_3, just like U_1 and U_2, is both property and identity preserving relative to *painting on Ann's wall*. Therefore, there should be nothing wrong with this set.

The issue with U_3 doesn't seem to be any formal properties of the ICs in it: there is nothing wrong with the ICs *the painting on Ann's wall that is either A or D* or *the painting on Ann's wall that is either B or D*, as they both are members of the suitable sets U_1 and U_2, respectively. The problem is having both of them together on the same set. This is not particularly surprising: in order to count elements in a set we must be able to be properly individuated them. We must therefore define what it means for two ICs to **overlap**, and then ban overlapping ICs from being in the same domain of quantification.

	2022	2023
Linguistics & Philosophy	Ann	Ann
Natural Language Semantics	Beth	Ella
Semantics & Pragmatics	Cleo	Flo
Journal of Semantics	Deb	Beth
Linguistic Inquiry	Cleo	Gabby

Figure 2.12: Journal editor scenario

Our first attempt is to block two ICs from being in the same domain of quantification if at some index they pick out the same individual. This constraint, first proposed in Gupta 1980, is defined below:

(83) **Non-overlapping domains**
$\mathbf{NO}(U_{\mathsf{se,t}}) \coloneqq \forall u, v \in U.\, \forall t.\, u(t) = v(t) \rightarrow u = v$

This turns out to be too strong a condition, however. The problem is again relational nouns: suppose last year four journals had their editors replaced, but the editor of two those journals were the same editor, as illustrated in Figure 2.12. Under such circumstances, it seems possible to utter:

(84) Five journal editors changed from 2022 to 2023.

This suggest that the ICs *the editor of Semantics & Pragmatics* and *the editor of Linguistic Inquiry* are in the domain of *five journals editors* even though they both pick out Cleo in 2022.

It seems, then, that while the overlapping concepts in (85) should not both be allowed to be in the same suitable quantification domain, it is not a problem to have the overlapping concepts in (86).

(85) a. $\mathbf{the}_{\{a,d\}}$(painting-on-anns-wall)
b. $\mathbf{the}_{\{b,d\}}$(painting-on-anns-wall)

(86) a. $\mathbf{the}_{\{cleo,flo\}}$(editorsp)
b. $\mathbf{the}_{\{cleo,gabby\}}$(editorlp)

There is an important difference between these two pairs of concepts, however. Suppose that both the ICs in (85) are defined at some index *i*, and that furthermore one of them picks out D at that index. Under these circumstances, the other IC must pick out D as well – for example, if the unique element in {A, D} that is a painting on the wall is

D, then the unique element in {B, D} that is a painting on the wall must also be D. On the other hand, it is conceivable that there is an index in which *the editor of Linguistic Inquiry that is Cleo or Flo* will pick out Cleo and *the editor of Semantics & Pragmatics that is Cleo or Gabby* will not – it could pick out Gabby at that index.

I thus propose that ICs can only overlap "coincidentally." I call the constraint in (87) **No Non-Coincidental Overlap**: it allows two different concepts u,v to be co-extensional at some index t_1 only if there is some other index t_2 s.t. $u(t_2)$ is the same as $u(t_1)$ but $v(t_2)$ picks out a different individual.

(87) **No Non-Coincidental Overlap**

$$\textbf{NNCO}(U_{\text{se,t}}) \coloneqq \forall u, v.\ u \neq v \rightarrow \forall t_1 \in \text{dom}(u) \cap \text{dom}(v).\ u(t_1) = v(t_1) \rightarrow \exists t_2 \in \text{dom}(u) \cap \text{dom}(v).\ u(t_1) = u(t_2) \wedge v(t_1) \neq v(t_2)$$

It is important to observe that **NNCO** is different from both Property and Identity Preservation is that it is not sensitive to properties of the NP — it is just a constraint on predicates of ICs. I thus propose that it is instead a presupposition of quantificational determiners that range over ICs: namely, given a determiner Det that ranges over ICs, its silent domain restriction must not contain ICs that overlap non-coincidentally (following von Fintel 1994, I take silent domain restrictions to be pronominal arguments of determiners).

(88) $[\![\text{Det}_{\text{se},C}]\!]^t(U_{\text{se,t}})(V_{\text{se,t}}) \neq \#$ only if $\textbf{NCO}(C)$

2.3.2 Domain restriction

A perhaps surprising issue with the analysis laid out in the previous section has to do with silent domain restriction. Sentence (89) can be uttered by someone who means that every flag **on the wall** changed.

(89) Every$_U$ flag changed.

So far, I've been following the proposal in von Fintel 1994 that silent domain restriction is a result of a covert pronoun that is a sister of the determiner in question. Silent domain restriction on *every*, will not, however, derive the desired reading.

The issue is that the NP *flag* will still be interpreted as (90) and *change* will only ever be true of an IC in (90) if one of its possible extensions ceases to be a **flag**. This is too strong a requirement: when (89) is interpreted as *every flag on the wall changed*, all that is required is that the things that were flags on the wall all ceased to be flags on the wall – not that they cease to be flags altogether.

(90) $\lambda u.\ \exists A_{\text{et}}.\ u = \mathbf{the}_A(\mathsf{flag})$

This suggests that the silent domain restriction that is interpreted as the property expressed by the PP *on the wall* has to be part of the ICs themselves instead of being part of *every*. I thus propose that we amend our entry for $\uparrow_{\text{se}}$ so that it has itself a property-denoting silent domain restrictor:

(91) $[\![\uparrow_{\text{IC},D}]\!]^t(N_{\text{set}}) := \lambda u.\ u = (\lambda t'.\ \iota x \in D(t')[N(t')(x)])$

Example (89) can thus be accounted as follows: the NP *flag* in this sentence is interpreted as (93), where the covert variable C is contextually resolved into the property *on the wall*.

(92) every $[\uparrow_{\text{IC},D}$ flag$]$

(93) $\lambda u_{\text{se}}.\ \exists A_{\text{et}}.\ u = (\lambda t'.\ \iota x \in D(t)[\mathsf{flag}(t')(x) \wedge A(x)])$
where $D \mapsto \mathsf{on.the.wall}$

This proposal would perhaps be more satisfactory if we were to syntactically decompose $\uparrow_{\text{se}}$ into ident and iota. Given that iota would basically a covert version of the definite determiner, it wouldn't be surprising that it too can be restricted by a covert domain restriction variation:

(94) a. $[\![\text{ID}_\alpha]\!]^t := \mathsf{ident}_\alpha$
b. $[\![\text{IOTA}_{\alpha,C}]\!]^t := \lambda f.\ \mathsf{iota}_\alpha(C \sqcap f)$

Everything that was proposed so far could be restated with two operators rather than one. In Figure 2.13, I show how the NP *price of cheese* could be shifted if we assumed the two operators in (94) instead of $\uparrow_{\text{se}}$: first, IOTA composes with the NP via FA; and thenID composes with [IOTA NP] via IFA.

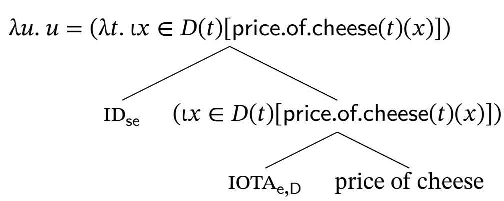


Figure 2.13: Shifting *price of cheese* with IOTA and ID

2.3.3 Adding world-intensionality

The final potential problem I address concerns the fact that Identity Preservation sometimes appear to be too strong. Suppose there are three paintings on the wall: A, B, and C. Suppose furthermore that I know the following: either A is being replaced by D and B by E, or A is being replaced by E and B by F. Even if I don't know how exactly things are going to change, I could truthfully utter the following sentence:

(95) Exactly two$_U$ paintings on the wall will change.

But what is the value of U when I utter this? The only possible values in which Identity Preservation is respected are the following two sets:

(96)
$$\left\{ \begin{array}{c} \lambda t.\ \iota x \in \{\ \mathsf{a}, \mathsf{d}\ \}[\mathsf{painting.otw}(t)(x)], \\ \lambda t.\ \iota x \in \{\ \mathsf{b}, \mathsf{e}\ \}[\mathsf{painting.otw}(t)(x)], \\ \lambda t.\ \iota x \in \{\ \mathsf{c}\ \}[\mathsf{painting.otw}(t)(x)] \end{array} \right\}$$

(97)
$$\left\{ \begin{array}{c} \lambda t.\ \iota x \in \{\ \mathsf{a}, \mathsf{e}\ \}[\mathsf{painting.otw}(t)(x)], \\ \lambda t.\ \iota x \in \{\ \mathsf{b}, \mathsf{f}\ \}[\mathsf{painting.otw}(t)(x)], \\ \lambda t.\ \iota x \in \{\ \mathsf{c}\ \}[\mathsf{painting.otw}(t)(x)] \end{array} \right\}$$

But in the present context, I can't choose among either of these sets since I don't know which of them is the actual outcome.

The solution to this puzzle is rather simple: we just need to incorporate world intensionality to our analysis. Thus, suppose now that indices of evaluation are world-time pairs. If we treat U in (95) as denoting a function from world-time pairs to predicates of ICs, the following value for it would derive the desired interpretation:

(98) $\lambda\langle w, t\rangle.\lambda u.\ \exists t' > t.\ \mathsf{painting.ontw}(t')(u(t'))$

In some worlds compatible with my belief, the above function gives us (96), in the other worlds compatible with my belief it gives us (97).

2.4 Previous proposals

2.4.1 Nathan 2006

Nathan (2006) not only discovered the PC/SC distinction but was also the first to offer an account of it. Like the theory I advanced, he assumed that the basic meaning of a noun was that of a one- or two-place predicates of individuals, but that they could be type-shifted into predicates of ICs. He proposed that nouns could be turned into predicates of ICs via two different type shifting operations: one that applied to relational nouns, and another that applied to non-relational nouns – the first derived a predicate of ICs that would yield PC readings, the second derived a predicate of ICs that would yield SC readings.

The main problem of Nathan's proposal is that, rather than explaining the distribution of PC and SC interpretations, it only re-states it — the two readings are each derived by a different semantic operation. The proposal I advanced, on the other hand, proposes a single type-shifting operation, and the differences between sentences with relational and non-relational nouns follow from structural properties of the NPs in these sentences.

Nathan's account of PC interpretations also has empirical problems. He proposes that these readings arise via the operation defined in (99), which I conceptualize as the meaning of a null operator I call $\textsc{ic}_N$. it applies to the intension of a relational noun R and – to use my own terminology – returns a predicate true of all ICs that are property preserving relative to $\lambda t.\ R(t)(z)$, given some z. When applied to the noun *governor* it returns the predicate in (100), which is true of ICs such as *the governor of Massachusetts*.

(99) $[\![\textsc{ic}_N]\!]^t(R_{\mathsf{seet}}) := \lambda u_{\mathsf{se}}.\ \exists z_{\mathsf{e}}.\ \forall t'.\ R(t')(z)(u(t'))$

(100) $[\![\textsc{ic}_N]\!]^t([\![\text{governor}]\!]_{¢}) = \lambda u_{\mathsf{se}}.\exists z_{\mathsf{e}}.\ \forall t'.\ \mathsf{governor}(z)(u(t'))(t')$

An immediate problem for this proposal is that it incorrectly predicts PC readings to only be available with DPs whose head noun doesn't have an overt internal argument. Therefore, it doesn't account for the fact that both sentences in (101) have PC readings (although remember that Nathan judged (101b) as odd) or for some of the data discussed in §2.2.5.

(101) a. Every New England governor changed.
b. Every governor of a New England state changed.

More worrisome is that it cannot yield the correct truth conditions for sentences with non-functional relational nouns, like *senator*: as already discussed, Identity Preservation is still observable in sentences of the form '[Det *senator*] *change*' and (99) only imposes Property Preservation. For example, the predicate in (102) would be true of the IC *the junior senator of Massachusetts*, which, as we already discussed, is a problematic state of affairs.

(102) $[\![\textsc{ic}_N]\!]^t(\mathsf{senator}) = \lambda u_{\mathsf{se}}.\exists z_{\mathsf{e}}.\ \forall t'.\ \mathsf{senator}(t')(z)(u(t'))$

2.4.2 Frana 2013

Accounting for the PC/SC distinction is not one of the main goals of Frana (2013): she is concerned with developing a theory of so-called **concealed questions** (Baker 1968), which are DPs that can be paraphrased by embedded questions (e.g., ***my favorite movie*** *is obvious* ≈ *it's obvious* ***what my favorite movie is***). However, Frana mentions in passing that her proposal can be extended to account for Nathan's observation. In this subsection, I argue that this is not the case.

Frana's proposal is in a sense an extension of Nathan's: she adopts his account of PC interpretations in full (although she does observe that it can only give the right results for functional relational nouns). Her main innovation is a possible new account of SC interpretations. Although she frames her proposal within the Copy Theory of Movement (Chomsky 1995, Fox 2002), for ease of exposition, I will discuss it using a notational variant in which SC readings are derived via a new type-shifting operations that applies to NPs. This operation is defined as follows:[9]

(103) $$[\![\textsc{ic}_F]\!]^t(N_{\mathsf{set}}) \coloneqq \lambda u_{\mathsf{se}}.\ \exists z_e.\ u = (\lambda i.\ \iota x[N(i)(x) \wedge x = z]) \\ = \lambda u_{\mathsf{se}}.\ \exists z_e.\ u = \mathbf{the}_{\{z\}}(\lambda x.\lambda i.\ N(i)(x))$$

Notice that $\textsc{ic}_F$ creates a proper subset of the ICs that my proposal does for non-relational nouns: it is a special case in which existential quantification over NP modifiers is restricted to singletons.

It is straightforward to see the problem with this proposal: none of the ICs created by $\textsc{ic}_F$ can ever change — whenever they are defined, they map every index to the same individual:

(104) $$[\![\text{every } [\textsc{ic}_{\text{F}}\text{flag}] \text{ changed}]\!]^t \\ = \forall u_{\mathsf{se}}.\ (\exists z.\ u = \mathbf{the}_{\{z\}}(\mathsf{flag})) \rightarrow \mathbf{change}(u)(t) \\ = \forall z.\ \mathbf{change}(\mathbf{the}_{\{z\}}(\mathsf{flag}))(t)$$

Frana does propose to change the meaning of the ι-operator in such a way as to remove this existence presupposition, however. In a nutshell, the idea is that, if A is not true of any entity, rather than being undefined, $\iota x[A(x)]$ picks out $*$, an individual which no natural language predicate is true of. Under this proposal, the following could be true even if z was no longer a flag at t_2:

(105) $$\mathbf{the}_{\{z\}}(\mathsf{flag})(t_1) \neq \mathbf{the}_z(\mathsf{flag})(t_2)$$

[9] Frana 2013's actual proposal relies on a modified version of the rule of **trace conversion** of Fox 2002, which is a syntactic operation to interpret lower copies.

The main issue, however, is that this presupposition is crucial to explain why *every painting on the wall changed* is undefined in contexts in which every painting was removed. That is, this amendment makes us unable to make a difference between cases in which a painting is replaced from those in which it is simple removed.

2.4.3 Schwager 2007

Schwager offers a pragmatic account of the SC/PC distinction. She questions the characterization of the distribution of these readings given by Nathan – instead, she argues the relevant property of nouns that give rise to SC readings is that they have a "role" associated with them. Thus, while *governor* is a role noun, *flag* isn't. Her argument is based on the fact that nouns such as *bodyguard* in (106) are relational, yet (106) only has a SC reading.

(106) One bodyguard (of Arnold) changed.

I question the assessment that sentences with *bodyguard* lack a PC interpretation. Indeed sentences with an NP *bodyguard of Arnold* do lack a PC interpretation, but only because their internal argument is satisfied by a proper name. If its internal argument is an indefinite, as in (107), the sentence does have a PC reading: (107) can be true if the bodyguard of every professor changed but the set of bodyguards remained the same after the changed.[10]

(107) Every bodyguard of a professor of ours changed.

Furthermore, if the SC/PC distinction was pragmatic in the way described by Schwager, it's unclear why only (108b) would have a PC interpretation: the NPs *governor* and *member of the council of governor* are supposed to be contextually equivalent, after all.

(108) a. Every member of the council of governors changed.
b. Every governor changed.

In any case, the proposal of Schwager also has empirical shortcomings. To show this, I present a slightly different version of her proposal here, but the reader is referred to the original paper for its fully accurate rendition. Schwager adopts the proposal of Aloni (2001) that suitable domain for quantification over ICs need to make reference to **conceptual covers**, defined as follows:

[10]To be fair, Schwager (2007) was focused on cases in which we were only talking about bodyguards of the same person. My point is only that it only makes sense of talking about PC readings of sentences with *bodyguard* if we're talking about bodyguards of different people.

(109) **Conceptual Covers**

$$\mathbf{CC}(U_{\mathrm{se,t}}) \coloneqq \forall t.\ \forall x.\ \exists! u \in C.\ u(t) = x$$

Building on the notion of a conceptual cover, Schwager defines the notion of a *P*-cover: a subset of conceptual cover that completely covers the entities true of a particular property during every atomic part of a given interval.

(110) ***P*-cover**

$$\mathbf{C}_{P_{\mathrm{set}},t}(U_{\mathrm{se,t}}) \coloneqq \exists V_{\mathrm{se,t}}.\ \mathbf{CC}(V) \wedge U \subseteq V \\ \wedge \forall t' \subseteq t.\ (\neg \exists t''.\ t' \subset t'') \rightarrow P(t') = \{\, u(t') \mid u \in U \,\}$$

Schwager's proposal is that quantification over ICs is often restricted by contextually salient *P*-covers, where the value of *P* is given by the noun. She proposes that PC readings arise because nouns like *governor* make salient a *governor*-cover composed of ICs of the form *the governor of z*, where *z* is some state. Nouns like *bodyguard* in a sentence like (106), however, make no roles salient and therefore do not supply good covers for PC readings. Schwager argues that such nouns only make salient **temporally constant** covers, i.e., covers composed of rigid designators. Her proposal, then, is that, if that, when no particular *P*-cover is supplied by the context, a pragmatic principle can be evoked in which the sentence is interpreted as if it involved universal quantification over all possible *P*-covers. This, she claims, is the source of SC interpretations.

Sentence (106) would thus be interpreted as follows:

(111) $\forall U_{\mathrm{se,t}} \in \mathbf{C}_{[\![\mathrm{bodyguard}]\!]_{\text{¢}},t}.\ \{\, u \in U \mid \mathbf{change}(u)(t) \,\} \geq 1$

To unpack these truth conditions, suppose that at the extension of bodyguard at the beginning and at the end of t are as follows (where $t = t_{\mathrm{beg}} \cup t_{\mathrm{end}}$):

(112) a. $[\![\mathrm{bodyguard}]\!]^{t_{\mathrm{beg}}} = \{\mathsf{ann}, \mathsf{beth}\}$

b. $[\![\mathrm{bodyguard}]\!]^{t_{\mathrm{end}}} = \{\mathsf{beth}, \mathsf{cleo}\}$

Sentence (106) would be true under those circumstances and the present analysis captures this. To see this, we must first see what the domain of possible *bodyguard*-covers is:

(113)
$$\mathbf{C}_{[\![\mathrm{bodyguard}]\!]_{\text{¢}},t} = \left\{ \begin{array}{l} \{[t_{\mathrm{beg}} \mapsto \mathsf{ann}, t_{\mathrm{end}} \mapsto \mathsf{beth}], [t_{\mathrm{beg}} \mapsto \mathsf{beth}, t_{\mathrm{end}} \mapsto \mathsf{cleo}]\}, \\ \{[t_{\mathrm{beg}} \mapsto \mathsf{ann}, t_{\mathrm{end}} \mapsto \mathsf{cleo}], [t_{\mathrm{beg}} \mapsto \mathsf{beth}, t_{\mathrm{end}} \mapsto \mathsf{beth}]\} \end{array} \right\}$$

Since it is true both sets of ICs in (113) contain at least one IC that changed, (111) comes out as true. Furthermore, it correctly predicts *Two bodyguards changed* to be false, since only the first member in (113) contains at least two ICs that changed.

The problem of this proposal is that it only works for upward entailing determiners. The following two sentences should also be true given (112), but they come off as false:

(114) a. Exactly one bodyguard changed.

b. Less than two bodyguards changed.

The issue is that only the second member of (113) verifies the quantificational statements above, and that's because the first set in (113) contains two changing ICs. Therefore, the sentences in (114) are false for the same reason that *Two bodyguards changed* is — they are only true of one *bodyguard*-cover at *t*.

Another potential issue with the proposal is that it's not clear what it predicts for sentences with *senator* — as discussed above, they have properties from both PC and SC readings. Schwager's proposal, as it is, would only have two possible ways of accounting for these facts: either *senator* provides a salient *senator*-cover and the sentence gets an PC reading, or it doesn't provide a salient *senator*-cover and the sentence gets an SC reading.

2.5 Conclusion

The starting point of the present paper was Montague 1973, where an argument was made that DPs must be analyzed as generalized quantifiers over ICs and NPs as predicates of ICs. The proposal as it was, however, was too unconstrained, especially in light of data discussed by Nathan 2006. After presenting Nathan's observation under a new perspective, I advanced an explicit account as to how NPs come to be interpreted as predicates of ICs. This new proposal provides an explicit theory of how quantification over ICs is constrained that can account for Nathan's observation in a natural way. Competing proposals were shown to be conceptually flawed and, most importantly, empirically as well.

Chapter 3

Structuring concealed questions

Concealed questions (CQs) are DPs that can be naturally paraphrased as embedded questions (Baker 1968). Some illustrative examples are given below in (1).

(1) a. Ann knows **Filipe's birthday**.
≈ *Ann knows what Filipe's birthday is.*

b. Beth predicted **every Academy Award winner**.
≈ *Beth predicted who every Academy Award winner would be.*

c. **One of Cleo's secrets** is shocking.
≈ *It's shocking what one of Cleo's secrets is.*

In an early paper on the semantics of CQs, Heim (1979) identified three puzzles that have driven much of the research into this phenomenon. The first is a puzzle of failure of substitution: it consists in the observation that, despite having the form of a valid argument, arguments like (2) are surprisingly invalid.

(2) Ann knows Filipe's birthday.
Filipe's birthday is (also) Caracalla's birthday.
$\not\therefore$ Ann knows Caracalla's birthday.

The invalidity of (2) is unexpected because even though *Filipe's birthday* and *Caracalla's birthday* are stated to be the same, substituting one for the other does not preserve the truth of the first premise.

The invalid argument in (2) is reminiscent of Barbara Partee's **temperature paradox**, shown in (3). As in (2), the substitution of two DPs — here, *the temperature* and *ninety* — is not truth-preserving despite the identity statement.

(3) The temperature rises.
The temperature is ninety.
$\not\therefore$ Ninety rises.

As discussed in chapter 1, Montague (1973) proposed a well-known account of this puzzle in which *rise* was proposed to be a predicate of individual concepts (ICs), i.e., a predicates of functions from indices (worlds, in this chapter) to individuals:

(4) $[\![\text{rise}]\!]^w \coloneqq \lambda u_{\mathsf{se}}.\ \textbf{rise}(u)(w)$

If each sentence in (3) is translated as in (5), the paradox is resolved: *rises* combines with the **intension** of its subject, and the second premise only states that the **extension** of the two DPs are identical. Since the intensions of the DPs could still be different, substitution is not predicted to be truth-preserving.

(5) a. $\textbf{rise}(\lambda w'.\ [\![\text{the temperature}]\!]^{w'})(w)$
b. $[\![\text{the temperature}]\!]^w = [\![\text{ninety}]\!]^w$
c. $\textbf{rise}(\lambda w'.\ [\![\text{ninety}]\!]')(w)$

Heim (1979) contemplated an analysis of CQs that would account for (1a) in the same way Montague accounted for (3), where the meaning of CQ-embedding verbs involved a relation between an individual and an IC. For example, CQ-embedding *know* would be true of an individual x and an IC u at w if it was the case that x knew that the actual value of u is the individual $u(w)$:

(6) $[\![\text{know}_{\text{IC}}]\!]^w \coloneqq \lambda x_{\mathsf{e}}.\lambda u_{\mathsf{se}}.\ \mathsf{know}(\lambda w'.\ u(w) = u(w'))(x)(w)$

The first premise of (1a) could thus be analyzed as follows:

(7) $[\![\text{Ann knows Filipe's birthday}]\!]^w$
$= [\![\text{know}_{\text{IC}}]\!]^w(\lambda w'.\ [\![\text{Filipe's birthday}]\!]^{w'})([\![\text{Ann}]\!]^w)$
$= \mathsf{know}(\lambda w'.\ [\![\text{Filipe's birthday}]\!]^w = [\![\text{Filipe's Birthday}]\!]^{w'})(\mathsf{ann})(w)$

Not only does this proposal account for the invalidity of (2), but it also yields truth conditions that match our intuitions: *Ann knows Filipe's birthday* is true whenever the extension of *Filipe's birthday* in Ann's belief worlds matches its extension in the actual world. Heim called this the **individual concepts approach** to CQs.

Despite its initial appeal, Heim ended up abandoning the ICs approach to CQs because of two other puzzles she identified. The first concerns two possible interpretations that sentences with **quantified CQs** (i.e., CQs that are unambiguously quantificational DPs) may have, which following Roelofsen and Aloni (2008) I call **set** and **pair-list** readings:

(8) Beth knows every phone number.

a. **Set reading**:
for every phone number x, Beth knows x is a phone number

b. **Pair-list reading**:
for every x, Beth knows what x's phone number is

Under its set reading, (8) conveys that Beth is able to identify which sequences of numbers are phone numbers; and under its pair-list reading, the sentence conveys that Beth can also properly map every phone number to its owner.

The second puzzle concerns the ambiguity of sentences with **nested concealed questions**, i.e., CQs modified by a relative clause whose gap is interpreted as a CQ. Following the terminology in Frana (2017), these sentences may have a **question** and a **meta-question** reading:

(9) Ann knows the price that Beth knows.

a. **Question reading**:
There's a unique price Beth knows and Ann knows that price too.

b. **Meta-question reading**:
Ann knows which price Beth knows.

Under its question reading, (9) conveys that Ann and Beth know the same price, and Ann doesn't need to know anything about what Beth knows. Under its meta-question reading, the sentence conveys that Ann knows Beth knows the price of some z but she herself doesn't need to know what the price of z is.

Both of these two ambiguities pose challenges to the ICs approach to CQs. Specifically, set and meta-question readings are the problematic ones, since neither of them seem to involve the relation between an individual and an IC that the entry of $know_{\text{IC}}$ in (6) makes reference to. For example, the set reading of (8) conveys that Ann knows which individuals are in the extension of the NP *phone number*, whereas the meta-question reading of (9) doesn't require Ann to know the extension of any IC — she just needs to know which IC is the one Beth knows the extension of (e.g., the price of cheese).

Romero (2005) and Frana (2017) both proposed accounts of these ambiguities within the ICs approach that have shown that these challenges are not insurmountable, but their proposals do, however, have both empirical and conceptual shortcomings. In the present chapter, I build on these previous proposals to develop a novel account of these ambiguities. These proposals' main insights are synthesized into an approach to CQs which is not only simpler but also more empirically adequate.

The key idea I pursue is that these ambiguities at least partly due to the underlying structure of the NPs within the CQs. Following Montague 1973, I take DPs to at least sometimes be translated into quantifiers over ICs, as shown in (10).

(10) $[\![\text{every phone number}]\!]^w = \lambda V_{\text{se,t}}.\ \forall u_{\text{se}}.\ [\![\text{phone number}]\!]^w(u) \to V(u)$

A crucial ingredient of this analysis of DPs is that NPs are interpreted as predicates of ICs. Differently from Montague 1973, I take the basic meaning of an NP to be that of a predicate of individuals and that they can be shifted into predicates of ICs via a null operator I call $\uparrow_{\text{se}}$. Heim's ambiguities can then be derived from how $\uparrow_{\text{se}}$ interacts with other syntactic objects within the NP.

This chapter is structured as follows. In §3.1, I present the theory of CQ embedding of George (2011), itself an extension of the theory of question embedding of Spector and Egré (2015). The goal of this section is show how the meaning of CQ embedding *know* in (6) can be compositionally derived from declarative-embedding *know* through a general mechanism that can apply to many other verbs. In §3.2, I discuss how quantified CQs can be interpreted given the theory of CQ embedding I adopted. In this section, I lay out my theory of how NPs are shifted into predicates of ICs and provide an account of set readings building on Frana 2017. In §3.3, I move on to nested CQs and advance an account of meta-question readings which generalizes the proposal of Romero (2005) by allowing NPs to be shifted into predicates of functions from worlds to ICs, an idea already alluded to in Heim (1979). Finally, §3.4 concludes.

3.1 Embedding concealed questions

In this section, I lay out the theory of CQ embedding that I adopt in this chapter. As proposed by Heim (1979), I take the semantics of CQ embedding to ultimately involve a relation between an individual and an IC. However, differently from her, I assume, with George (2011), that the basic meaning of CQ-embedding predicates is that of a propositional attitude, and that embedding is possible due to a general mechanism for shifting ICs into propositions.

Despite differences in implementation, the theory is essentially that of George (2011): it consists of an extension of the theory of question embedding proposed in Spector and Egré (2015) based on an idea that goes back to Groenendijk and Stokhof (1982). The advantages of this proposal is that it provides a general recipe for interpreting different kinds of CQ-embeding predicates, and it relies on a unified semantic procedure for embedding both questions and CQs. The present theory of CQ embedding, thus, fits well within a more general theory of clausal embedding.

An outstanding challenge I will not address, however, concerns which kinds of DPs make good CQs. An observation that goes back to Löbner (1981) is that DPs that can be easily interpreted as CQs are typically built from relational nouns. Contrast the examples in (11): while the sentence with *the price of cheese* is readily interpretable, the one with *the phonologist* is odd if no additional context is given.

(11) a. Ann discovered the price of cheese.

b. ?? Ann discovered the phonologist.
Compare with: *Ann discovered who the phonologist is.*

Furthermore, as observed by Nathan (2006) and Caponigro and Heller (2007), DPs with non-relational nouns can become better CQs once they are modified by a relative clause or some other kinds of modifiers, such as superlatives:

(12) a. Ann discovered the phonologist *who ate her lunch*.

b. Ann discovered the *smartest* phonologist.

An issue with this generalization is that contextual information is often enough to turn DPs with non-relational nouns into good CQs:

(13) Three people walk into a room and we know that one of them is a phonologist, one is a syntactician, and the other is a semanticist. I say I don't know who is who, but Ann tells me: **— The phonologist is obvious**.

Furthermore, not all DPs with relational nouns make good CQs. Nathan offers the noun *carburetor* as an example:

(14) ? The truck's carburetor is obvious.
Compare with *It's obvious what the truck's carburetor is.*

As I do not have a solution to these issues, I leave them as an unresolved puzzle. The theory of CQs laid out in this chapter predicts all DPs to be equally good CQs.

The present section is organized as follows. In §3.1.1, I discuss data involving CQs and coordination to argue for a particular kind of analysis of CQ embedding. Then, in §3.1.2 I present a simplified version of the theory of question-embedding proposed in Spector and Egré (2015). Finally, in §3.1.3 I show how this theory can be extended to account for CQ-embedding if we incorporate a suggestion in Groenendijk and Stokhof

1982, which gives us the theory in George (2011). In §3.1.4, I sketch how this theory can be used to account for the data discussed in §3.1.1.

3.1.1 Concealed questions and coordination

As discussed in the introduction, Heim (1979) contemplated an account of CQ embedding in which CQ-embedding predicates involve a relation between the attitude holder and an IC. She proposed, for example, that English had at least two *know* homonyms, one of which would be analyzed along the following lines:

(15) $[\![\text{know}_{\text{IC}}]\!]^{w} := \lambda u_{\text{se}}.\lambda x_{\text{e}}.\ \textsf{know}(\lambda w'.\ u(w) = u(w'))(x)(w)$

An argument against this kind of analysis can be found in data involving CQs and coordination. As observed by Aloni and Roelofsen (2011), CQs can be coordinated with both declarative and interrogative CPs:

(16) a. The psychic knows Filipe's birth date and when he will pass.
b. The psychic knows Filipe's birth date and that he will pass in August.

There are, abstractly, two competing analysis of the coordinated structures above, which are illustrated in (17). They diverge on what constituents are being coordinated: these sentences' underlying structure could be transparent, but it is also possible that *and* is coordinating VPs and some ellipsis process deletes the second occurrence of *know*.

(17) a. … knows [[Filipe's birth date] and [when he will pass]]
b. … [knows Filipe's birth date] and [~~knows~~ when he will pass]

Regardless of the analysis, the data in (16) calls into question theories where the English lexicon is taken to contain a CQ-embedding entry for *know* different from clause-embedding *know*. If the correct underlying structure of (16a) turns out to be (17a), the data shows that a single lexical entry *know* is able to embed a coordination of a DP and a CP. If the correct underlying structure turns out to be (17b) instead, we still reach the same conclusion: ellipsis of the second occurrence of *know* would only be possible if its meaning were identical to that of its non-elided antecedent.

The data in (16) does seem to suggest that CQ-embedding predicates should not be analyzed as predicating on ICs, contra Heim (1979). However, another set of data involving CQs points against this conclusion. These data consist of sentences with VPs like *rise* and *change*, which, as already discussed, Montague (1973) analyzed as predicates of ICs.

Crucially – contra a claim made in Nathan 2006 – such VPs can be coordinated with CQ-embedding VPs, as shown in the examples in (18).

(18) a. The price rose and was immediately revealed to the public.

b. The temperature lowered and is no longer known to us.

Again, there are two possible underlying structures that these sentences may involve — one in which the VPs are coordinated directly, and another in which the subject moves in an across-the-board fashion out of the two VPs:

(19) a. the price [[rose] and [was revealed]]

b. the price λ_1 [[t_1 rose] and [t_1 was revealed]]

Under either analysis, the data in (18) seems to suggest that the VP *be revealed* can be interpreted as a predicate of ICs: if the correct structure is (19a), then *rise* and *be revealed* must be translated into predicates of the same type to be coordinated; if the correct structure is (19b), *was revealed* must still be treated as a predicate of ICs since the type of the trace left by *the price* must be the same in both VPs.

The data in (16) and (18) may at first appear to be contradictory, but in fact they point us towards a specific analysis of CQ embedding. A solution that would account for both sets of data is that CQ embedding is mediated by a null operator OP that shifts ICs into objects that can compose with a clause-embedding predicate:

(20) [OP the winner] was revealed

The coordination facts can be accounted for as in (21): DPs can be coordinated with clausal complements after they are shifted by OP, and CQ-embedding predicates can be turned into predicates of ICs if the DP moves out of the OP phrase.

(21) a. Ann revealed [[OP the winner] and [that they're from Chile]]

b. The price λ_1 [[$t_{1,se}$ rose] and [[OP $t_{1,se}$] was revealed]]

The theory laid out in the incoming subsections, the one of George (2011), has the above properties and can therefore account for the coordination facts reviewed here. It should be noted, however, that the proposals of Aloni (2008), Aloni and Roelofsen (2011), and Romero (2007) could also account for these facts.

3.1.2 A theory of question embedding

In this subsection, I present a simplified version of the theory of question embedding of Spector and Egré (2015), in which the basic meaning of a clause-embedding predicate is that of a propositional attitude. Their key proposal is a general recipe for deriving the question-embedding meaning of a predicate in terms of its proposition-embedding meaning: given a clausal-embedding predicate V and interrogative Q, $V\ Q$ will denote a function true of those entities that bear the V-relation to a complete answer to the question Q.

(22) a. $[\![\text{Ann knows who laughed}]\!]^w = 1$
iff $\exists p.\ p$ is a complete answer to 'Who laughed' $\wedge$ Ann knows p

b. $[\![\text{Ann is certain who laughed}]\!]^w = 1$
iff $\exists p.\ p$ is a complete answer to 'Who laughed' $\wedge$ Ann is certain that p

The proposal crucially relies on the notion of a **complete answer**, which, in the theory of Spector and Egré, corresponds to the notion of a **strongly exhaustive answer** (Groenendijk and Stokhof 1982). In a nutshell, a strongly exhaustive answer to a question corresponds to a cell of the partition that the question induces in the logical space: given a question 'Who laughed?', a strongly exhaustive answer is a proposition denoted by a sentence of the form *only x laughed*, for some x.[1] To give a formal rendition of the theory of Spector and Egré, we must therefore devise a way of getting from questions to complete answers.

First, we must determine what questions are. Following Hamblin 1973, I identify questions with the set of their possible answers. For example, an interrogative like *who laughed* will be mapped to the set of propositions (denoted by sentences) of the form *x laughed* for some individual-denoting x:

(23) $[\![\text{who laughed}]\!]^w \coloneqq \lambda p_{\mathsf{st}}.\ \exists x.\ p = \mathsf{laugh}(x)$

Following Heim (1994), we will get from questions to complete answers via two semantic operations. The first takes a question Q and returns a function from a world to the intersection of all the propositions in Q that at that world:

(24) $[\![\text{ANS}]\!]^w \coloneqq \lambda Q_{\mathsf{st,t}}.\lambda w'.\lambda w''.\ \forall p \in Q.\ p(w') \rightarrow p(w'')$
$\coloneqq \textbf{ans}(Q)$

Thus, applying ANS to the question 'Who laughed?' will give us a function that will map a world w to the intersection of all proposition of the form *x laughed*, given some x, that are true at w. If Beth and Cleo are the only people who laughed at world w',

[1] As I present it, the proposal predicts that embedded questions always involve strong exhaustivity, which is known to be a bad prediction at least since Heim (1994). This is because I'm only presenting a simplified version of the theory: the actual complete proposal of Spector and Egré (2015) can in fact handle different degrees of exhaustivity.

then applying this function to w' will yield the proposition denoted by *Beth and Cleo laughed*, which is not yet a strongly exhaustive answer:

(25) $$[\![\text{ANS}]\!]^w([\![\text{who laughed}]\!]^w)(w') = \lambda w''.\ \forall x.\ \mathsf{laugh}(x)(w') \rightarrow \mathsf{laugh}(x)(w'')$$
$$= \lambda w''.\ \mathsf{laugh}(\mathsf{beth})(w'') \wedge \mathsf{laugh}(\mathsf{cleo})(w'')$$

We therefore need a second operator. The EXH-operator defined in (26), from Groenendijk and Stokhof 1982, takes an intensional object A and returns the function from a world w' to the proposition true in worlds where the value of A is the same as $A(w')$:

(26) $$[\![\text{EXH}_\alpha]\!]^w(A_{s\alpha}) \coloneqq \lambda w'.\lambda w''.\ A(w') = A(w'')$$
$$\coloneqq \mathbf{exh}_\alpha(A)$$

If Beth and Cleo are the only people who laughed at world w', we can get from the question denoted by *Who laughed?* to its strongly exhaustive answer as follows:

(27) $$[\![\text{EXH}_{\mathsf{st}}]\!]^w([\![\text{ANS}]\!]^w([\![\text{who laughed}]\!]^w))(w')$$
$$= \lambda w''.\ \mathbf{ans}([\![\text{who laughed}]\!]^w)(w') = \mathbf{ans}([\![\text{who laughed}]\!]^w)(w'')$$
$$= \lambda w''.\ \forall x.\ \mathsf{laugh}(x)(w') \leftrightarrow \mathsf{laugh}(x)(w'')$$
$$= \lambda w''.\ \forall x.\ (\mathsf{beth} = x \vee \mathsf{cleo} = x) \leftrightarrow \mathsf{laugh}(x)(w'')$$

We can the restate the proposal of Spector and Egré more formally as in (26). Technically, the formula involves existential quantification over worlds, but the result is equivalent as quantifying over potential complete answers.

(28) $$[\![V\,Q]\!]^w \coloneqq \lambda x_{\mathsf{e}}.\ \exists w'.\ [\![V]\!]^w([\![\text{EXH}_{\mathsf{st}}]\!]^w([\![\text{ANS}]\!]^w([\![Q]\!]^w))(w'))(x)$$

The main advantage of this proposal is its generality: we can apply it to different kinds of clause-embedding verbs and derive the attested truth conditions.

(29) a. $[\![\text{Ann knows who laughed}]\!]^w$
$$= \exists w'.\ \mathsf{know}(\lambda w''.\ \forall x.\ \mathsf{laugh}(x)(w') \leftrightarrow \mathsf{laugh}(x)(w''))(\mathsf{ann})(w)$$
b. $[\![\text{Ann is certain who laughed}]\!]^w$
$$= \exists w'.\ \mathsf{certain}(\lambda w''.\ \forall x.\ \mathsf{laugh}(x)(w') \leftrightarrow \mathsf{laugh}(x)(w''))(\mathsf{ann})(w)$$

The proposal correctly captures the fact that *know* but not *be certain* is veridical, i.e., the fact that if *Ann knows who laughed* is true, then *Ann knows only x laughed* is also true, where *x* denotes the people who actually laughed. It simply follows from the fact that *know* is factive: although (29a) involves quantification over any possible complete answer, the fact that *know* is only ever defined for propositions that are true, will make (29a) equivalent to (30).

(30) $\mathsf{know}(\lambda w'.\ \forall x.\ \mathsf{laugh}(x)(w) \leftrightarrow \mathsf{laugh}(x)(w'))(\mathsf{ann})(w)$

I implement the proposal compositionally via an additional phonologically null operator $\mathcal{Q}$, which introduces existential quantification over possible answers:

(31) $[\![\mathcal{Q}]\!]^w \coloneqq \lambda \mathcal{P}_{\mathsf{sst}}.\lambda Q_{\mathsf{st,t}}.\ \exists w'.\ Q(\mathcal{P}(w'))$

The structure of an embedded interrogative, then, is going to be assumed to be as in (32a). It cannot be interpreted *in situ* — *know* must combine with a proposition, yet the embedded interrogative denotes a function from sets of propositions to truth values. Thus, the interrogative will be assumed to QR, yielding the LF in (32b), which is then translated into the formula in (33).

(32) a. Ann knows [$\mathcal{Q}$ EXH$_{\mathsf{st}}$ ANS [who laughed]]

b. [$\mathcal{Q}$ EXH$_{\mathsf{st}}$ ANS [who laughed]] λ_1 Ann knows $t_{1,\mathsf{se}}$

(33) $[\![\mathcal{Q}]\!]^w(\mathbf{exh}_{\mathsf{st}}(\mathbf{ans}([\![\text{who laughed}]\!]^w)))(\lambda p.\ \mathsf{know}(p)(\mathsf{ann})(w))$
$= \exists w'.\ \mathsf{know}(\mathbf{exh}_{\mathsf{st}}(\mathbf{ans}([\![\text{who laughed}]\!]^w))(w'))(\mathsf{ann})(w)$

The LF in (33) yields exactly the same results as the schema in (28).

3.1.3 An extension to concealed questions

In an end note, Groenendijk and Stokhof (1982) attribute to Barbara Partee the idea that CQs could be accounted for by applying EXH directly to DPs that denote ICs. For example, applying it to the intension of *Filipe's birthday* will yield the function from w to the proposition true in all worlds in which the extension of *Filipe's birthday* is the same as its extension in w:

(34) $\mathbf{exh}_{\mathsf{e}}(\lambda w'.[\![\text{Filipe's birthday}]\!]^{w'})(w)$
$= \lambda w'.\ [\![\text{Filipe's birthday}]\!]^{w} = [\![\text{Filipe's birthday}]\!]^{w'}$

Embedding this under *know* will correctly capture the truth conditions of the sentence *Ann knows Filipe's birthday*: it is true whenever the extension of *Filipe's birthday* in Mary's belief worlds is the same as its extension at the actual world. In fact, this yields the exact entry for *know*$_{\text{IC}}$ we entertained above:

(35) $[\![\text{know}_{\text{IC}}]\!]^w = \lambda u_{\mathsf{se}}.\lambda x_{\mathsf{e}}.\ \mathsf{know}(\lambda w'.\ u(w) = u(w'))(x)(w)$
$= \lambda u_{\mathsf{se}}.\lambda x_{\mathsf{e}}.\ [\![\text{know}]\!]^w(\mathbf{exh}_{\mathsf{e}}(u)(w))(x)(w)$

The theory of question embedding presented above can thus naturally account for CQ embedding as well: all we need to assume is that a sentence like (36) is mapped to an LF like (36a), where $\mathcal{Q}$ combined directly with *Filipe's birthday*. This LF can then translated into (36b).

(36) Ann is certain of Filipe's birthday.

a. [$\mathcal{Q}$ EXH$_{\text{e}}$ Filipe's birthday] λ_1 Ann is certain of $t_{1,\text{st}}$

b. $\exists w'.\ \mathsf{certain}(\lambda w''.\ [\![\text{Filipe's birthday}]\!]^{w'} = [\![\text{Filipe's birthday}]\!]^{w''})(\mathsf{ann})(w)$

This theory of CQ embedding is equivalent to the one proposed by George (2011), the only differences being certain details of presentation.

For ease of exposition, for the remaining of this paper, I will often simplify LFs with CQs in the following way:

(37) Ann [knows$_{\text{IC}}$ Filipe's birthday]
$\Leftrightarrow$ Ann λ_0 [[$\mathcal{Q}$ EXH Filipe's birthday] λ_1 [$t_{0,\text{e}}$ knows $t_{1,\text{st}}$]]

Thus, although I may talk about "CQ-embedding *know*" or have LFs with "*know*$_{\text{IC}}$", I always mean it as an abbreviation for the underlying structure above.

I also simplify formulas that involve CQ-embedding, as we will see many of them. First, I will often substitute quantification over worlds for quantification over individuals as follows:

(38) a. $\exists w''.\ \mathsf{certain}(\lambda w'.\ [\![\text{Filipe's birthday}]\!]^{w''} = [\![\text{Filipe's birthday}]\!]^{w'})(\mathsf{ann})(w)$
$= \exists x.\ \mathsf{certain}(\lambda w'.\ x = [\![\text{Filipe's birthday}]\!]^{w'})(\mathsf{ann})(w)$

b. $\exists w''.\ \mathsf{know}(\lambda w'.\ [\![\text{Filipe's birthday}]\!]^{w''} = [\![\text{Filipe's birthday}]\!]^{w'})(\mathsf{ann})(w)$
$= \exists x.\ \mathsf{know}(\lambda w'.\ x = [\![\text{Filipe's birthday}]\!]^{w'})(\mathsf{ann})(w)$

Notice that the factivity of *know* will require Ann to know the actual extension of *Filipe's birthday* for (38b) to be true. However, for *Ann is certain of Filipe's birthday* to be true, all that is needed is that the there is some particular individual x that Ann is certain that x is the extension of *Filipe's birthday*.

Because the formulas in (38) are still fairly long, I will also make use of the following abbreviation:

(39) $\textbf{know}_{\alpha}(A_{\text{s}\alpha})(x_{\text{e}})(w_{\text{s}}) \coloneqq \exists w'.\ \mathsf{know}(\textbf{exh}_{\alpha}(A)(w'))(x)(w)$

Needlessly to say, the proposal naturally account for the puzzle of failure of substitution. The invalid argument in (2), repeated here in (40), is essentially accounted for like the temperature paradox is accounted for in Montague 1973.

(40) Ann knows Filipe's birthday.
Filipe's birthday is (also) Caracalla's birthday.
$\not\therefore$ Ann knows Caracalla's birthday.

Each sentence (40) is translated as follows:

(41) a. $\exists x.\ \mathsf{know}(\lambda w'.\ x = \mathsf{filipes\text{-}birthday}(w'))(\mathsf{ann})(w)$

b. $\mathsf{filipes\text{-}birthday}(w) = \mathsf{caracallas\text{-}birthday}(w)$

c. $\exists x.\ \mathsf{know}(\lambda w'.\ x = \mathsf{caracallas\text{-}birthday}(w'))(\mathsf{ann})(w)$

The argument is not expected to go through: the second premise of (40) only states that the descriptions are co-extensional at the world of evaluation, but the $know_{\text{IC}}$ composes with their intension.

3.1.4 Accounting for coordination facts

In this fairly technical section, I show how the coordination facts discussed in §3.1.1 can be accounted for within the present theory. The analyses aren't particularly insightful, the content of this section is merely to show that it can be done, and nothing hinges on the particular details of implementation. Readers not particularly interested in these issues may freely skip to the next section.

First, I show how we can account for the fact that CQs can be coordinated with interrogative and declarative clauses:

(42) a. The psychic knows Filipe's birth date and when he will pass.

b. The psychic knows Filipe's birth date and that he will pass in August.

To do this, I assume the type-flexible meaning of *and* proposed by Partee and Rooth (1983), which is given in (43).

(43) a. $[\![\mathrm{and}_\alpha]\!]^w := \sqcap_\alpha$

b. $A \sqcap_\alpha B := \begin{cases} A \wedge B & \text{if } \alpha = \mathrm{t} \\ \lambda x_\beta.\ A(x) \sqcap_\sigma B(x) & \text{if } \alpha = \beta\sigma \end{cases}$

This allows us to account for (42a) as involving coordination of $\mathcal{Q}$Ps. An LF is given in (44), where the coordinated $\mathcal{Q}$Ps are QRed to generate an interpretable structure.

(44) [$\mathcal{Q}$ EXH Filipe's birth date] $\mathrm{and}_{(\mathrm{stt})\mathrm{t}}$[$\mathcal{Q}$ EXH when he will pass]
λ_1 the psychic knows $t_{1,\mathrm{st}}$

The coordination of $\mathcal{Q}$P is interpreted as shown in (45): it takes a predicate of propositions, and interprets it under the scope of the existential in each conjunct.

(45) $\lambda Q.\ (\exists x.\ Q(\lambda w'.x = [\![\text{Filipe's birth date}]\!]^{w'}))$
$\wedge\ (\exists w'.\ Q(\mathbf{exh}_{\text{st}}(\mathbf{ans}([\![\text{when ...}]\!]^{w}))(w')))$

The entire LF of (44) is translated into (46): the result is the same as having conjunction scope over the clause-embedding predicate.

(46) $\exists x.\ \text{know}(\lambda i.\ x = [\![\text{Filipe's birth date}]\!]^{i})(\text{the.psychic})(w))$
$\wedge\ (\exists w'.\ \text{know}(\mathbf{exh}_{\text{st}}(\mathbf{ans}([\![\text{when ...}]\!]^{w}))(w'))(\text{the.psychic})(w))$

To account for (42b), I make use of a polymorphic version of the type-shifter LIFT from Partee 1986, which will allow us to turn a declarative into a function from set of propositions to truth-values:

(47) $[\![\text{LIFT}]\!]^{w}(x_{\alpha}) \coloneqq \lambda f_{\alpha t}.\ f(x)$

(48) $[\![\text{LIFT}]\!]^{w}(\lambda w'.\ [\![\text{that he will pass in August}]\!]^{w'})$
$= \lambda Q.\ Q(\lambda w'.\ [\![\text{that he will pass in August}]\!]^{w'})$

Applying LIFT to the intension of a declarative clause allows us to coordinate it with the $\mathcal{Q}$P. Thus, (42a) ends up being interpreted in a very similar way to (58):

(49) a. [$\mathcal{Q}$ EXH Filipe's birth date] $\text{and}_{(\text{stt})\text{t}}$[LIFT that he will pass in August] λ_1 the psychic knows $t_{1,\text{st}}$

b. $(\exists x.\ \text{know}(\lambda w'.\ x = [\![\text{Filipe's birth date}]\!]^{w'})(\text{the.psychic})(w))$
$\wedge\ \text{know}(\lambda w'.\ [\![\text{that he will pass in August}]\!]^{w'})(\text{the.psychic})(w)$

We can now move on to the second set of coordination data — cases like (50a), where a CQ-taking VP is coordinated with a VP that denotes a predicate of ICs. These can be analyzed straightforwardly: we can just assume that the CQ in the second conjunct moves out of the $\mathcal{Q}$P, as shown in (50b).

(50) a. The price rose and was immediately revealed to the public.

b. the price λ_1 [$t_{1,\text{se}}$ rose] and [[$\mathcal{Q}$ EXH $t_{1,\text{se}}$] was revealed]

3.2 Quantified concealed questions

3.2.1 The problem of quantified concealed questions

The theory of CQ-embedding laid out in the previous section can straightforwardly account for sentences in which CQs are definite descriptions. However, it runs into issues as soon as we look into sentences with quantified CQs, such as (51).

(51) a. Ann knows **every password**.

b. **Most prices in this store** depends on **a price in that store**.

c. **No secret but yours** was surprising.

Quantificational DPs are standardly analyzed as generalized quantifiers over individuals and, although there are two possible strategies for interpreting the above sentence under this proposal, they both fail miserably.[2]

The first way of generating an interpretable LF for a sentence like (51a) is to have *every password* QR and leave behind an individual-denoting trace:

(52) every password λ_1 [$_{\text{VP}}$ Ann knows$_{\text{IC}}$ $t_{1,\text{e}}$]

CQ-embedding *know* can compose with the intension of the trace left behind by *every password*, but the resulting interpretation is incorrect. As shown in (53), because traces are rigid designators (i.e., they identify the same object across all possible worlds), the sentence is predicted to convey that Ann believes every phone number to be identical to itself. Because everything is identical to itself, this is equivalent to saying Ann believes a tautology, which is true whenever Ann has consistent beliefs.

(53) $[\![\text{every password}]\!]^w(\lambda x.\ [\![\text{know}_{\text{IC}}]\!]^w(\lambda w'.\ x)(\mathsf{ann}))$
$= \forall x.\ \mathsf{password}(x)(w) \rightarrow \exists z.\ \mathsf{know}(\lambda w'.\ z = x)(\mathsf{ann})(w)$
$= \forall x.\ \mathsf{password}(x)(w) \rightarrow \mathsf{know}(\lambda w'.\ x = x)(\mathsf{ann})(w)$
$= \mathsf{know}(\lambda w'.\ \top)(\mathsf{ann})(w)$
$= \mathsf{Dox}(\mathsf{ann})(w) \neq \varnothing$

The second strategy interprets the DP within the $\mathcal{Q}$-constituent. Because EXH is polymorphic, we could compose it directly with the intension of a quantified CQ:

(54) [$\mathcal{Q}$ EXH$_{\text{et,t}}$ every password] λ_1 Ann knows $t_{1,\text{st}}$

Applying EXH to the intension of *every password*, yields the proposition in (55), which is true in every world where *every password* has the same extension as it does at the world of evaluation. Since *every* is world-independent, this amounts to the proposition true in worlds where the extension of the NP *password* is the same as in the world of evaluation.

(55) $[\![\text{EXH}_{\text{et,t}}]\!]^w(\lambda w'.\ [\![\text{every password}]\!]^{w'})$
$= \lambda w'.\ [\![\text{every password}]\!]^w = [\![\text{every password}]\!]^{w'}$
$= \lambda w'.\ [\![\text{every}]\!]^w([\![\text{password}]\!]^w) = [\![\text{every}]\!]^{w'}([\![\text{password}]\!]^{w'})$
$= \lambda w'.\ [\![\text{password}]\!]^w = [\![\text{password}]\!]^{w'}$

[2]The discussion here will be reminiscent to the one in §1.1.2.

The problem is that, by the same reasoning, applying EXH to the DP *a password* yields the same proposition, and therefore the sentence *Ann knows a password* is incorrectly predicted to have the same meaning as (51a).

More generally, any proposal in which the quantified CQ doesn't take scope over the VP can be shown to be inappropriate. For example, (56) has a reading in which *every password* scopes over the disjunction of VPs — i.e., the sentence can be true if half of the passwords are known to Ann and the other half is known to Beth.

(56) Every password is either known to Ann or known to Beth.

If *every password* had to be interpreted within the $\mathcal{Q}$-constituent, this reading of the sentence would be unavailable as it would require the DP to reconstruct under the scope of the disjunction:

(57) $[\lambda \mathcal{G}_{\mathsf{s,ett}}.\ \mathbf{know}_{\mathsf{ett}}(\mathcal{G})(\mathsf{ann})(w) \vee \mathbf{know}_{\mathsf{ett}}(\mathcal{G})(\mathsf{beth})(w)](\lambda w'.\ [\![\text{every password}]\!]^{w'})$

$= \mathbf{know}_{\mathsf{ett}}(\lambda w'.\ [\![\text{every password}]\!]^{w'})(\mathsf{ann})(w)$

$\vee\ \mathbf{know}_{\mathsf{ett}}(\lambda w'.\ [\![\text{every password}]\!]^{w'})(\mathsf{beth})(w)$

Sentence (56) shows that quantified CQs **can** scope over the CQ-embedding verb — the data in (58), on the other hand, shows that they **must**. Sentence (58a), where *disagree* embeds an interrogative containing *every password*, can be true even if Ann and Beth agree on some passwords – they just can't agree on all of them. Sentence (58b), however, can only be true if they don't agree on any of the passwords. In other words, in (58b), *every password* must scope over *disagree*.

(58) a. Ann and Beth disagree on what every password is.

b. Ann and Beth disagree on every password.

We thus must conclude that the LF in (54) is not licit. Given that EXH was proposed to be polymorphic, it is not straightforward why this should be the case. I will leave this matter aside as an unresolved issue. It is possible to block this reading by constraining the possible types of EXH, but this would not be a particularly insightful explanation of this state of affairs. A more promising route to pursue would be to explain the unavailability of this kind of LF as resulting from the fact that, as discussed above, the determiner ends up not contributing to the overall meaning of the sentence.

In any case, we can conclude from the discussion in this subsection that treating quantified CQs as generalized quantifiers over individuals will not yield the desired results. We could, of course, make amendments to the theory of CQ embedding proposed in the last section. Instead, I pursue an approach in which the meaning of quantified CQs is re-analyzed.

3.2.2 Quantification over individual concepts and its problems

Heim (1979) was in fact aware of quantified CQs when she proposed her IC approach to the phenomenon. These weren't problematic for her, however: she framed her proposal within the fragment of Montague (1973) where DPs were analyzed as generalized quantifiers **over ICs**. Thus, *every password* would be analyzed as (59), where *every* involves quantification over ICs rather than individuals and *password* is translated into a predicate of ICs:

(59) $[\![\text{every password}]\!]^w = [\![\text{every}]\!]^w([\![\text{password}]\!]^w)$
$= \lambda V_{\mathsf{se,t}}.\ \forall u_{\mathsf{se}}.\ \textbf{password}_{\mathsf{se,t}}(u)(w) \rightarrow V(u)$

Montague (1973) analyzed DPs this way precisely to account for sentences in which quantificational DPs were arguments of predicates of ICs. Under this proposal, sentence (51a) can be straightforwardly analyzed as follows:

(60) a. every password λ_1 [Ann knows$_{\text{IC}}$ $t_{1,\mathsf{se}}$]
b. $\forall u_{\mathsf{se}}.\ \textbf{password}(u)(w) \rightarrow \textbf{know}_{\mathsf{e}}(u)(w)$

Although we don't face the same problems as we would were DPs treated as quantifiers over individuals, this analysis is far from satisfactory. Crucially, because there's no explicit proposal as to which ICs the NP *password* is true of, we cannot really access what the truth conditions we predict these sentences to have.

This issue becomes even more evident when we take into account the fact that, as observed by Heim (1979), certain quantified CQs are ambiguous. Sentence (61) has two readings, which, following Roelofsen and Aloni (2008), I will call the its **pair-list** and its **set** readings:

(61) Ann knows exactly three phone numbers.
a. **Pair-list Reading**
$\exists! X.\ |X| = 3 \wedge \forall x \in X.$ Ann knows what x's phone number is
b. **Set Reading**:
$\exists! X.\ |X| = 3 \wedge \forall x \in X.$ Ann knows that x is a phone number

These two readings are logically independent. Consider the contexts in (62): sentence (61) is only true in context A under its pair-list reading, and it is only true in context B under its set reading.

(62) a. **Context A**. Ann knows that the list contains only phone numbers but she can only maps three phone numbers to their owners.

b. **Context B**. Ann only knows that three of number sequences on the list are phone numbers but doesn't know whose phone numbers they are.

Under the analysis of quantificational DPs in Montague 1973, sentence (61) would only have a single translation:

(63) $\exists! U_{(\mathsf{se})\mathsf{t}}.\ |U| = 3 \wedge \forall u_{\mathsf{se}} \in U.\ \textbf{phone.number}(u)(w) \wedge \textbf{know}_{\mathsf{e}}(u)(\mathsf{ann})(w)$

We already discussed the issue that it is hard to assess what the predicted truth conditions are under this proposal, but another issue comes up now, related to the set reading: the analysis of CQ-embedding developed in the previous section was built to account for the fact that CQs can be paraphrased as identity questions, but the paraphrase given in (61b) isn't an identity question.

Furthermore, the availability of pair-list readings seems to be constrained by the formal properties of the DPs involved. Namely, Frana (2017) observes that only relational nouns without an overt internal argument give rise to these readings. For example, sentence (64a) only has a set reading (unless the context is rich enough to turn *prime number* into a relational noun).

(64) a. Ann knows exactly three prime numbers.

b. $\exists! X.\ |X| = 3 \wedge \forall x \in X.$ Ann knows x is a prime number

As Frana observes, the pair-list *vs* set ambiguity seems to be correlated with an ambiguity identified by Nathan (2006) in sentences of the form '[Det NP] *changed*' which are discussed in chapter 2. Sentence (65), just like (61), has two readings:

(65) Exactly three governors changed.

a. $\exists! X.\ |X| = 3 \wedge \forall x \in X.$ the governor of x changed

b. $\exists! X.\ |X| = 3 \wedge \forall x \in X.$
x is a governor who was replaced by someone who wasn't a governor

These readings are also logically independent. Observe the contexts in (66): sentence (65) is true in context A only if interpreted as (65a), and it is true in context B only if interpreted as (65b).

(66) a. **Context A**. There are five governors and three of them switch positions with each other.

b. **Context B**. There are five governors: two of them switch positions with each other and the other three are replaced by new people.

On the other hand, sentence (67) is only true in context (65b).

(67) Exactly three of the members of the governor council changed.

In the previous chapter, I proposed a novel theory of the interpretation of NPs as predicates of ICs which was able to account for these observations by Nathan (2006). I now show that the same theory can explain set/pair-list ambiguity as well.

3.2.3 From NPs to predicates of individual concepts

I now review the approach to DPs as quantifiers over ICs that I developed in 2. The first feature of the proposal is that natural language quantificational determiners are systematically ambiguous between quantifiers over individuals quantifiers over ICs:

(68)
$$\begin{aligned} [\![\text{every}_\alpha]\!]^w(A_{\alpha t})(B_{\alpha t}) &\coloneqq \forall a_\alpha.\, A(a) \rightarrow B(a) \\ [\![\text{a}_\alpha]\!]^w(A_{\alpha t})(B_{\alpha t}) &\coloneqq \exists a_\alpha.\, A(a) \wedge B(a) \\ [\![\text{exactly one}_\alpha]\!]^w(A_{\alpha t})(B_{\alpha t}) &\coloneqq \exists! a_\alpha.\, A(a) \wedge B(a) \end{aligned}$$

where $\alpha = \mathsf{e}$ or $\alpha = \mathsf{se}$

The second feature, which is the crucial one, is that NP intensions — properties of individuals — are turned into predicates of ICs through the interaction of (the polymorphic versions of) two type-shifting operations from Partee 1986, iota and ident:

(69) a. $\mathsf{iota}_\alpha \coloneqq \lambda f_{\alpha t}.\, \iota x_\alpha[f(x)]$

b. $\mathsf{ident}_\alpha \coloneqq \lambda a_\alpha . \lambda b_\alpha .\, a = b$

In (70), I show how these operations can turn an NP like *price of milk* into a predicate of ICs. First, we use iota_e to turn this NP into an IC, namely, the IC that will map any world w to the unique price of milk at w. Then, $\mathsf{ident}_\mathsf{se}$ can apply to this IC and give us a predicate true of any ICs identical to it.

(70)
$$\begin{aligned} &\mathsf{ident}_\mathsf{se}(\lambda w.\, \mathsf{iota}_\mathsf{e}([\![\text{price of milk}]\!]^w)) \\ &= \lambda u.\, u = (\lambda w.\, \iota x_\mathsf{e}[[\![\text{price of milk}]\!]^w(x)]) \end{aligned}$$

I take these operations to be performed a single phonologically null operator, $\uparrow_\mathsf{se}$, which may apply to any property-denoting node within an DP:

(71)
$$\begin{aligned} [\![\uparrow_\mathsf{se}]\!]^w(N_\mathsf{set}) &\coloneqq \mathsf{ident}_\mathsf{se}(\lambda w'.\, \mathsf{iota}_\mathsf{e}(N(w'))) \\ &= \lambda u_\mathsf{se}.\, u = (\lambda w'.\, \iota x[N(w')(x)]) \end{aligned}$$

By itself, $\uparrow_{se}$ doesn't create predicates of ICs that are in any way useful – it can only create predicates true of a single IC, as shown in (70). However, as we have seen in the previous chapter, predicates of ICs that are suitable for quantification can be created through the interaction of $\uparrow_{se}$ and other quantifiers within the DP. In the incoming sections, I show first how to derive pair-list readings for sentences with quantified CQs and then move on to set readings.

3.2.4 Deriving pair-list readings

I begin by showing how the present theory can account for the pair-list reading of quantified CQs. In a nutshell, the goal is to show how a sentence such as (72) can get to be interpreted in exactly the same way as sentence (73).[3]

(72) Ann knows every capital of a South American country.

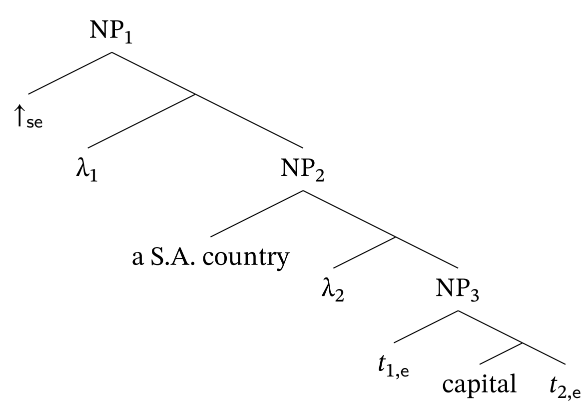
(73) Ann knows the capital of every South American country.

In sentence (72), differently from previous examples we have seen of quantified CQs, the noun *capital* has an overt internal argument, namely the indefinite *a South American country*. I start with examples like this for reasons that will soon be clear.

The quantified CQ in (72) must be interpreted as a generalized quantifier over ICs, thus, $\uparrow_{se}$ must apply to some node within the NP to turn it into a predicate of ICs. This operator will scopally interact with the indefinite *a South American country*: different predicates of ICs will be derived depending on the relative scope of these two operators.

Let's first consider a structure where $\uparrow_{se}$ scopes above the indefinite, as in (74):

(74)



This will not work: this LF is interpreted as a predicate true of a single IC, as shown in (75). Furthermore, the one IC it is true of has an undesirable presupposition that is

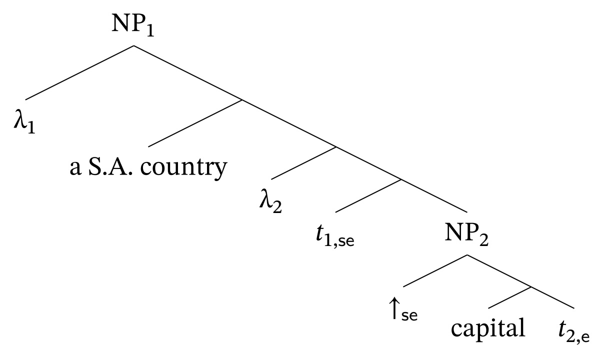
[3]The discussion in this subsection is essentially the same as the one in §2.2.2.

not satisfied in any world close to our own — namely, that there's a unique capital of a South American country.

$$(75)\quad \begin{aligned} [\![\text{NP}_1]\!]^w &= \lambda u.\, u = (\lambda w'.\, \iota x[[\![\text{NP}_2]\!]^{w', g^{[1\mapsto x]}}]) \\ &= \lambda u.\, (\lambda w'.\, \iota x[\exists z.\, \textsf{sa-country}(z)(x)(w') \wedge [\![\text{NP}_3]\!]^{w', g^{[1\mapsto x, 2\mapsto z]}}]) \\ &= \lambda u.\, u = (\lambda w'.\, \iota x[\exists z.\, \textsf{sa-country}(z)(i) \wedge \textsf{capital}(z)(x)(w')]) \end{aligned}$$

Let's then consider the other possible LF, where the indefinite scopes over $\uparrow_{\textsf{se}}$:

(76)



This structure is interpreted as a predicate that is true of (potentially) more than just one IC: as shown in (77), it is interpreted as the predicate true of all ICs of the form *the capital of z*, where z is a South American country.

$$(77)\quad \begin{aligned} [\![\text{NP}_1]\!]^w &= \lambda u.\, \exists z.\, \textsf{sa-country}(z)(w) \wedge [\![\text{NP}]\!]^{w, g^{[2\mapsto z]}}(u) \\ &= \lambda u.\, \exists z.\, \textsf{sa-country}(z)(w) \wedge u = (\lambda w'.\, \iota x[\textsf{capital}(z)(x)(w')]) \end{aligned}$$

From now on, I use the abbreviation in (78) to simplify formulas like (77) into (79):

(78) $\textbf{the}(A_{\textsf{est}}) \coloneqq \lambda w.\, \iota x[A(x)(w)]$

(79) $\lambda u.\, \exists z.\, \textsf{sa-country}(z)(w) \wedge u = \textbf{the}(\textsf{capital}(z))$

The predicate in (79) is what we need to derive the pair-list reading of sentence (72). The LF for the whole sentence is given in (80), where NP_1 has the structure in (76).

(80) $[\text{every}_{\textsf{se}}\ \text{NP}_1]\ \lambda_3$ Ann $\text{knows}_{\textsf{IC}}\ t_{3,\textsf{se}}$

This LF is then translated into the formula in (81), which is exactly the pair-list reading: for every concept u of the form *the capital of z*, where z is some South American country, it is true that Ann knows the actual value of u.

(81) $\forall u_{\textsf{se}}.\, (\exists z.\, \textsf{sa-country}(z)(w) \wedge u = \textbf{the}(\textsf{capital}(z))) \rightarrow \textbf{know}_{\textsf{e}}(u)(\textsf{ann})(w)$

Based on the equivalencies in (82), we can simplify the above formula as in (83). This simplification shows that we're essentially quantifying over countries rather than capitals, just as in the sentence *Ann knows the capital of every South American country*.

(82) a. $(\exists x.\ \phi) \rightarrow \psi \Leftrightarrow \forall x.\ (\phi \rightarrow \psi)$, if x is not free in ψ

b. $\forall x.\ (x = d) \rightarrow \phi \Leftrightarrow \phi[d/x]$, if y is not free in ϕ

(83) $\forall u_{\mathsf{se}}.\ (\exists z.\ \textsf{sa-country}(z)(w) \wedge u = \textbf{the}(\textsf{capital}(z))) \rightarrow \textbf{know}_{\mathsf{e}}(u)(\textsf{ann})(w)$
$= \forall u_{\mathsf{se}}.\ \forall z.\ \textsf{sa-country}(z)(w) \wedge u = \textbf{the}(\textsf{capital}(z)) \rightarrow \textbf{know}_{\mathsf{e}}(u)(\textsf{ann})(w)$
$= \forall z.\ \textsf{sa-country}(z)(w) \rightarrow \textbf{know}_{\mathsf{e}}(\textbf{the}(\textsf{capital}(z)))(\textsf{ann})(w)$

We can now go back to the more basic sentences where the relational noun *capital* doesn't have an overt internal arguments, as (84).

(84) Ann knows every capital.

These sentences are accounted for in the exact same way. Following much of the literature, I assume that relational nouns are detransitivized via existential closure of their internal argument (Barker 2011). I assume that this operation is performed by the operator EX, which is a polymorphic operator that will existentially close the first argument of any function of a boolean type.

(85) $[\![\text{EX}]\!]^w \coloneqq \textbf{Ex}$

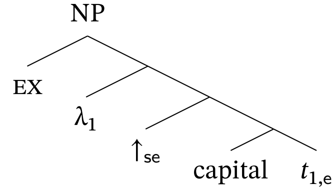
(86) $\textbf{Ex}(f_{\alpha\beta}) \coloneqq \begin{cases} \exists x_\alpha.\ f(x) & \text{if } \beta = \mathsf{t} \\ \lambda y_\alpha.\ \textbf{Ex}(\lambda x_\sigma.\ f(x)(y)) & \text{if } \beta = \sigma\tau \end{cases}$

In sentences in which *capital* is interpreted as a predicate of individuals, EX applies to it directly and yields the predicate true of individuals that are the capital of some country:

(87) $[\![\text{EX}]\!]^w([\![\text{capital}]\!]^w) = \lambda x_{\mathsf{e}}.\ \exists z.\ \textsf{capital}(z)(x)(w)$

As in the sentence in which the relational noun takes an indefinite as an internal argument, we can derive the pair-list reading if $\uparrow_{\mathsf{se}}$ applies to *capital* before EX does:

(88)



(89) $[\![\text{NP}]\!]^w = \lambda u.\ \exists z.\ u = \textbf{the}(\textsf{capital}(z))$

The LF for (84) is given in (90a), which is then translated into (90b), which is, again, the pair-list reading.

(90) a. [every EX λ_1 [$\uparrow_{\text{se}}$ [capital $t_{1,e}$]]] λ_1 Ann knows$_{\text{IC}}$ $t_{1,se}$

b. $\forall u.\ (\exists z.\ u = \mathbf{the}(\text{capital}(z))) \rightarrow \mathbf{know}_{\text{e}}(u)(\text{ann})(w)$
$= \forall z.\ \mathbf{know}_{\text{e}}(\mathbf{the}(\text{capital}(z)))(\text{ann})(w)$

This discussion shows that the present theory can naturally account for the pair-list readings of quantified CQs. We must now show how the set reading of (84) is to be derived. In the next subsection, I start discussing the interpretation of CQs that contain non-relational nouns and then I go back to discuss the set reading of sentences like (84).

3.2.5 Deriving set readings

Quantified CQs can also contain NPs headed by non-relational nouns. An example is given in (91), a sentence which is true whenever (92) is. Within the present theory, the challenge posed by these sentences is two-fold: (i) we must be able to find a way to derive predicates of ICs that are suitable to quantification, and (ii) these sets must be such that they yield the correct truth conditions for these sentences. Many of the features of the analysis developed in this section are from Frana (2017).

(91) Ann correctly guessed every student that was hired.

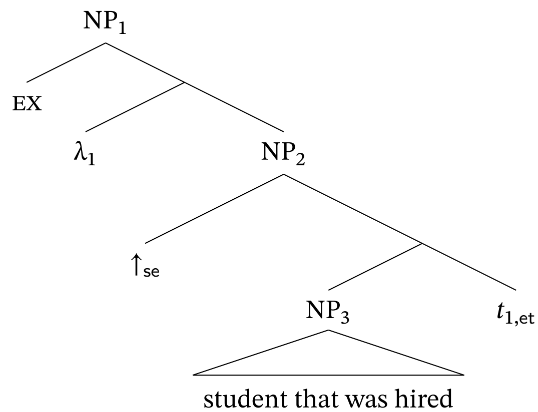
(92) Every student that was hired is such that Ann correctly guessed they were hired.

The immediate problem is that, again, applying $\uparrow_{\text{se}}$ directly to the NP will yield a predicate of ICs true of a single IC:

(93) $[\![\uparrow_{\text{se}}$ [student that was hired]$]\!]^w = \lambda u.\ u = \mathbf{the}(\text{student-hired})$

As in chapter §2, I assume that predicates of ICs are created from non-relational nouns via the interaction of $\uparrow_{\text{se}}$ and EX, just as for relational nouns. The difference, however, is that EX will existentially quantify over a **modifier** of the NP — as shown in figure the idea is that EX is base generated as a sister to the NP and then it QRs over $\uparrow_{\text{se}}$ while leaving a trace of type et.

(94)



This LF yields the predicate true of any IC of the form *the student that was hired in A*, where A is some set of individuals:

(95)
$$\begin{aligned} [\![\text{NP}_1]\!]^{w} &= \lambda u.\ \exists A_{\text{et}}.\ [\![\text{NP}_2]\!]^{w,g^{[1\mapsto z]}}(u) \\ &= \lambda u.\ \exists A_{\text{et}}.\ u = (\lambda w'.\ \iota x[[\![\text{NP}_3]\!]^{w'} \sqcap A]) \\ &= \lambda u.\ \exists A_{\text{et}}.\ u = (\lambda w'.\ \iota x[\textsf{student-hired}(x)(w') \wedge A(x)]) \end{aligned}$$

I introduce a second way to abbreviate my formulas: with the operator in (96), we can rewrite (95) into (97).

(96) $\textsf{\textbf{the}}_A(N_{\textsf{est}}) \coloneqq \lambda w.\ \iota x[N(x)(w) \wedge A(x)]$

(97) $\lambda u.\ \exists A_{\textsf{et}}.\ u = \textsf{\textbf{the}}_A(\textsf{student-hired})$

In (98), I show some examples of ICs that (97) is true of: in (98a), we have the IC that will map any world to Beth if she's a student that was hired; in (98b), we have the IC that will map any world to the one of Beth and Cleo that is a student that was hired.

(98) a. $\textsf{\textbf{the}}_{\{\textsf{beth}\}}(\textsf{student-hired}) = \lambda w.\ \iota x[\textsf{student-hired}(x)(w) \wedge x = \textsf{beth}]$

b. $\textsf{\textbf{the}}_{\{\textsf{beth},\textsf{cleo}\}}(\textsf{student-hired}) = \lambda w.\ \iota x[\textsf{student-hired}(x)(w) \wedge x \in \{\textsf{beth}, \textsf{cleo}\}]$

The ICs in (98a), which map worlds to a single individual, are exactly the ones Frana (2017) argues to give rise to the set readings. In the next subsection I show that ICs like (98b) are also needed to account for the full range of readings of sentences with CQs, but I set them aside for now.

As pointed out by Frana (2017), we do not quite get the right readings with these ICs. Suppose we map sentence (99) into the LF (100), where C the quantifier's silent domain restriction whose value is given in (101).

(99) Ann is certain of every student that was hired.

(100) [every$_C$ NP$_1$] λ_1 Ann is certain$_{\text{IC}}$ of $t_{1\text{se}}$

(101) $C = \left\{ \begin{array}{c} \textbf{the}_{\{\text{beth}\}}(\text{student-hired}) \\ \textbf{the}_{\{\text{cleo}\}}(\text{student-hired}) \\ \textbf{the}_{\{\text{deb}\}}(\text{student-hired}) \end{array} \right\}$

This LF would be translated into (102), which can be simplified into (103) given the equivalencies in (82) and the value of C:

(102) $\forall u_{\text{se}} \in C.\ (\exists A_{\text{et}}.\ u = \textbf{the}_A(\text{student-hired})) \rightarrow \textbf{certain}_{\text{e}}(u)(\text{ann})(w)$

(103) $\forall x \in \{\text{beth, cleo, deb}\}.\ \textbf{certain}_{\text{e}}(\textbf{the}_{\{x\}}(\text{student-hired}))(\text{ann})(w)$
$= \forall x \in \{\text{beth, cleo, deb}\}.\ \exists z.\ \text{certain}(\lambda w'.\ z = \textbf{the}_{\{x\}}(\text{student-hired})(w'))(\text{ann})(w)$

The formula in (103) needs to be unpacked, as it is not obvious what it means to be certain of an IC like $\textbf{the}_{\{\text{beth}\}}(\text{student-hired})$. First I focus on the meaning of the proposition that certain takes as its first argument:

(104) $\lambda w'.\ z = \textbf{the}_{\{x\}}(\text{student-hired})(w')$

This proposition is only defined in worlds in which the IC $\textbf{the}_{\{x\}}(\text{student-hired})$ is defined, i.e., worlds where x is a student who was hired. We can thus rewrite (104) as:

(105) $\lambda w' : \text{student-hired}(x)(w').\ z = x$

Formula (103) is equivalent to:

(106) $\forall x \in \{\text{beth, cleo, deb}\}.\ \exists z.\ \text{certain}(\lambda w' : \text{student-hired}(x)(w').\ z = x)(\text{ann})(w)$

Presuppositions under *certain* project into the attitude holder's beliefs, as shown in (107), thus, we predict that (99) should presuppose that, for each of Beth, Cleo and Deb, Ann believes that she is a student that was hired. The problem is that this shouldn't be presupposed but asserted: sentence (99) **asserts** rather than **presupposes** that Ann is certain that Beth, Cleo and Deb are students that were hired.

(107) Ann is certain Beth stopped smoking.
Presupposition: Ann believes Beth used to smoke.

To solve this issue, Frana (2017) suggests that the presuppositions of the relevant ICs could be locally accommodated (Heim 1983) under the embedding predicate. Although she herself pursues a different solution, I adopt it here. The particular implementation of local accommodation does not affect the proposal, but, here, I assume that this is done via the following covert operator (Beaver 1992):

(108) $[\![\mathcal{A}]\!]^w \coloneqq \lambda p. \begin{cases} 1 & \text{if } p(w) \wedge w \in \mathsf{dom}(p) \\ 0 & \text{otherwise} \end{cases}$

The result of applying $\mathcal{A}$ to (105) yields the following proposition:

(109) $\lambda w'. \mathsf{student\text{-}hired}(x)(w') \wedge z = x$

Thus, applying $\mathcal{A}$ under the scope of *certain* in (99) would yield the desired reading — Ann is certain of the IC *the student that was hired that is Beth* if Ann is certain that Beth is a student that was hired:[4]

(110) $\forall x \in \{\mathsf{beth}, \mathsf{cleo}, \mathsf{deb}\}. \exists z. \mathsf{certain}(\lambda w'. \mathsf{student\text{-}hired}(x)(w') \wedge z = x)(\mathsf{ann})(w)$
$= \forall x \in \{\mathsf{beth}, \mathsf{cleo}, \mathsf{deb}\}. \mathsf{certain}(\mathsf{student\text{-}hired}(x))(\mathsf{ann})(w)$

I will use the following shorthand in the formulas to come:

(111) $\mathbf{certain}^{\mathcal{A}}_{\alpha}(u)(x)(w) \coloneqq \exists w''. \mathsf{certain}(\lambda w'. [\![\mathcal{A}]\!]^{w'}(\mathbf{exh}_{\alpha}(u)(w'')))(x)(w)$

We can now go back to the pair-list *vs* set ambiguity displayed by sentences such as (112). In the present proposal, the ambiguity follows from the internal composition of the NP: the pair-list reading is derived when $\uparrow_{\mathsf{se}}$ scopes under EX; the set reading, on the other hand, is derived when EX closes off the internal argument of *capital* and another occurrence of EX binds a NP modifier from above $\uparrow_{\mathsf{se}}$.

(112) Ann knows every capital.

a. **Pair-list reading**:
every [EX λ_1 $\uparrow_{\mathsf{se}}$ [capital $t_{1,e}$]]

b. **Set reading**:
every [EX λ_1 $\uparrow_{\mathsf{se}}$ [[EX capital] $t_{1,et}$]]

3.2.6 A comparison with Frana (2017)

In this subsection, I compare my analysis of quantified CQs with that of Frana (2017), which is another proposal that falls within what Heim (1979) calls the ICs approach to CQs. My proposal is heavily built on insights by Frana (2017), but it differs from it in significant respects. I argue that my proposal is to be preferred on explanatory as well as empirical grounds.

[4] The LF that would yield this interpretation: DP λ_1 [$\mathcal{Q}$ λ_2 $\mathcal{A}$ [$t_{2,s}$ EXH t_{1se}]] λ_2 Ann is certain $t_{2,st}$

Set readings

I first discuss the account Frana's account of set readings. For ease of exposition, I frame it within the theory of CQ-embedding presented in 3.1 and, furthermore, I assume that set readings involve local accommodation as discussed in the previous section. The core of Frana's proposal remains intact in my exposition, however.

The crucial ingredient of Frana's account of set readings is the adoption of the Copy Theory of Movement (Chomsky 1995), and, more specifically, the theory of the interpretation of copies of Fox (2002). Within this theory of movement, for example, QR of *every dog* in (113a) creates the LF in (113b).

(113) a. Ann saw every dog.

b. [every dog] [Ann saw every dog]

Fox (2002) proposes that, in order for these LFs to be interpreted, lower copies are subject to the operation of **trace conversion**, defined as follows (following Heim 2019, I generalize this operation to yield traces of all types):

(114) **Trace conversion**

(Det) NP → $\text{the}_{n,\alpha}$ NP

(115) $[\![\text{the}_{n,\alpha}]\!]^{w,g} := \lambda f_{\alpha t}.\ \iota x_\alpha[f(x) \wedge x = g_n]$
$= \lambda f_{\alpha t} : f(g_n).\ g_n$

Applying trace conversion to (113b) together with λ-insertion, yields the LF in (116a) which is translated into (116b).

(116) a. every dog λ_1 [Ann saw [$\text{the}_{1,\text{e}}$ dog]]

b. $[\![\text{every dog}]\!]^w(\lambda x : \mathsf{dog}(x)(w).\ \mathsf{saw}(x)(\mathsf{ann})(w))$
$= \forall x.\ \mathsf{dog}(x)(w) \rightarrow \mathsf{saw}(x)(\mathsf{ann})(w)$

Frana's proposal is that set readings are derived via DPs quantifying over individuals rather than ICs. Even though I argued in §3.2.1 that this wouldn't yield the correct truth conditions, that was only because I assumed a naive theory of the interpretation of movement chains. By adopting the Copy Theory of Movement, however, we get something very similar to what I proposed:

(117) a. Ann knows every student that was hired.

b. [every student that was hired]
λ_1 Ann $\text{knows}^{\mathcal{A}}_{\text{IC}}$ [$\text{the}_{1,\text{e}}$ [student that was hired]]

c. $\forall x.\ \mathsf{stndt\text{-}hired}(x)(w) \rightarrow \mathbf{know}^{\mathcal{A}}_{\mathsf{e}}(\lambda w' : \mathsf{stndt\text{-}hired}(x)(w').\ x)(\mathsf{ann})(w)$
$= \forall x.\ \mathsf{stndt\text{-}hired}(x)(w) \rightarrow \mathsf{know}(\mathsf{stndt\text{-}hired}(x))(\mathsf{ann})(w)$

There are two empirical challenges for this proposal. The first concerns the fact that Frana's system is in fact weaker than the one I proposed, as it cannot simulate quantification over ICs of the following form:

(118) $\mathbf{the}_{\{\mathsf{rio},\mathsf{barcelona}\}}(\mathbf{Ex}(\mathsf{capital}))$

This IC is defined in all worlds in which exactly one of Rio and Barcelona are a capital, and, when defined, it yields the one among them that is a capital. The following scenario-sentence pair suggests that such ICs are useful:

(119) **Scenario**. There are no capitals on the list. Ann thinks there are five capitals in it and she's sure of four of them. She is now unsure if the fifth capital is Rio or Barcelona.

(120) Ann is unsure of exactly one capital (on the list).

Sentence (120) states that there is exactly one capital IC that she is unsure of – namely (120). Frana's proposal would only be able to analyze (120) as follows (to handle non-veridical predicates, Frana suggests that NPs could in principle be interpreted only in lower copies):

(121) a. [exactly one C] λ_1 Ann is unsure$^{\mathcal{A}}$ [the$_{1,\mathsf{e}}$ capital]
b. $\exists! x \in C.\ \mathsf{unsure}(\mathbf{Ex}(\mathsf{capital})(x))(\mathsf{ann})(w)$

This would predict the sentence to be false as there isn't exactly one individual s.t. Ann is unsure whether it is a capital — there are two.

The other problem concerns an ambiguity that to the best of my knowledge hasn't been previously observed. Sentence (122), where the CQ contains a disjunction of NPs, has two possible readings:

(122) Ann knows every semanticist or philosopher (in the department).

a. **Reading I**:
for every x such that x is a semanticist or a philosopher, Ann knows that x either is a semanticist or a philosopher

b. **Reading II**:
for every semanticist, Ann knows that they are a semanticist, and for every philosopher Ann knows that they are a philosopher

Reading II entails Reading I, which could lead one to question whether the sentence is indeed ambiguous. Evidence for the existence of Reading II comes from the fact that the sentence in (123) can be judged as true in the given scenario:

(123) **Scenario** The semanticist in the department is Beth, and the philosophers are Cleo and Deb. Ann knows that Beth is a semanticist and the Cleo is a philosopher, but she's unsure if Deb is a semanticist or a philosopher. She knows no one else is a linguist or a philosopher.
Ann doesn't know every semanticis or philosopher in the department

Since sentence (122) is true under Reading I in the scenario above, the fact that the negation of (122) can be judged as true shows that this sentence also has an interpretation that corresponds to Reading II.

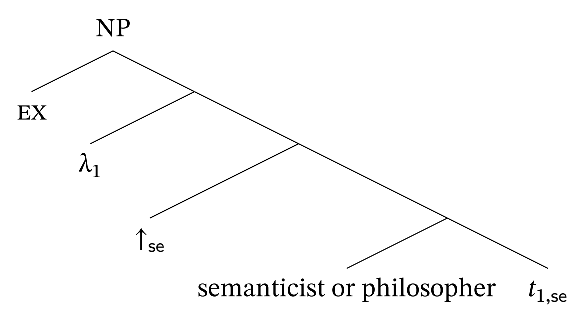
The analysis of set readings in Frana (2017) can only derive Reading I: the only LF she can generate is the one in (124), which is interpreted as (125).

(124) every semanticist or philosopher
λ_1 Ann knows$^{\mathcal{A}}_{\text{IC}}$ [the semanticist or philosopher [ID $pro_{1,\text{e}}$]]

(125) $\forall x.\ \mathsf{semanticist} \sqcup \mathsf{philosopher}(x)(w) \rightarrow$
$\mathsf{know}(\mathsf{semanticist} \sqcup \mathsf{philosopher}(x))(\mathsf{ann})(w)$

My proposal can capture both readings, however. Again, this ambiguity will be treated as a matter of scope: Reading I corresponds to the reading you get when $\uparrow_{\text{se}}$ scopes over disjunction, while Reading II corresponds to the reading you get when you have the opposite scopal configuration.

The NP structure that would yield Reading I is given in (126), which is then translated into the formula in (127).

(126)


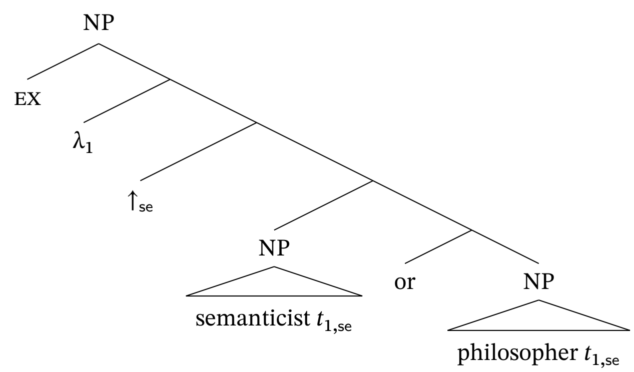
(127) $\lambda u.\ \exists A_{\text{et}}.\ u = \mathbf{the}_A(\mathsf{semanticist} \sqcup \mathsf{philosopher})$

If this is the interpretation of the NP in (122), the sentence would be interpreted as (128): for every salient set of individuals A, Ann must know which element of A is a linguist or philosopher.

(128) $\forall u \in C. (\exists A. u = \textbf{the}_A(\text{semanticist} \sqcup \text{philosopher})) \rightarrow \textbf{know}^{\mathcal{A}}_{\text{e}}(u)(\text{ann})(w)$

Reading II is derived if the NP has the structure in (129):

(129)



(130) $\lambda u. \exists A_{\text{et}}. u = \textbf{the}_A(\text{semanticist}) \vee u = \textbf{the}_A(\text{philosopher})$

If this is the interpretation of the NP in (124), the sentence would be interpreted as (131): for every salient A, Ann knows which of A is a linguist, and for every salient B, Ann knows which of B is a philosopher.

(131)
$$\begin{aligned} &\forall u \in C. (\exists A. u = \textbf{the}_A(\text{semanticist}) \vee u = \textbf{the}_A(\text{philosopher})) \\ &\qquad\qquad\qquad \rightarrow \textbf{know}^{\mathcal{A}}_{\text{e}}(u)(\text{ann})(w) \\ &= \forall u \in C. (\exists A. u = \textbf{the}_A(\text{semanticist})) \rightarrow \textbf{know}^{\mathcal{A}}_{\text{e}}(u)(\text{ann})(w) \\ &\qquad \wedge \forall u \in C. (\exists A. u = \textbf{the}_A(\text{philosopher})) \rightarrow \textbf{know}^{\mathcal{A}}_{\text{e}}(u)(\text{ann})(w) \end{aligned}$$

Thus, although my account of set readings shares many features with Frana's, her proposal cannot cover all possible readings these sentences may have.

Pair-list readings

Now I move on the Frana's account of pair-list readings. Her proposal consists of two type-shifters. The first is due to Nathan (2006), which she calls IC-SHIFT, which turns relational nouns into predicates of ICs:

(132) $[\![\text{IC-SHIFT}]\!]^w(\mathcal{R}_{\text{seet}}) \coloneqq \lambda u_{\text{se}}. \exists z. \forall w'. R(i)(z)(u(w'))$

Applying this to a noun like *governor* would yield a predicate that would be true of ICs like *the governor of Massachusetts*, since there is one individual z s.t. across all worlds (in which the IC is defined) its value is someone who is the governor of z.

(133) $[\![\textsc{ic-shift}]\!]^w([\![\text{governor}]\!]_{¢}) == \lambda u_{\text{se}}.\ \exists z.\ \forall w'.\ \mathsf{governor}(z)(u(w'))(w')$

Because this analysis is in fact Nathan's, the same arguments that were raised against it in the previous chapter can be raised here. The fact that IC-SHIFT only applies to relational nouns is by design — that's why pair-list readings are restricted to relational nouns. Although this yields similar results to my own proposal, it re-states puzzle it is attempting to explain. In contrast, my proposal assumes that both set and pair-list readings are derived via the same type-shifting operations — the difference between these readings are due to the internal structure of the relevant NPs.

Furthermore, IC-SHIFT only works for relational nouns that are **functional**, where N is a functional relational noun iff $\forall x.\ \exists! y.\ [\![N]\!]^w(x)(y)$. The noun *(American) senator*, for example, is not functional — each state in the U.S. has two senators. To see that IC-SHIFT will not work for these nouns, observe that applying it to *senator* will create a predicate that is true of ICs like *the taller senator of Massachusetts* and *the shorter senator of Massachusetts*.

(134) $[\![\textsc{ic-shift}]\!]^w(\lambda w'.\ [\![\text{senator}]\!]^{w'}) = \lambda u_{\text{se}}.\ \exists z.\ \forall w'.\ \mathsf{senator}(z)(u(w'))(w')$

Now suppose that Ann knows who the two senators of each state is, but the one thing she gets wrong is who is taller than who. Sentence (135) is incorrectly predicted to be able to be judged as true under this scenario, since it's not true that Ann know who the taller senator of any state is.

(135) Ann doesn't know any senator.

To account for these, Frana has to introduce yet another type-shifter, specifically for these nouns. She furthermore makes the unusual assumption that domain of indiviudals contains both individuals and pairs of individuals. I will not present the specifics of proposal here, but will just shown that these nouns can be naturally accounted for in my own proposal: NPs like *senator* can be turned ito predicates of ICs by using the strategy we used to derived pair-list and set readings together:

(136) $\textsc{ex}\ \lambda_1\ \textsc{ex}\ \lambda_2\ \uparrow_{\text{se}}\ [[\text{senator}\ t_{e,\text{e}}]\ \text{t}_{1,\text{et}}]$

(137) $\lambda u.\ \exists A_{\text{et}}.\ \exists z_{\text{e}}.\ u = \mathbf{the}_A(\mathsf{senator}(z))$

Crucially, ICs such as *the taller senator of Massachusetts* are not in (137) — instead, the ICs are of the form *the senator of Massachusetts that is Ann or Beth* (see §2.2.4 for a more detailed discussion).

3.3 Nested concealed questions

This section is devoted to the ambiguity found in sentences with **nested concealed questions**, i.e., CQs modified by relative clauses whose gap is interpreted as a CQ. Heim (1979) was the first to observe that these constructions are ambiguous between two readings, which following Frana (2017) I call **question** and **meta-question** readings:

(138) Ann knows the capital Beth knows.

a. **Question reading**:
Beth knows exactly one capital and Ann knows that capital too.

b. **Meta-question reading**:
Ann knows which capital Beth knows.

These readings are logically independent. For example, when uttered in context (139), sentence (138) is only true under its question reading: Ann and Beth both know the capital of Brazil, but Ann isn't aware that Beth knows it.

(139) Beth knows that the capital of Brazil is Brasília but she doesn't know any other capital. Ann doesn't know that Beth knows the capital of Brazil but she herself knows that it is Brasília.

When uttered in context (140), (138) is only true under its meta-question reading: Ann knows Beth knows the capital of Brazil but she herself doesn't know it.

(140) Beth knows that the capital of Brazil is Brasília and she doesn't know any other capital. Ann doesn't know the capital of Brazil, but she knows that Beth does.

In §3.3.1, I show that, while the current approach to CQs can easily derive question readings, meta-question readings are a problem. In §3.3.2, I present the proposal of Romero (2005), where meta-question readings are derived by allowing CQ-embedding predicates to also take functions from worlds to ICs as arguments. Her proposal, however, cannot be account for data with quantified nested CQs. In §3.3.3, I show that my theory of how NPs are shifted into predicates of ICs can also be used to shift them into predicates of functions from worlds to ICs. This allows us to generalize Romero's proposal to account for quantified nested CQs. I conclude with §3.3.4, where I discuss how the analysis of meta-question readings developed here can also be used to account for a previously unobserved reading of sentences with VPs interpreted as predicates of ICs.

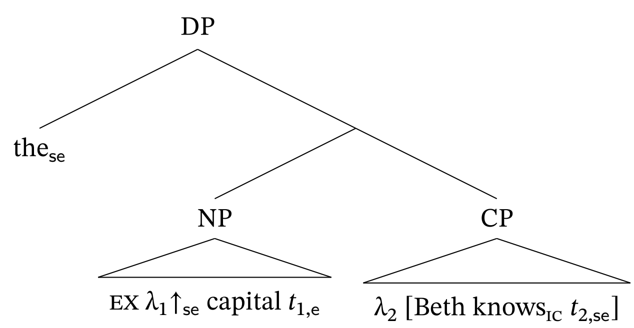
3.3.1 The problem with meta-question readings

The present approach to CQs can easily account for the question reading of (138). Under this reading, the relative clause *(that) Beth knows* is not interpreted under the scope of the CQ-embedding predicate: the sentence can be true even if Ann doesn't know anything about what Beth knows. Because of this, we cannot derive the question reading by having $know_{\text{IC}}$ compose with the intension of the_{e} *captial Beth knows*, as in (141).

(141) $[\![\text{know}]\!]^{w}(\lambda w'.\ [\![\text{the}_{\text{e}} \text{ capital Beth knows}]\!]^{w'})([\![\text{Ann}]\!]^{w})$

The definite CQ, therefore, must be interpreted in a different way. The question reading will be derived if we shift *capital* into a predicate of ICs and then have the relative clause modify it:

(142)



The structure above is interpreted as (143): the extension of the DP is the unique IC u s.t. Beth knows the extension of u and u is of the form *the price of z*, for some z.

(143) $[\![\text{DP}]\!]^{w} = \iota u_{\text{se}}[[\![\text{NP}_2]\!]^{w}(u) \wedge [\![\text{CP}]\!]^{w}(u)]$
$= \iota u_{\text{se}}[\exists z_{\text{e}}.\ u = \textbf{the}(\text{capital}(z)) \wedge \textbf{know}_{\text{e}}(u)(\text{beth})(w)]$

The entire sentence is analyzed as illustrated in (144), where I omit certain less important details of the LF in (142) for ease of exposition.

(144) a. Ann knows_{IC} [the_{se} [$\uparrow_{\text{se}}$ capital] [that Beth knows]]
b. $\textbf{know}(\iota u_{\text{se}}[\exists z_{\text{e}}.\ u = \textbf{the}(\text{capital}(z)) \wedge \textbf{know}_{\text{e}}(u)(\text{beth})(w)])(\text{ann})(w)$

The relative clause is not interpreted under the scope of matrix $know_{\text{IC}}$ — it composes with the extension of the_{se} *capital that Beth knows*, which is an IC of the the form *the price of z*, for some z. The relative clause is able to escaped the scope of the CQ-embedding predicate by outscoping $\uparrow_{\text{se}}$.

This analysis of question reading naturally account for a property of these sentences which, to the best of my knowledge, has been unnoticed so far. Observe the two arguments given in (145) and (146), where the first premise is supposed to be interpreted under its question reading:

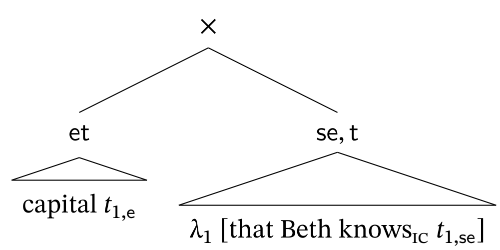
(145) Ann knows the capital that Beth knows.
The capital that Beth knows is the capital of Brazil.
$\therefore$ Ann knows the capital of Brazil.

(146) Ann knows the capital that Beth knows.
The capital that Beth knows is the city founded by Juscelino Kubitschek.
$\not\therefore$ Ann knows the city founded by Juscelino Kubitschek.

The two arguments have the exact same logical structure, yet only (145) is valid. The current analysis is able to correctly predict this state of affairs because it relies on an explicit theory of how NPs are interpreted as predicates of ICs: under the analysis of *Ann knows the capital that Beth knows* given in (144), we require Ann and Beth to know the value of an IC of the form *the capital of z*, for some z.

We can now turn to the meta-question reading. Under these readings, the relative clauses in the nested CQs **must** be interpreted under the scope of the matrix CQ-embedding predicate. Nonetheless, it is still not possible to analyze these examples as in (141). The problem is that the relative clause *that Beth knows* is interpreted as a predicate of ICs, and, as such, it can't modify the noun *capital* if it's not shifted:

(147)



We could in principle solve this issue via syntactic reconstruction, but, even if we find a way to interpret structure *the*$_{\text{e}}$ *capital Beth knows*, our approach to CQs is still inadequate to account for meta-question readings. The meaning of CQ-embedding *know*, after all, is the following:

(148) $[\![\text{know}_{\text{IC}}]\!]^w \coloneqq \lambda u_{\text{se}}.\lambda x_{\text{e}}.\ \exists z.\ \text{know}(\lambda w'.\ z = u(w'))(x)(w)$

Knowing an IC involves knowing what its extension is. The problem with the meta-question reading is that *Ann knows the capital that Beth knows* doesn't entail that Ann knows the extension of any capital IC. Thus, the problem seems to be with the meaning of CQ-embedding *know*.

3.3.2 Romero 2005: moving to individual concept concepts

Romero (2005) offers a simple and elegant account of meta-question readings. The key idea is that in those cases, the CQ-embedding predicate composes with a function from worlds to individual concepts, i.e., an **individual concept concept** (ICC). Here, I present her proposal within the theory I have developed so far.

Given that EXH is polymorphic, we can derive a sensible meaning for CQ-embedding predicates as predicates of ICCs:[5]

(149) $[\![\text{know}_{\text{ICC}}]\!]^{w} \coloneqq \lambda c_{\mathsf{sse}}.\lambda x_{\mathsf{e}}.\ \exists i.\ [\![\mathsf{know}]\!]^{w}(\mathbf{exh}_{\mathsf{se}}(c)(i))(x)$
$= \lambda c_{\mathsf{sse}}.\lambda x_{\mathsf{e}}.\ \exists u_{\mathsf{se}}.\ \mathsf{know}(\lambda i.\ u = c(i))(x)(w)$
$= \lambda c_{\mathsf{sse}}.\lambda x_{\mathsf{e}}.\ \mathbf{know}_{\mathsf{se}}(c)(x)(w)$

Under this analysis, to know an ICC *c*, is to know which IC *u* is the one that *c* picks out in the actual world.

Now that we allow *know* to be interpreted as (149), we can easily account for the meta-question reading of a basic sentence like *Ann knows the capital Beth knows*. All we need to say is that $know_{\text{ICC}}$ combines with **intension** of the LF given in (142), namely, the following function:

(150) $\lambda w'.\ \iota u_{\mathsf{se}}[\exists z_{\mathsf{e}}.\ u = \mathbf{the}(\mathsf{capital}(z)) \wedge \mathbf{know}_{\mathsf{e}}(u)(\mathsf{beth})(w')]$

In worlds in which Beth only knows the capital of Brazil, the value of the formula above is the IC of the form *the capital of Brazil*, in those in which Beth only knows the capital of Mexico, its values is the IC of the form *the capital of Mexico*.

Under this analysis, the LF and translation of the sentence *Ann knows the capital that Beth knows* under its meta-question reading would be the following:

(151) a. Ann $\text{knows}_{\text{ICC}}$ [the_{se} [$\uparrow_{\mathsf{se}}$ capital] [that Beth knows]]
b. $\exists v_{\mathsf{se}}.\ \mathsf{know}(\lambda i.\ v = \iota u[\exists z.\ u = \mathbf{the}(\mathsf{capital}(z)) \wedge \mathbf{know}_{\mathsf{e}}(u)(\mathsf{beth})(i)])(\mathsf{ann})(w)$

[5]The underlying structure of $know_{\text{ICC}}$ is identical to that of $know_{\text{IC}}$, the only different being the type of EXH (EXH_{e} *vs* EXH_{se}).

The sentence comes out as true if the value of the ICC (150) in Ann's belief worlds matches its value in the actual world. That is the case whenever Ann knows what is the IC of the form *the capital of z*, for some z, that Beth knows the actual extension of.

Romero's proposal indeed yields the correct analysis of the meta-question readings of basic sentences involving nested CQs. The problem is that, as pointed out by Aloni and Roelofsen (2011), the same ambiguities arise with quantificational CQs — sentence (152) is also ambiguous between a question and a meta-question reading.

(152) Ann knows every capital Beth knows.

We now face the same issue we discussed in §3.2.1. We can account for meta-question readings of definite CQs by having *know* compose with the DP's intension, but this analysis won't extend to quantificational CQs because these DPs must actually take scope **over** the CQ-embedding verb.

Instead of abandoning Romero's proposal, I will propose a way to generalize it. The path forward was already hinted at by Heim (1979) herself, who claimed that these meta-question readings required interpreting NPs as predicates of ICCs. This was a problem for Heim because, in her fragment, assuming NPs could be either predicates of ICs or predicates of ICCs implied assuming multiple and potentially unrelated homonyms for nouns. This is not a problem for the current proposal, however, since we have a general way for turning any predicate of type $\mathsf{s}\alpha\mathsf{t}$ into a predicate of type $\mathsf{s}\alpha, \mathsf{t}$.

3.3.3 From NPs to predicates of individual concept concepts

The building blocks of $\uparrow_{\mathsf{se}}$ were the polymorphic functions iota and ident. We used these functions to turn predicates of individuals into predicates of ICs but we can now use the very same functions to turn a predicate of ICs into a predicate of ICCs:

(153) $$[\![\uparrow_{\mathsf{sse}}]\!]^{w}(\mathcal{U}_{\mathsf{s(se,t)}}) \coloneqq \mathsf{ident}_{\mathsf{sse}}(\lambda i.\ \mathsf{iota}_{\mathsf{se}}(\mathcal{U}(i))) = \lambda c_{\mathsf{sse}}.\ c = (\lambda i.\ \iota u_{\mathsf{se}}[\mathcal{U}(i)(u)])$$

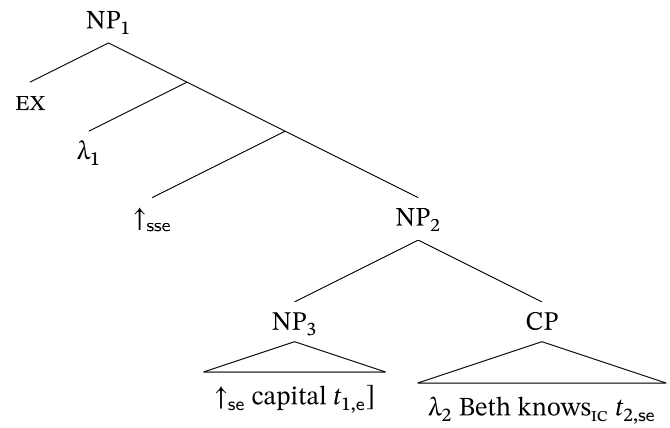
We can in fact propose a single polymorphic function to account for all the relevant shifting operations:

(154) $$[\![\uparrow_{\mathsf{s}\alpha}]\!]^{w}(A_{\mathsf{s}\alpha\mathsf{t}}) \coloneqq \mathsf{ident}_{\mathsf{s}\alpha}(\lambda i.\ \mathsf{iota}_{\alpha}(A(i)))$$

To derive the meta-question reading of (152), repeated below in (155), I propose that *captial that Beth knows* has the underlying structure in (156).

(155) Ann knows every capital Beth knows.

(156)



This structure is then interpreted as follows:

(157) $$\begin{aligned}[\![\text{NP}_1]\!]^{w} &= \lambda c_{\mathsf{sse}}.\ \exists z_{\mathsf{e}}.\ c = (\lambda w'.\ \iota u_{\mathsf{se}}[[\![\text{NP}_2]\!]^{w', g^{[2\mapsto z]}}(u)]) \\ &= \lambda c_{\mathsf{sse}}.\ \exists z_{\mathsf{e}}.\ c = (\lambda w'.\ \iota u_{\mathsf{se}}[u = \textbf{the}(\mathsf{capital}(z)) \wedge \textbf{know}_{\mathsf{e}}(u)(\mathsf{beth})(w')])\end{aligned}$$

This is the predicate of ICCs of that will map any world w' to the IC *the capital of* z as long as Beth knows the capital of z at w', for some z.

All we need, then, is to adjust our meaning for determiners to allow for them to range over ICCs as well:

(158) $$\begin{aligned}[\![\text{every}_{\alpha}]\!]^{w}(A_{\alpha\mathsf{t}})(B_{\alpha\mathsf{t}}) &\coloneqq \forall a_{\alpha}.\ A(a) \rightarrow B(a) \\ [\![\text{a}_{\alpha}]\!]^{w}(A_{\alpha\mathsf{t}})(B_{\alpha\mathsf{t}}) &\coloneqq \exists a_{\alpha}.\ A(a) \wedge B(a) \\ [\![\text{exactly one}_{\alpha}]\!]^{w}(A_{\alpha\mathsf{t}})(B_{\alpha\mathsf{t}}) &\coloneqq \exists! a_{\alpha}.\ A(a) \wedge B(a)\end{aligned}$$
where $\alpha = \mathsf{e}$ or $\alpha = \mathsf{se}$ or $\alpha = \mathsf{sse}$

We have all the pieces that we need. The LF that will yield the meta-question reading of (155) is the following, where NP$_1$ has the structure in (156):

(159) [every NP$_1$] λ_0 Ann knows$^{\mathcal{A}}_{\text{ICC}}$ $t_{0,\mathsf{sse}}$

Note that we have to assume that local accommodation has taken place under the scope of *know*: in the ICCs in (157), the relative clause is part of their definedness conditions — give some z, some ICC will only be defined in worlds in which Beth knows the capital of z, and in only those worlds it will return the IC *the capital of* z. If there is no local accommodation, the sentence will presuppose what it should assert. The above LF is translated as in (160): the sentence is predicted to mean exactly what it should: for every z, Ann knows that Beth knows the capital of z.

(160) $\forall c_{\mathsf{sse}}. (\exists z_{\mathsf{e}}. c = (\lambda w'. \iota u_{\mathsf{se}}[u = \mathbf{the}(\mathsf{capital}(z)) \wedge \mathbf{know}_{\mathsf{e}}(u)(\mathsf{beth})(w')]))$
$\rightarrow \mathbf{know}^{\mathcal{A}}_{\mathsf{se}}(c)(\mathsf{ann})(w)$
$= \forall z. \mathbf{know}^{\mathcal{A}}_{\mathsf{se}}(\lambda w'. \iota u_{\mathsf{se}}[u = \mathbf{the}(\mathsf{capital}(z)) \wedge \mathbf{know}_{\mathsf{e}}(u)(\mathsf{beth})(w')])(\mathsf{ann})(i)$
$= \forall z. \mathsf{know}(\mathbf{know}_{\mathsf{e}}(\mathbf{the}(\mathsf{capital}(z)))(\mathsf{beth}))(\mathsf{ann})(w')$

Nothing in this proposal hinges on the CQ getting a set or pair-list reading. I leave it to the reader to verify that the present analysis can also yield the same results for CQs that get a set reading.

3.3.4 Other predicates of individual concept concepts

Schwager (2007) observed the following ambiguity in sentences in which the argument of an irreducible predicate of ICs is a DP with a superlative modifier:

(161) The highest price will rise.

a. **Reading I**: At some future interval, the highest price at that interval will be greater than the current highest price.
b. **Reading II**: For some *x*, the price of *x* is the highest price now and the price of *x* will rise.

(162) The lowest price will rise.

a. **Reading I**: At some future interval, the lowest price at that interval will be greater than the current lowest price.
b. **Reading II**: For some *x*, the price of *x* is the lowest price now and the price of *x* will rise.

To see that we're dealing with a genuine ambiguity, consider the scenario in Figure 3.1. Sentence (161) is true under Reading I: tomorrow's highest price, $9, is greater today's, $8. However, it is false under Reading II: the price of cheese, the current highest price, is not going to rise tomorrow. We have the opposite state of affairs with sentence (162). It is false under Reading I: tomorrow's lowest price, $5, is the same as today's. However, it is true under Reading II: the price of milk, the current lowest price, will rise tomorrow.

	today	tomorrow
price of milk	$5	$9
price of cheese	$8	$5

Figure 3.1: Price scenario

Under the current approach these ambiguities can be reduced to simply a matter of scope. Specifically, Reading I arises when $\uparrow_{se}$ scopes over the modifier, whereas Reading II arises when $\uparrow_{se}$ scopes under it:

(163) a. **Reading I**: [$\uparrow_{se}$ [MOD NP]]

b. **Reading II**: [MOD [$\uparrow_{se}$ NP]]

In Reading I, the superlative is part of the IC that is claimed to rise; in Reading II, the IC that is claimed to rise is an IC of the form *the price of z*, for some z, and the superlative is interpreted relative to the index of evaluation.

To get this analysis off the ground, I assume that the adjective *highest* is ambiguous between two readings: one in which it is a modifier of predicates of individuals, and another in which it is a modifier of predicates of ICs:[6]

(164) $[\![\text{highest}_{\text{e}}]\!]^t \coloneqq \lambda f_{\text{et}}.\lambda x_{\text{e}}.\ f(x) \wedge \forall y \in f.\ x \neq y \rightarrow x > y$

(165) $[\![\text{highest}_{\text{se}}]\!]^t \coloneqq \lambda U_{\text{se,t}}.\lambda u_{\text{se}}.\ U(u) \wedge \forall v \in U.\ u \neq v \rightarrow u(t) > v(t)$

In (166) and (167), I show the LFs for Reading I and Reading II of (161), respectively. Under Reading I, *the highest price* is translated into that IC u s.t. u maps any index i to the highest price at i; under Reading II, *the highest price* is translated into that IC u s.t. u that maps i to the price of z at i, given some z, and the value of u at the index of evaluation is the highest price.

(166) a. [the$_{\text{se}}$ $\uparrow_{\text{se}}$ [highest$_{\text{e}}$ [EX price]]] will rise

b. $\textbf{rise}(\iota u_{se}[u = (\lambda t'.\ \iota x[[\![\text{highest}]\!]^{t'}(\textbf{Ex}([\![\text{price}]\!]^{t'}))(x)])])(t)$

(167) a. [the$_{\text{se}}$ [highest$_{\text{se}}$ [EX λ_1 $\uparrow_{\text{se}}$ [price $t_{1,\text{e}}$]]] will rise

b. $\textbf{rise}(\iota u_{se}[\exists z.\ u = \textbf{the}(\text{price}(z))$
$\wedge\ \forall y \neq z.\ \textbf{the}(\text{price}(z))(t) \neq \textbf{the}(\text{price}(y))(t)])(t)$

In this subsection, I'd like to point out that certain sentences of the form (161) turn out to, in fact, be three-way ambiguous:

(168) The highest price will remain the same.

a. **Reading I**:
The highest price now is the value x and in the future the highest price then will still be x.

[6] In this subsection, I take indices of evaluation to be time.

b. **Reading II**:
For some z, the price of z is x and it is the highest price now and the price of z in the future will still be x.

c. **Reading III**:
For some z, the price of z is highest price now and in the future the price of z will still be the highest price.

The three readings are logically independent. The following scenario only verifies Reading I: the highest price today (i.e., the price of milk) is \$5, and the highest price tomorrow (i.e., the price of cheese) will still be \$5.

	today	tomorrow
the price of milk	\$5	\$4
the price of cheese	\$4	\$5

The next scenario only verifies Reading II: the highest price today is the price of milk (i.e., \$5), the price of milk will remain the same tomorrow (i.e., still \$5).

	today	tomorrow
the price of milk	\$5	\$5
the price of cheese	\$4	\$6

The last scenario only verified Reading III: the highest price today is the price of milk, and the highest price tomorrow will still be the price of milk (even though it won't be \$5 anymore).

	today	tomorrow
the price of milk	\$5	\$6
the price of cheese	\$4	\$5

Reading I and II can be accounted as before — it is just a matter of scope between *highest* and $\uparrow_{\mathsf{se}}$. The peculiar case, is Reading III, which seems to involve identity of ICCs instead of ICs. To account for this reading, I will follow, once again Romero (2005). I take *remain the same* to be ambiguous between the two lexical entries in (169): one which involves identity of ICs, and another which involves identity of ICCs, where t_{beg} means the left bound of interval t, and t_{end} means the right bound of interval t.

(169) a. $[\![\text{remain the same}_{\mathsf{e}}]\!]^t \coloneqq \lambda u_{\mathsf{se}}.\ u(t_{\mathsf{beg}}) = u(t_{\mathsf{end}})$

b. $[\![\text{remain the same}_{\mathsf{se}}]\!]^t \coloneqq \lambda c_{\mathsf{se}}.\ c(t_{\mathsf{beg}}) = c(t_{\mathsf{end}})$

We can get Reading III as follows: *remain the same*$_{\text{se}}$ combines with the intension of the DP modified by *highest*$_{\text{se}}$:

(170) a. [the$_{\text{se}}$ [highest$_{\text{se}}$ [EX λ_1 $\uparrow_{\text{se}}$ [price $t_{1,e}$]]] remain the same$_{\text{se}}$

b. $\iota u[\exists z.\, u = \textbf{the}(\text{prc}(z)) \wedge \forall y \neq z.\, \textbf{the}(\text{prc}(z))(t_{\text{beg}}) > \textbf{the}(\text{prc}(z))(t_{\text{beg}})]$
$= \iota v[\exists z.\, v = \textbf{the}(\text{prc}(z)) \wedge \forall y \neq z.\, \textbf{the}(\text{prc}(z))(t_{\text{end}}) > \textbf{the}(\text{prc}(z))(t_{\text{end}})]$

The sentence comes out as true whenever the IC whose value is the highest price at t_{beg}, is the same IC as the one whose value is the highest price at t_{end}.

3.4 Conclusion

In the present chapter, I proposed an account of three puzzles that were first observed in Heim (1979): the puzzle of failure of substitution, the set *vs* pair-list ambiguity, and the ambiguity of nested CQs. The account was framed within the ICs approach to CQs, where the basic meaning CQ embedding involves a relation between an individual and an IC. The insights of these analyses were partly due to previous work by Romero (2005) and Frana (2017), but the resulting theory was shown to overcome the empirical and conceptual shortcomings that these proposals had. The crucial feature of the analysis was the approach to quantification over ICs that was proposed in the previous chapter. The ambiguities Heim identified could then be accounted for as following the underlying structure of the NPs involved.

Chapter 4

Question intruders

Consider the following scenario-sentence pair:

(1) **Bat scenario** A bat is inside Ann and Ben's apartment but they can't find it. Ben tells Ann that the bat is hiding in the living room, but she's not convinced. Neither is aware that the bat is actually hiding in the bathroom.

(2) Ann disagrees with Ben on which room he thinks the bat is hiding in.

Sentence (2) is ambiguous between two readings, one that is expected and one that is surprising. On its expected reading, Ann and Ben disagree on the answer to the question denoted by the embedded question — namely, 'Which room does Ben thinks the bat is hiding in?' — and is therefore false: since they're both aware Ben thinks the bat is in the living room, there's no disagreement between them on this respect. On its unexpected reading, the disagreement is about a question that is not the one denoted by the embedded interrogative: (2) can somehow convey that there's an answer to 'Which room is the bat hiding in?' such that Ben thinks it is true and Ann disagrees with him that it is. The puzzle, in a nutshell, is that, in this reading of (2), *he thinks* appears to not be interpreted where it should, i.e., inside the interrogative clause.

These two readings of (2) can be stated as follows:

(3) a. There is a proposition p s.t. p is an answer to 'Which room **does Ben think** the bat is hiding in?' and Ann disagrees with Ben that p.

b. There is a proposition p s.t. p is an answer to 'Which room is the bat hiding in?' and **Ben thinks** p and Ann disagree with Ben that p.

In the first reading, the expected one, the proposition that Ann disagrees with Ben on is an answer to the question denoted by the interrogative clause. In the second reading, the unexpected one, *he thinks* – which is not even a constituent – escapes the scope of the embedded question and is interpreted as a predicate true the question's answers.

The behavior of *he thinks* in (1) may remind some of what Urmson (1952) calls **parenthetical verb phrases**, i.e., sequences of a subject and a clause embedding verb that may appear interpolated within a sentence:

(4) Ben saw, **he thinks**, the bat hiding behind the fridge.

However, it is easy to show that the unexpected reading of (2) is not due to *he thinks* being a parenthetical VP. Other than the fact that it doesn't require the prosody associated parentheticals, interpolating *he thinks* at different places in the clause actually leads to ungrammaticality:

(5) *Ann disagrees with Ben on which room the bat, **he thinks**, is hiding.

Furthermore, sentence (6) is ambiguous in the same way as (2), even though *he believes* takes a non-finite clause as its complement. In contrast, parenthetical VPs cannot on their own license infinitive clauses, as shown in (7).

(6) Ann disagrees with Ben on which room he believes the bat to be hiding in.

(7) *Ben to see, he believes, the bat hiding behind the fridge.

Therefore, it seems that, even under the unexpected reading of our basic sentence, we're dealing with a *bona fide* instance of clause-embedding by *think*.

Furthermore, the misplaced interpretation of *he thinks* in (2) seems strictly tied to the fact that it appears within an interrogative and not a declarative clause. Compare it with (8), where *disagree* embeds a declarative clause that denotes the answer to the question denoted by *which room does Ben think the bat is hiding in*.

(8) Ann disagrees with Ben that he thinks the bat is in the living room.

Differently from our basic sentence, this sentence is unambiguously false as it can only convey that Ann, differently from Ben, doesn't believe that Ben thinks the bat is in the living room. This is, of course, expected: that's exactly what any compositional theory of the meaning of declarative clause embedding predicts (8) to mean.

I refer to strings like *he thinks* in (2) as *(question) intruders* given that they are syntactically intruding an interrogative within which they are not actually interpreted.[1]

[1]This name was suggested by Patrick "Pat Dave" D. Elliott.

The present chapter is devoted to describing this phenomenon – which, as far as I'm aware, has not been previously observed – and proposing an account of it. Intruders, I claim, offer a window into how the meaning of interrogative clauses is compositionally built. Specifically, I argue that that it shows that (i) an operator within interrogative clauses determines the form of the answers to the question it denotes (e.g., the proto-question rule of Karttunen 1977); and (ii) that this operator may take scope at different constituents within an interrogative clause.

Karttunen (1977) proposed that *wh*-interrogative are interpreted as questions (i.e., sets of propositions) via the interaction of two semantic operations: a type-shifter, and an existential quantifier — in (9), the first operation is performed by the ?-operator, and the second by the *wh*-phrase.

(9) *which room is the bat hiding in?*
$\rightsquigarrow$ which room λ_1 ? [the bat is hiding in $t_{1,e}$]

Crucially, the ?-operator determines what's part of the answer to the question and what is not — anything above it, is interpreted as part of the restriction of the question. My proposal, in a nutshell, is that the ambiguity in (2) follows from where the ?-operator is interpreted:

(10) a. **Expected reading**:
… [which room λ_1 [? **he thinks** [the bat is hiding in $t_{1,e}$]]]

b. **Unexpected reading**:
… [which room λ_1 [**he thinks** [? the bat is hiding in $t_{1,e}$]]]

The idea, then, is that intruders are just the parts of the interrogative clause that are not interpreted under the scope of ?. My proposal, therefore, goes against much of modern implementations of Karttunen 1977, where the ?-operator is taken to be the semantics of the interrogative complementizer to which *wh*-phrases move to (e.g., Cresti 1995).

The problem, however, is that the LF in (10b) is not interpretable as it is: *thinks* takes a proposition as its first argument, but the ?-phrase denotes a set of propositions. In the present chapter, I entertain two strategies for interpreting such structures. The first one of these is simple: all that is needed is to assume that the ?-phrase is able QR from the complement of *think* (as in Lahiri 2002). The problem, however, is that this proposal faces many over-generation issues. The second strategy I entertain overcomes some of these problems, but it requires the postulation of otherwise unnecessary phonologically null operators.

One of the advantages of this second strategy is that it can also account for intruders in so-called **concealed questions**, i.e., DPs that can be paraphrased as embedded questions, e.g. *Ann disagrees with Ben on* ***Filipe's birthday*** $\approx$ *Ann disagrees with Ben on* ***what Filipe's birthday is*** (Baker 1968). An example of a concealed question intruder is given in sentence (11), which can also be true in the bat scenario.

(11) Ann disagrees with Ben on the room he thinks the bat is hiding in.

The analysis of concealed questions developed in chapter 3 shares many features with Karttunen's theory of how interrogative clauses are interpreted. These similarities allow us to give a unified analysis of intruders in both interrogative clauses and concealed questions.

This chapter is organized as follows: §4.1 discusses the key properties of intruders – their distribution and meaning; §4.2 present the key idea of my analysis of intruders and offers one possible strategy for interpreting the relevant structure; §4.3 discusses intruders in so-called concealed questions and entertains a alternative analysis of the phenomenon; §4.4 concludes.

4.1 The main properties of intruders

4.1.1 The distribution and form of intruders

The goal of the present section is to show question intruders are a more general phenomenon than one may initially think. The example discussed in the introduction had very particular properties: the question-embedding predicate was *agree*, and the intruder was of the form α *thinks*, where α was a pronoun bound by a DP in the matrix clause. I now show that intruders occur with a wide range of question embedding verbs, and that intruders themselves can have different forms.

A note to the reader is in order before discussing the intruder data. For reasons unclear to me, the judgments of the sentences I present are of varying acceptability: informal data collection indicates that some examples of intruders are much more natural than others. The account of intruders I propose in this paper will not capture this: it predicts all of these sentences to be equally acceptable. I leave this issue to be resolved in future research on this topic.

The distribution of intruders

Aside from non-veridical question embedding predicates like *agree*, **emotive factive** verbs like *surprise* can also embed interrogatives with intruders. This is shown in the example in (12):

(12) **Context** A job search is happening in Ann's department. The candidates are Beth and Cleo. Ann thinks Cleo is the superior candidate and she is under the misconception Beth got the job, which she finds surprising.

a. It surprises Ann which candidate she mistakenly thinks was hired. *true*

b. It surprises Ann that she mistakenly thinks Beth was hired. *not true*

Sentence (12a) seems to have an interpretation that can be paraphrased as follows: for some proposition p, Ann mistakenly thinks p is the answer to the question 'Which candidate was hired?' and p is surprising to Ann. On the other hand, sentence (12b), where *surprise* embeds a declarative, is not true: it requires Ann to be aware that she is mistaken – which is expected, since *It surprises* α *that* ϕ is only ever true if α *is believes that* ϕ also is. Similar examples with other emotive factives (e.g., *be happy*, *be shocking*, etc.) work equally well.

We now move on to communication verbs. The examples in (13) show that *tell* can also embed interrogatives with intruders: in the context, Ann only tells me who she hired and is unaware she was tricked into hiring them; nonetheless, (13a) can be truthfully uttered. On the other hand, sentence (13b), with a declarative, seems to require Ann to have said something about being tricked, and therefore the sentence is false.

(13) **Context** Ann is hiring research assistants for her lab. You secretly help Cleo and Deb look better than they actually are and Ann ends up hiring them. Ann is unaware of this and one day tells me: "I hired Cleo and Deb."

a. Ann told me which candidates you tricked her into hiring. *true*

b. Ann told me that you tricked her into hiring Cleo and Deb. *not true*

Interrogative clauses with intruders can also be embedded by factive predicates of knowledge. This can be seen by the fact that the following two sentences can be interpreted in a way in which they convey the same information: namely, that before Watson found out which suspect was guilty, Sherlock already knew it

(14) Sherlock already knew which suspect Watson only later found out was guilty.

(15) Watson only later found which suspect Sherlock already knew was guilty.

One can often force intruder readings with the help of additive focus particles like *too* or *also*: in the sentences in (41), the additive presupposition triggered by *also* can only be satisfied if *Beth also told me/knows* is interpreted as an intruder. For example, the presupposition triggered by *also* in (16a) is that someone other than Beth told me certain people came — if *Beth also told me* is interpreted as an intruder, the presupposition is satisfied because the sentence would convey that Ann told me that some people came; if it isn't as intruder, the presupposition won't be satisfied because the sentence would instead convey that Ann told me that **Beth told me** some people came.

(16) a. Ann only told me which people BETH also told me came.
b. Ann only knows which people BETH also knows came.

In general, it seems to be possible to have intruders in questions embedded by *responsive* predicates, i.e., predicates that can embed both declarative and interrogative complements in the terminology of Lahiri 2002. Interestingly, I have been unable to find cases of intrusion in clauses embedded by *rogative* predicates (i.e., predicates that only embed interrogative complements). For example, in (17), I try to create an example in which *he mistakenly thinks* is interpreted as an intruder, but people I consulted with report that (17a) necessarily entails that Ann must have asked Bob: 'Who do you mistakenly think was hired?'.

(17) **Context** Someone was hired and Bob thinks she knows who that is, but we know that she's mistaken. Ann doesn't know about the fact that Bob is mistaken and asks him: 'Who was hired?'
a. Ann asked Bob who he mistakenly thinks was hired.

If it is true that rogative predicates never embed interrogatives with intruders, this is a crucial property of the phenomenon. The analysis I propose will not provide an account of this, however.

The form of intruders

In the examples we've seen so far, intruders typically are strings involving a clause-embedding predicate and its non-clausal arguments. Verbs in intruders tend to be doxastic attitudes, but this doesn't seem to be a requirement. In sentence (13a), for example, the verb is *trick*. The following sentence shows that *announce* can also be an intruder: when *know* embeds a declarative, Ann must know about the announcement, but that is not the case when *know* embeds the interrogative clause.

(18) **Context** Tomorrow we will announce that Beth and Cleo were hired. We find out that Ann already knows that Beth and Cleo were hired but she has no idea about the announcement.

a. Ann knows which people we'll announce that we've hired. *true*

b. Ann knows we'll announce that we've hired Beth and Cleo. *not true*

Furthermore, although we have seen many examples in which the DP in the intruder is a pronoun co-index with a matrix clause argument, we have also seen examples where this is not the case.

There are also cases in which intruders include propositional operators other then propositional attitudes. For example, *actually* seems to be able to escape the scope of the embedded questions (but not of the declarative) in the example below:

(19) **Context** Flo thinks Ann, Beth and Cleo were hired; Gabby thinks Beth, Cleo and Deb were. Unbeknownst to them, only Beth and Cleo were hired.

a. Flo and Gabby agree on which candidates were ACTUALLY hired. *true*

b. Flo and agree that Beth and Cleo were ACTUALLY hired. *not true*

The example below shows that even the epistemic modal *migth* can potentially intruder an interrogative clause:

(20) **Context** Ann thinks Beth was hired and tells us: "Beth was hired." However, although Beth might be hired, no official decision is out yet.

a. Ann just told us which candidate MIGHT have been hired. *true*

b. Ann just told us only that Beth MIGHT have been hired. *not true*

When intruders are unavailable

Intruder readings are not always possible. For example, we cannot interpret *her mom mistakenly thinks* as intruder in (21a) even though we already know that such strings can be intruders, and that *surprise* can embed interrogatives with intruders. However, if change it slightly to (21b), the intruder reading becomes available.

(21) **Context** Both Ann and her mom are under the misconception that the car I bought is a Ferrari. Ann's mom expected me to do spend my money on such a tacky thing, but Ann thinks this is really out of character.

a. It surprises Ann which car her mom mistakenly thinks I bought.

b. It surprises Ann which car she and her mom mistakenly think I bought.

I speculate that (21a) lacks an intruder reading because it triggers inferences that are in conflict with this reading. Its missing intruder reading would be the following: there is a proposition Ann's mom mistakenly thinks is the answer to 'Which car did I buy?' and that proposition is believed by and surprising to Ann. I'd like to suggest that the issue is that by having the clause *her mom mistakenly thinks* φ rather than *she (= Ann) mistakenly thinks* φ or *she (= Ann) and her mom mistakenly think* φ, we draw an inference that Ann doesn't fully agree with her mom that φ. This is in contradiction with the intruder reading, which requires Ann and her mom to believe the same proposition. An explanation along these lines would also account for the contrast between (21a) and (21b).

The purpose of this discussion is to show that one has to be careful in assessing sentences that lack an intruder reading: sometimes, they could in principle be available but they are in conflict with other aspects of the meaning of the sentence.

Local summary

The data discussed in this subsection allows us to draw the following two conclusions about intruders. The first concerns their distribution: intruders can appear in interrogative clauses embedded by responsive predicates. The second concerns their form: given a an interrogative of the form $\varphi[\psi]$, φ can be interpreted as an intruder if ψ is denotes a proposition.

4.1.2 The meaning of sentences with intruders

In the beginning of this chapter, I paraphrased the intruder reading of sentence (22a) as (22b). In this subsection, I show that this paraphrase is not fully accurate: once we take exhaustivity into account, we see that the semantics of questions with intruders is more intricate than (22b) suggests. Furthermore, I show that intruders are presupposed rather than asserted.

(22) a. Ann disagrees with Ben on which room he thinks the bat is hiding.

b. There is a proposition p s.t. p is an answer to 'Which room is the bat hiding in?' and **Ben thinks** p and Ann disagree with Ben that p.

Exhaustivity

Consider the context-sentence pair in (23) and (24) :

(23) **Context** Ella thinks only Ann, Beth and Cleo passed the exam, while Flo thinks only Beth, Cleo and Deb did. The only people who actually passed the exam are Ann and Deb.

(24) Ella and Flo agree on which people they think passed the exam.

Sentence (24), under its intruder reading, is not true. The intuition is that this is so because the set of people Beth thinks passed the exam is different from the set of people Flo does – although the sets intersect, this is not enough to make (24) true.

This is not reflected in our rendition of the truth condition of sentences with intruders, which in this case would be:

(25) There is a proposition p s.t. p is an answer to 'Which people passed the exam?' and **Ella and Flo think** p and Ella and Flo agree that p.

It is not enough for there to be some possible answer to 'Which people passed the exam?' that Ella and Flo think is true and agree on — *Beth and Cleo passed the exam* is such an answer, yet (24) is still false. We can fix this if we instead existentially quantify over *exhaustified* answers.[2] For now, I assume that an exhaustified answer to the question 'Which people passed the exam?' is a proposition of the form *only* α *passed the exam*, for some α that denotes students. We can then rewrite (59) as in (30a), or, equivalently, as in (30b).

(26) There is a proposition p s.t. p is an exhaustified answer to 'Which people passed the exam?' and **Ella and Flo think** p and Ella and Flo agree that p.

(27) There are people x s.t. **Ella and Flo think** only x passed the exam and Ella and Flo agree only x passed the exam.

This now predicts (24) to be false in (23): there is no exhaustified answer to 'Which people passed the exam?' that Ella and Flo agree on. The exhaustified answer Ella believes is *only Ann, Beth and Cleo passed the exam* and the one Flo believes is *only Beth, Cleo and Deb passed the exam*.

The problem we just discussed is independent of intruders. As pointed out by Spector and Egré (2015), we can analyze question embedding through existential quantification over answers only if these are (strongly) exhaustive answers — if they were not exhaustified, we would end up assigning sentences truth conditions that are too weak.

[2]That question embedding involves existential quantification over possible exhaustified answers is the proposal of Spector and Egré 2015, which we will explicitly adopt in the next section. However, I will stress that the discussion of exhaustivity in questions embedded by *agree* in the text is far too simplistic. See discussion in Uegaki 2019 for the problems posed by *agree* in particular.

Now I can address the real issue with truth conditions we've been assuming so far. Perhaps surprisingly, this slightly modified example is true in (23):

(28) Ella and Flo agree on which people they mistakenly think passed the exam.

Given that we assign (28) the truth conditions in (29), we predict that the sentence should be false, as there is no x s.t. both Ella and Flo believe only x passed the exam.

(29) There are people x s.t. **Ella and Flo mistakenly think** only x passed the exam and Ella and Flo agree only x passed the exam.

Sentence (28) is intuitively different from (24) because in this sentence we're ignoring the people Ella and Flo are correct about – namely, Ann and Deb – and just focusing on those they mistakenly think passed – namely, Beth and Cleo. And when we focus only on those two, it is indeed true that Ella and Flo are in agreement. What seems to be happening, then, is that the intruder is restricting exhaustification – the correct truth conditions of this sentence seems to be the following:

(30) a. There is a proposition p s.t. p is an exhaustified answer to 'Which people passed the exam?' when we take into consideration only those propositions **Ella and Flo mistakenly think** is true, and Ella and Flo and Beth agree that p.
  b. There are people x s.t, among those people **Ella and Flo mistakenly think** passed the exam, Ella and Flo agree that only x passed the exam.

The puzzle of intruders was initially stated as follows: how come intruders are not interpreted within the embedded clause? The discussion in this section shows that this is only part of the puzzle — we must also figure out where exactly they are interpreted if we are to account for how these sentences are interpreted.

Intruders are presupposed

As we've discussed in §4.1.1, the following sentence has an intruder reading:

(31) It surprises Ann which car she and her mom think I bought.

Under this reading, the sentence has an inference that Ann's mom thinks I bought a car. In the sentences in (32), I put sentence (31) under the scope of different entailment-cancelling operators, yet this inference still comes through.

(32) a. It doesn't surprise Ann which car she and her mom think I bought.

b. Does it surprise Ann which car she and her mom think I bought?

c. If it surprises Ann which car she and her mom think I bought, it will be funny. ⇒ *Ann's mom think I bought a car*

This inference can however be filtered out in examples like the following:

(33) If Ann and her mom think I bought a car, it will surprise Ann which car she and her mom think I bought.

The information conveyed by intruders therefore behaves like a presupposition. This is a puzzling property of this phenomenon: if intruders are presupposed, then they must be under the scope of a presupposition trigger — but where is the trigger?

4.2 An analysis of intruders

4.2.1 Background on the semantics of interrogatives

In this section, I lay out the theory of the semantics of embedded clauses assumed in this chapter. Specifically, I take interrogative clauses to be interpreted as proposed by Karttunen (1977), and I adopt a simplified version of theory of the semantics of question embedding of Spector and Egré (2015).[3]

Interpreting interrogative clauses

Following Hamblin 1973, I take interrogative clauses to denote sets of propositions — a question, under this view, is modeled as a set of possible answers. For example, the interrogative *which of Ann and Beth arrived* is analyzed as the set of propositions (denoted by sentences) of the form *α arrived* where α is *Ann* or *Beth*:

(34) $\lambda p.\ \exists x \in \{\mathsf{ann}, \mathsf{beth}\}.\ p = \mathsf{arrived}(x)$

I assume questions to have world-dependent denotations. For example, under one of its interpretations,[4] the interrogative *Which student arrived?* denotes in a world w the set of propositions of the form *α arrived*, where α denotes a student in w:

[3]The theory of Spector and Egré (2015) was already presented Chapter 3. This is done again here, but the implementation — which is a simplified version of Fox 2020 — is very different.

[4]Interrogatives with complex *wh*-determiners are ambiguous with respect to whether their restrictor are interpreted *de re* or *de dicto* relative to the question. The reading described in the text is the *de re* reading of *Which student arrived*; in its *de dicto* reading, the interrogative should denote the set of propositions of the form *α is a student that arrived* for some α. For the rest of this chapter, I ignore the existence of such *de dicto* interpretations as they do not bear on our discussion of intruders.

(35) $[\![\text{which student arrived}]\!]^w = \lambda p.\, \exists x.\, \mathsf{student}(x)(w) \wedge p = \mathsf{arrived}(x)$

In this respect, I follow Karttunen 1977. Although this is a fairly standard assumption, I draw attention to it because the analysis of intruders I propose crucially relies on this aspect of the theory.

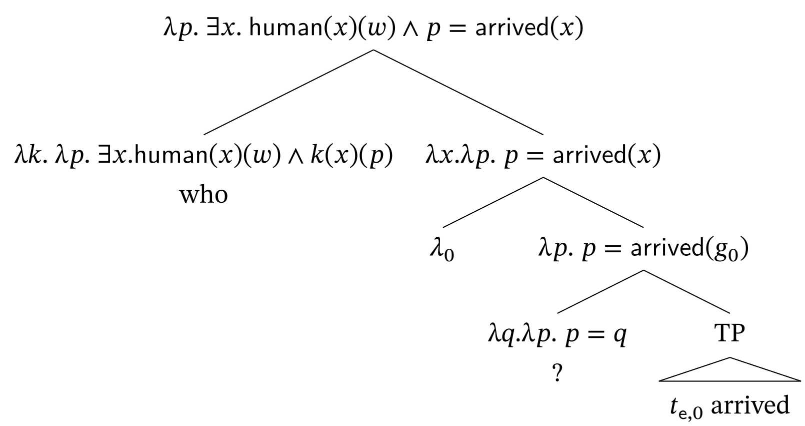
I adopt semantic analysis of interrogative clauses proposed by Karttunen (1977), as implemented in Cresti 1995.[5] Questions are built in two steps: first, an operator, which we'll call ?, converts a question into a *proto-question* (a singleton set of propositions); then, a *wh*-phrase scopes over it to generates a question with multiple answers. The relevant lexical entries are given below:

(36) a. $[\![?]\!]^w = \lambda q_{\mathsf{st}}.\lambda p_{\mathsf{se}}.\, p = q$

b. $[\![\text{who}]\!]^w = \lambda k_{\mathsf{e,stt}}.\lambda p_{\mathsf{st}}.\, \exists x.\, \mathsf{human}(x)(w) \wedge k(x)(p)$

In (37), I show how the interrogative *who arrived* is interpreted. For now, I adopt the standard proposal that ?-operator is in fact the interrogative complementizer $\mathrm{C}_{[+wh]}$: because *wh*-phrases must scope over ? to yield an interpretable LF, equating ? and $\mathrm{C}_{[+wh]}$ offers a semantic explanation for why *wh*-phrases tend to overtly move.

(37)



Question embedding

Although several complex issues surround the topic of the semantics of question embedding, a minimally empirically adequate theory will be enough for the purposes of our discussion of intruders. Here, I adopt a simplified version of the theory of question embedding proposed in Spector and Egré 2015 but, unless explicitly stated, nothing hinges on this particular assumption.

[5]Cresti, in turn, attributes the implementation to lecture notes by Irene Heim and Jim Higginbotham

The goal of Spector and Egré (2015) is to provide a general theory of the meaning of responsive predicates by defining their question-taking meaning in terms of their proposition-taking meaning – as such, the theory falls within the category of approaches Uegaki (2019) calls *question to proposition reduction*. As already foreshadowed in our discussion exhaustivity and intruders in §4.1.2, the theory in Spector and Egré 2015 proposes that question-embedding involves existential quantification over exhaustified answers:

(38) Given a noun phrase α, responsive predicate V and interrogative clause Q: $\alpha\ V\ Q$ is true at w iff there is an S that denotes an exhaustified answer to the question denoted by Q s.t. $\alpha\ V\ S$ is true at w

My presentation of Spector and Egré (2015) is based on Fox (2020). Exhaustification is defined as in Krifka 1995: given a question Q and proposition p, exhaustifying p relative to Q yields the proposition that p is the strongest true proposition in Q.

(39) $\textbf{exh}_Q(p) \coloneqq \lambda w'.\ p(w') \wedge \forall q \in Q.\ q(v) \rightarrow p \subseteq q$

We then define the set of exhaustified answers to a question Q via pointwise exhaustification:

(40) $\textbf{PwE}_Q \coloneqq \lambda p.\ \exists q \in Q.\ p = \textbf{exh}_Q(q)$

The above operator takes a question as its argument and returns the set of all its possible exhaustified answers.

Sentence (41a), in this approach, would be translated into (41b): *Ann knows who arrived* is true whenever Ann knows some exhaustified answer to the question denoted by *who arrived*, i.e., if there is some x s.t. Ann knows that only x arrived.[6]

(41) a. Ann knows who arrived.

b. $\exists p \in \textbf{PwE}_{[\![\text{who arrived}]\!]^w}.\ [\![\text{know}]\!]^w(p)(\mathsf{ann})$
$= \exists p.\ \exists x.\ p = \textbf{exh}(\mathsf{arrived}(x)) \wedge [\![\text{know}]\!]^w(p)(\mathsf{ann})$
$= \exists x.\ [\![\text{know}]\!]^w(\textbf{exh}(\mathsf{arrived}(x)))(\mathsf{ann})$

For now, I treat the presuppositions triggered by question-embedding predicates as part of their asserted meaning, so we can rewrite (41b) as under the simplistic assumption that *know* is the same as *believe* coupled with an factivity:

[6]For convenience, I will often omit the question argument of **exh**. Although incomplete, it will always be simple to reconstruct the set the propositions that it is being exhaustified in relative to.

(42) $\exists x.\ \mathsf{believe}(\mathbf{exh}(\mathsf{arrive}(x))) \wedge \mathbf{exh}(\mathsf{arrive}(x))(w)$

If Beth and Cleo are the only people that arrived, the truth conditions we assign to (41a) predict it to be true only if Ann is fully aware not only that Beth and Cleo arrived but also that no one else did. Thus the sentence is correctly predicted to be false if Ann only knows Beth arrived or if Ann thinks Beth, Cleo and Deb are the people who arrived.[7]

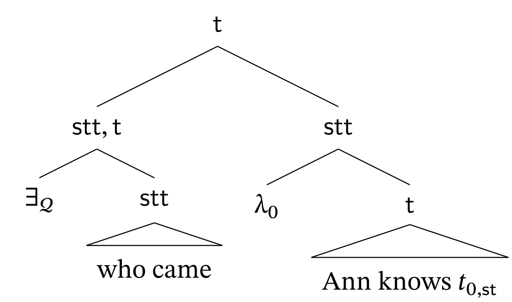
To compositionally implement the proposal, I take embedded interrogatives to have a silent determiner $\exists_{\mathcal{Q}}$ with the meaning in (43). Once it combines with an interrogative, it yields a generalized quantifier over propositions.

(43) $[\![\exists_{\mathcal{Q}}]\!]^w = \lambda Q_{\mathsf{stt}}.\lambda k_{\mathsf{stt}}.\ \exists p \in \mathbf{PwE}_Q.\ k(p)$

An interpretable LF for a basic sentence involving question embedding would thus require the embedded interrogative to QR and create, via movement, a constituent that denotes a function from propositions to truth-values, as illustrated in (44). The proposal that embedded interrogatives must QR goes back to Lahiri (2002), who called it **interrogative raising**.

(44) a. Ann knows [$\exists_{\mathcal{Q}}$ who came]

b.



The LF in (44b) is translated into the formula in (44b), which yields exactly the truth conditions informally sketched in (38).

(45) $[\![\exists_{\mathcal{Q}}]\!]^w([\![\text{who came}]\!]^w)(\lambda p.\ [\![\text{know}]\!]^w(p)([\![\text{Ann}]\!]^w))$
$= \exists p \in \mathbf{PwE}_{[\![\text{who came}]\!]^w}.\ \mathsf{believe}(p)(\mathsf{ann})(w) \wedge p(w)$

[7]There are complications, however – requiring Ann to know the exhaustified answers to 'Who came?' is sometimes too strong a requirement, as first observed by **ham1994interrogative**. I ignore this issue completely however – the theory developed here only yields what is often called *strongly exhaustive* readings. It should be pointed out that it could be enriched to account for other readings as well, as it is done in Spector and Egré 2015 and, more recently, in Fox 2020.

Intruders, again

Now that we've laid out a compositional analysis of English interrogative clauses, we can see what we predict interrogatives with intruders to mean. Here I analyze sentence (1), repeated here in (46).

(46) Ann disagrees with Ben on which room he thinks the bat is hiding in.

We start by interpreting the embedded clause. The only possible LF for *which room he thinks the bat is hiding in* given our current assumptions is one in which *which room* moves from the embedded clause to Spec,CP and the head of that CP is interpreted as the ?-operator:

(47) which room λ_0 $C_{[+wh]}$ [he$_2$(= Ben) thinks [the bat is hiding in $t_{0,\mathsf{e}}$]]

This structure is translated into (48): the function true of those propositions of the form *Ben thinks the bat is hiding in* α, where α is a room at the world of evaluation.

(48) $\lambda p.\ \exists x.\ \mathsf{room}(x)(w) \wedge p = \mathsf{believes}(\mathsf{the\text{-}bat\text{-}is\text{-}hiding\text{-}in}(x))(\mathsf{ben})$

The LF of the entire clause in would be the following (46):

(49) [$\exists_Q$ which room he thinks the bat ...] λ_0 Ann disagrees with Ben $t_{\mathsf{st},0}$

Given the non-presuppositional entry for *disagree* in (50), this LF would be translated into (51): the formula which is true whenever there is some room x s.t. Ben but not Ann believe that the bat is hiding in x. Although this is one of the readings of (46), it does not corresponds to its intruder reading.

(50) $[\![\text{disagree with}]\!]^w = \lambda x_{\mathsf{e}}.\lambda p_{\mathsf{st}}.\lambda y_{\mathsf{e}}.\ \mathsf{believe}(p)(x)(w) \wedge \neg\mathsf{believe}(p)(y)(w)$

(51) $\exists x.\ \mathsf{room}(x)(w) \wedge \neg\mathsf{believe}(\mathbf{exh}(\mathsf{think}(\mathsf{the\text{-}bat\text{-}is\text{-}hiding\text{-}in}(x))(\mathsf{ben})))(\mathsf{ann})(w)$
$\wedge\ \mathsf{believe}(\mathbf{exh}(\mathsf{think}(\mathsf{the\text{-}bat\text{-}is\text{-}hiding\text{-}in}(x))(\mathsf{ben})))(\mathsf{ben})(w)$

The problem here seems to be our assumptions about how the embedded interrogative is interpreted. If (47) is its only possible LF, there is no way we can capture intruder readings: as soon as *he thinks* is under the scope of the ?-operator, *he thinks* will not be interpreted as an intruder. My proposal, which is presented in this section, is precisely that there are other possible interpretable LFs for the embedded clause in (46).

4.2.2 A short excursion on *de re* restrictors

The theory of the interpretation of embedded interrogative just presented offers a simple account of cases in which the *wh*-phrase's restrictor is interpreted *de re* relative to the question embedding predicate.[8] Even though all examples we analyzed did involve a *wh*-phrase being interpreted *de re*, in this section I will go over the features of the theory that allow this to happen even though the *wh*-phrase itself is never assumed to scope outside of the embedded interrogative. In the next subsection, I will make use of these same features to account for intruders.

First, I review the argument that *de re* reading of *wh*-restrictors are indeed real. The fact that (52) is valid shows that in the sentence *Ann knows which student came* the noun *students* need not be interpreted under the scope of *know*: Ann may know the answer to *which students came* even if she is not aware the relevant individuals are students.

(52) Beth, Cleo and Deb are students and no one else is a student.
Ann thinks Beth, Cleo and Deb are professors.
Ann knows Beth and Cleo arrived and that Deb hasn't arrived.
∴ Ann knows which students came.

How is this possible if we don't ever take the *which*-phrases to scope out of interrogative clauses? The first part of the answer is that we take the denotation of *which students came* to be the one in (53): a set of propositions of the form α *came* – the answers themselves say nothing about whether α is a student.

(53) $[\![\text{which students came}]\!]^w = \lambda p.\ \exists x.\ \mathsf{students}\ x\ w \wedge p = \mathsf{came}(x)$

The second part of the answer is that, crucially, $\exists_Q$ only takes the extension of its sister node as an argument. The LF for the sentence in the conclusion of (52) is in (54a): as can be seen in (54b), the interrogative and the question embedding predicate are evaluate relative to the same world. As a consequence, *students* is evaluated in the same world as *know* – and that's how *de re* is derived.

(54) a. $[\exists_Q$ which students came$]$ λ_1 Ann knows $t_{1,\mathrm{st}}$

b. $[\![(54a)]\!]^w = [\![\exists_Q]\!]^w([\![\text{which students came}]\!]^w)(\lambda p.\ [\![\text{know}]\!]^w(p)(\mathsf{ann}))$

What this discussion shows is that it is possible for *wh*-phrases to have a *de re* interpretation because embedded interrogatives have a escape hatch: anything that is

[8] In fact, as we already noted, it can only generate these readings.

interpreted above the ?-operator will automatically outscope the question embedding predicate even if are still interpreted inside the interrogative clause.

4.2.3 An account of intruders

The scope of ?

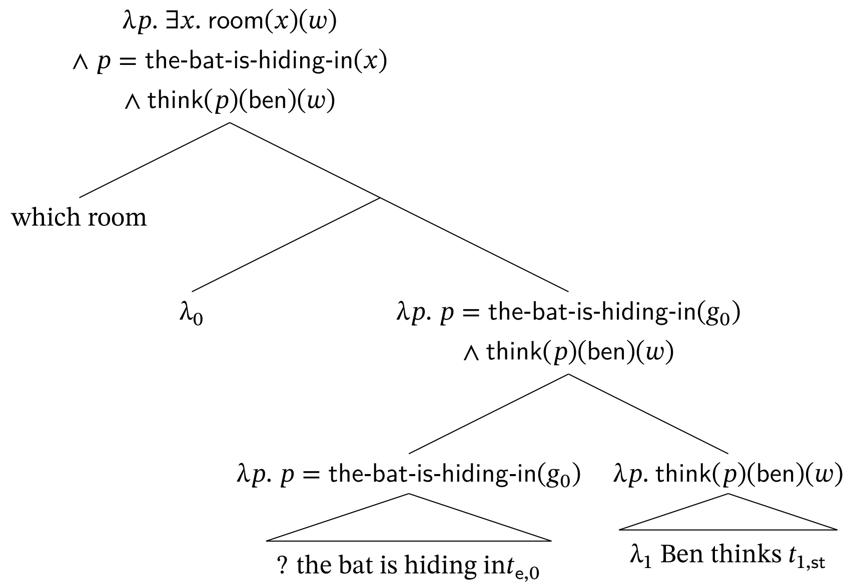
In the previous section, we concluded the following: within an embedded interrogatives, whatever is interpreted under the ?-operator is also interpreted under the scope of the clause embedding verb; whatever is interpreted above it, isn't. Having taken this into consideration, my proposal is simple and straightforward: intruders are just a part of the interrogative clause that is not interpreted under the scope of the ?-operator.

Up until now, following much of the modern compositional implementations of Karttunen 1977, I have assumed $C_{[+wh]}$ has the semantics of the ?-operator. This assumption, however, has as a consequence that everything within the complement of $C_{[+wh]}$ is interpreted as part of the question nucleus. The simple proposal I make is that the ?-operator may actually take scope at different nodes within an interrogative clause. Thus, sentence (55a) will have an interpretation in which *he thinks* is an intruder whenever the ?-operator takes scope only over the most embedded clause, as shown in (55b).

(55) a. Ann disagree with Ben on which room he thinks the bat is hiding in.
b. which room λ_0 he_2(= Ben) thinks [? the bat is hiding in $t_{0,\text{e}}$]

The issue is that the structure in (55b) is not actually interpretable: *think* must take as its first argument a proposition, but the ?-constituent denotes a set of propositions. We can get an interpretable LF, however, if we assume that the ?-constituent QRs, as shown in (56). As in the rule of interrogative raising of Lahiri 2002, the movement of the clause creates a constituent that denotes a set of propositions, and then it composes with it via (a modified version of) Predicate Modification (Heim and Kratzer 1998). Even though *he thinks* is not a constituent in overt syntax, clausal QR of its complement turns it into a constituent at LF that denotes a set of propositions. The LF in (56) is translated the function true of those propositions of the form *the bat is hiding in* α, for some α that is a room where Ben thinks the bat is hiding. The intruder is thus interpreted as the restrictor of the question.

(56)



Intruders are interpreted *de re*

The initial puzzle of this paper was stated as follows: how can a string of words within an embedded question not interpreted within the scope of the question embedding predicate? The answer I proposed is that, like *de re wh*-restrictors, this follows from the fact that those strings are interpreted outside the scope of the ?-operator.

To avoid discussing exhaustivity at this point, let's first analyze a sentence with intruders in which the answers to the question are already inherently mutually exclusive, such as (57a) – when someone is the tallest student, no one else is. The denotation of the embedded question, under the reading in which *she thinks* is an intruder, would be the one in (57b): the set of propositions of the form α *is the tallest student* s.t. Ann mistakenly thinks α is the tallest student. Because only a single student can be the tallest student and Ann is assumed to not have contradictory beliefs, (57b) can only ever be true of a single proposition. For convenience, then, we can ignore exhaustivity and just translate (57a) as involving existential quantification over answers, as in (57c).

(57) a. It surprises Ann who she mistakenly thinks is the tallest student.

b. $\lambda p.\ \exists x.\ p = \mathsf{tallest.stnt}(x) \wedge \mathsf{mstkl.think}(p)(\mathsf{ann})(w)$

c. $\exists p.\ \exists x.\ p = \mathsf{tallest.stnt}(x) \wedge \mathsf{mstkl.think}(p)(\mathsf{ann})(w)$
$\wedge\ \mathsf{believe}(p)(\mathsf{ann})(w) \wedge \mathsf{surprise}(p)(\mathsf{ann})(w)$

Because the embedded interrogative in (57a) is interpreted as a set of propositions of the form α *is the tallest student*, the sentence doesn't entail that Ann is aware of her mistaken beliefs: *she mistakenly thinks* merely restricts the question and is therefore interpreted *de re* relative to the question embedding predicate.

Exhaustivity

The proposal also explains how intruders interact with exhaustivity. In §4.1.2, I argued that a sentence like (58) should be interpreted as (59). I now show that this is exactly what the current analysis of intruders predicts – a result that is not particularly surprising, since intruders are assumed, after all, to be restrictors.

(58) Ella and Flo agree on which people they mistakenly think passed the exam.

(59) There is a proposition p s.t. p is an exhaustified answer to 'Which people passed the exam?' and **Ella and Flo think** p and Ella and Flo agree that p.

The embedded interrogative in (58) will have the denotation in (60), which is only true of the propositions both Ella and Flo mistakenly think is true.

(60) $\lambda p.\, \exists x.\, p = \mathsf{passed}(x) \wedge \mathsf{mstkl.think}(p)(\mathsf{ella} \sqcup \mathsf{flo})(w)$

When this question is embedded via $\exists_{\mathcal{Q}}$, the answers are only exhaustified relative to themselves — the sentence is translated into (61), which states that Ann and Flo both believe the same proposition of the form *only* α *passed*, but exhaustivity is restricted only to those propositions of the form α *passed* that they mistakenly believe to be true.

(61) $$\begin{aligned}&\exists p \in \mathbf{PwE}_{(60)}.\, \mathsf{believe}(p)(\mathsf{ella})(w) \wedge \mathsf{believe}(p)(\mathsf{flo})(w)\\ &= \exists p.\, \exists x.\, p = \mathbf{exh}_{(60)}(\mathsf{passed}(x)) \wedge \mathsf{mitkl.think}(\mathsf{passed}(x))(\mathsf{ella} \sqcup \mathsf{flo})(w)\\ &\qquad \wedge \mathsf{believe}(p)(\mathsf{ella})(w) \wedge \mathsf{believe}(p)(\mathsf{flo})(w)\end{aligned}$$

The resulting truth conditions then are exactly as stated in (59). The mistake that we had initially done was to have assumed that we first apply pointwise exhaustification to 'Which people arrived?' and then we combine it with the meaning of the intruder – the present analysis works as predicted because exhaustification comes only after the intruder has restricted the question.

Intruders are presupposed

So far, we have ignored that most (if not all) question responsive predicates are presupposition triggers when they combine with declarative complements. The examples below show the presuppositions of some of the predicates we've discussed:

(62) a. Ann knows that Beth passed the exam.
b. Ann doesn't know that Beth passed the exam.
$\Rightarrow_{presupposes}$ *Beth passed the exam*

(63) a. Ann is surprised that Beth passed the exam.
b. Ann isn't surprised that Beth passed the exam.
$\Rightarrow_{presupposes}$ *Ann believes passed the exam*[9]

(64) a. Ann agrees with Cleo that Beth passed the exam.
b. Ann doesn't agree with Cleo that Beth passed the exam.
$\Rightarrow_{presupposes}$ *Cleo believes Beth passed the exam*

To represent presuppositions, (differently from the previous chapters) I assume that the natural language expressions are mapped to a trivalent metalanguage with weak Kleene connectives and use the ∂-operator of Beaver 1992 to represent presupposed content (the formulas '$\partial\ \phi$' is true when 'ϕ' is true, and undefined otherwise). The entries for the responsive predicates just reviewed would then be the following:

(65) a. $[\![\text{know}]\!]^w = \lambda p.\lambda x.\ \mathsf{believe}\ p\ x\ w \wedge \partial(p\ w)$
b. $[\![\text{be surprised}]\!]^w = \lambda p.\lambda x.\ \mathsf{surprise}\ p\ x\ w \wedge \partial(\mathsf{believe}\ p\ x\ w)$
c. $[\![\text{agreewith}]\!]^w = \lambda y.\lambda p.\lambda x.\ \mathsf{believe}\ p\ x\ w \wedge \partial(\mathsf{believe}\ p\ y\ w)$

Taking into consideration the presuppositional content of these predicates requires us to re-evaluate the meaning we assigned to $\exists_Q$: we have to give it a meaning that will give us the correct presupposition projection patterns.[10] Spector and Egré (2015) assume that presuppositions projects existentially out of $\exists_Q$: a sentence of the form '$\alpha\ V\ Q$' presupposes that there is an S that denotes an answer to the question denoted by Q s.t. that $\alpha\ V\ S$ is defined. I thus give $\exists_Q$ the following meaning, where I make use of the accommodation operator $\mathcal{A}$ of Beaver 1992 (the formula '$\mathcal{A}\ \phi$' is true when 'ϕ' is and false otherwise):

(66) $[\![\exists_Q]\!]^w = \lambda Q.\lambda k.\ (\exists p \in \mathsf{PwE}_Q.\ \mathcal{A}(k(p))) \wedge \partial(\exists q \in \mathsf{PwE}_Q.\ k(q) \neq \#)$

[9]The predicate *surprise* is often assumed to be factive. While it is indeed true that its presupposition seems to be a factive one, Klein 1975 presents sentences like *Ann, who was unaware it was Sunday, was surprised that she could stay longer in bed* in which the factive presupposition seems to be filtered out. I therefore take the lexical presupposition of *surprise* and other emotive "factives" to be a belief presupposition that just happens to be typically strengthened into a factive presupposition. See Karttunen 1974 and Heim 1992 for a discussion of why this would be the case.

[10]Of course it would be ideal to have a theory where this didn't have to be stipulated, but offering such a theory goes beyond the goals of the present paper.

This new entry for $\exists_Q$ gives us the following translations:

(67) a. Ann knows who came.

b. $\exists x.\ \mathsf{believe}(\mathbf{exh}(\mathsf{came}(x)))(\mathsf{ann})(w) \wedge \mathbf{exh}(\mathsf{came}(x)) \wedge \partial(\exists y.\ \mathbf{exh}(\mathsf{came}(y)))$

(68) a. Ann is surprised at who came.

b. $\exists x.\ \mathsf{surprise}(\mathbf{exh}(\mathsf{came}(x)))(\mathsf{ann})(w) \wedge \mathsf{believe}(\mathbf{exh}(\mathsf{came}(x)))(\mathsf{ann})(w) \wedge \partial(\exists y.\ \mathsf{believe}(\mathbf{exh}(\mathsf{came}(y)))(\mathsf{ann})(w))$

(69) a. Ann agrees with Cleo on who came.

b. $\exists x.\ \mathsf{believe}(\mathbf{exh}(\mathsf{came}(x)))(\mathsf{ann})(w) \wedge \mathsf{believe}(\mathbf{exh}(\mathsf{came}(x)))(\mathsf{cleo})(w) \wedge \partial(\exists y.\ \mathsf{believe}(\mathbf{exh}(\mathsf{came}(y)))(\mathsf{cleo})(w))$

The specific content of each of the predicted presuppositions is not particularly important — what is important is that sentences in which questions are embedded always end up having an existential presupposition: the question that is embedded must have at least one exhaustified answer that is defined when applied to the matrix predicate. This presupposition entails a weaker conditions: in order for $\alpha\ V\ Q$ to be defined, the denotation of Q must contain at least one member.

It is now easy to see why we correctly predict intruders to be presuppositional: if Q has an intruder, then Q will only be non-empty if the intruder is true of at least one answer to the question. Therefore, existential projection from embedded – which is independently motivated – offers a natural account of the status of intruders as presuppositions.

For convenience, for the remaining of the paper, we will leave the issue of presuppositions aside and pretend, as we did before, that the presuppositions of question embedding verbs are part of their asserted content.

4.2.4 Some remeaning issues

_Wh_-phrases and ?

The crucial ingredient of my proposal was separating the ?-operator from $C_{[+wh]}$, the idea being that ? can take scope lower withing an interrogative clause. Although this move allows us to account for intruders in a natural way, it also predicts many sentences to have non-existent readings. For example, (70) is predicted to have an intruder reading: even though the *wh*-phrase is base generated in the *think* clause, it is possible to create an interpretable LF where the ?-operator actually applies to the most embedded clause, as shown in (71). This LF would denote a set containing the proposition *it's raining* as long as someone thinks it's raining, as shown in (72).

(70) Ann is surprised at who thinks it's raining.

(71) [who λ_0 [$t_{0,e}$ thinks [? it's raining]]]
→ [who λ_0 [[? it's raining] [$t_{0,e}$ thinks $t_{1,st}$]]]

(72) $\lambda p.\ p = \mathsf{rain} \wedge \exists x.\ \mathsf{believe}(p)(x)(w)$

Similarly, (73) is also predicted to have an unavailable intruder in which the ?-operator is only attached to the most embedded clause. The LF in (74) would be translated into (75): the function true of propositions of the form α *escaped* such that someone believes α escaped.

(73) Ann is surprised at who thinks who has escaped.

(74) [who λ_0 who λ_2 [$t_{0,e}$ thinks [? $t_{2,e}$]]]
→ [who λ_0 who λ_2 [[? $t_{2,e}$ escaped] [λ_1 $t_{0,e}$ thinks $t_{1,st}$]]]

(75) $\lambda p.\ \exists y.\ p = \mathsf{escaped}(y) \wedge \exists x.\ \mathsf{believe}(p)(x)(w)$

In general, then, it seems we don't want to allow parses in which there is a *wh*-trace not c-commanded by the ?-operator. One may argue that we were better off when we assumed that $C_{[+wh]}$ was the locus of ?, after all, $C_{[+wh]}$ is the highest head in an interrogative clause. Nonetheless, it is not actually correct that this proposal doesn't also suffer from over-generation issues. As observed by von Stechow (1996), pied-piping is a problem for a Karttunen-style theory of question compositionality. The problem is illustrated in (76): an answer to *Whose book did you read?* must specify the author's book, not just the book itself. In other words, (75) never seems to be able to mean the same thing as (77).

(76) A: Whose book did you read?
B: George Eliot's.
B′: #*Middlemarch*.

(77) A: Which book did you read?
B′: *Middlemarch*.

However, if the entire phrase *whose book* is outscopes the ?-operator, there should be a reading in which (75) and (77) mean the same thing. The relevant LF and interpretation are given below:

(78) who λ_0 [$t_{0,\mathrm{e}}$'s book] λ_1 $\mathrm{C}_{[+wh]}$ [you read $t_{1,\mathrm{e}}$]

(79) $\lambda p.\ \exists x.\ p = \mathsf{you.read}(\mathsf{book}(x)(w)))$
$= \lambda p.\ \exists x.\exists y.\ y = (\mathsf{book}(x)(w)) \wedge p = \mathsf{you.read}(y)$

My point is thus the following: the problem that we are facing with sentences (70) and (73) is similar to the problem posed by pied-piping. All these issues can be solved if we find a way to guarantee that the following holds:

(80) Within an interrogative clause, ? must c-command all *wh*-traces.

For the sake of concreteness, we can propose that a *wh*-phrase has a certain feature that must be checked against ?, which ends up requiring that every licensed *wh*-phrase be in a Spec-Head relation with ? at some point during the derivation. Under this proposal, the interrogative in (81) only has one possible LF, namely (81a) — LF (81b), which gives rise to the unattested intruder reading, is blocked because *who* is never in a Spec-Head relation with ? and therefore doesn't get its [?] feature checked.

(81) who thinks its raining

a. $\text{who}_{\cancel{[?]}}$ λ_0 ? [$t_{0,\mathrm{e}}$ thinks its raining]

b. $\text{who}_{[?]}$ λ_0 [$t_{0,\mathrm{e}}$ thinks [? its raining]]

Polar and Alternative Questions

Interestingly, intruders cannot appear in embedded polar questions or alternative questions, as shown by the context-sentence pair in (82) and (83): sentence (83) seems to convey that Ann and Ben are aware that Ben is mistaken. It's unattested intruder reading would be verified if, and only if, there is a p s.t. p is an answer 'Is it raining?' and Ben mistakenly thinks p is true and Ann agrees with Beth that p is true.

(82) *Context.* We know Ben is mistaken about whether it's raining, but we don't know ourselves whether it's raining. Ann talks to Ben and all we know is that Ben convinced her that he is right about whether it's raining.

(83) Ann agrees with Ben on whether he mistakenly thinks it's raining (or not).
not true

The analysis of intruder I presented above doesn't necessarily account for this property of intruders. For instance, Karttunen (1977) assigns the following translation to *whether (or not)*:

(84) $[\![\text{whether (or not)}]\!]^w = \lambda Q.\lambda p.\ Q(p) \vee (\exists q.\ Q(q) \wedge p = (\lambda v.\ \neg q(v)))$

Under this analysis, the following LF gives rise to the unattested intruder reading:

(85) whether [[? it's raining] [λ_0 Ben mistakenly thinks $t_{0,\mathrm{st}}$]]

(86) $\lambda p.\ (p = \mathsf{rain} \vee p = (\lambda v.\ \neg\mathsf{rain})) \wedge \mathsf{mstkl.think}(p)(\mathsf{ben})(w)$

There are alternative analyses of polar and alternative questions, however. Here's a proposal: suppose *whether* is base generated as the head of the complement of $C_{[+wh]}$ and then it head-moves into $\mathrm{C}_{[+wh]}$, leaving a trace of type $\mathtt{tt}$ (movement analysis of *whether* have been proposed in Larson 1985 and Han and Romero 2004, for example). The translation of *whether* in this view would be the following:

(87) $[\![\text{whether}]\!]^w = \lambda k.\lambda p.\ k(\lambda t.\ t) \vee k(\lambda t.\ \neg t)$

A simple *whether*-question would then be analyzed as follows:

(88) whether λ_8 ? [$t_{8,\mathrm{tt}}$ it's raining]

(89) $[\![\text{whether}]\!]^w(\lambda k.\lambda p.\ p = (\lambda v.\ k\ (\mathsf{raining}\ v)))$
$= \lambda p.\ p = \mathsf{raining} \vee p = (\lambda v.\ \mathsf{raining}\ v)$

Assuming that the movement of *whether* has to be local would block the undesired intruder readings. For example, to derive an intruder reading of (83), we'd need *whether* to be base-generated in the lowest clause and move it to the C head of the *think* clause, which would violate the condition that the movement of *whether* has to be local.

(90) whether λ_1 [Ben thinks [? $t_{1,\mathrm{tt}}$ it's raining]]

Stacked intruders

Assuming clauses can always QR also overgenerates readings. The following sentence has an intruder reading:

(91) Ann is surprised at who she and her mom think was hired.

But our current proposal incorrectly predicts the following sentence to have an intruder reading that makes it equivalent to (91):

(92) Ann is surprised at who she thinks her mom thinks was hired.

The reason is simple: we could in principle apply QR from the most embedded clause to the edge of the second most embedded clause, and then apply QR again. This is illustrated in a step-by-step fashion in (93). The resulting LF would then be translated into (94): the set of propositions of the form *α was hired* such that both Ann and her mom think are true.

(93) who λ_1 [she thinks [her mom thinks [? $t_{1,e}$ was hired]]] →
who λ_1 [she thinks [[? $t_{1,e}$ was hired] [λ_2 her mom thinks $t_{2,st}$]]] →
who λ_1 [[[? $t_{1,e}$ was hired] [λ_2 her mom thinks $t_{2,st}$]] [λ_3 she thinks $t_{3,st}$]]

(94) $\lambda p.\ \exists x.\ p = \mathsf{hired}(x) \wedge \mathsf{think}(p)(\mathsf{ann})(w) \wedge \mathsf{think}(p)(\mathsf{ann.mom}(w))(w)$

I'm unaware of a principled way to block this LF. It seems that what we would need is a constraint that only allows phrases headed by ? to QR to $C_{[+wh]}$. If that were the case, the second QR in (93) would be blocked.

The distribution of intruders

We saw in §4.1.1 that intruders are restricted to responsive predicates – they seem to be unable to be embedded under rogative predicates. The analysis has nothing to say about this: because we generate intruder readings by manipulating elements internal to the embedded clause, we cannot really explain the distribution of these clauses.

In fact, we even predict matrix questions to have intruder readings. Thus, (95) is predicted to also have an LF in which it is translated into (96), which would make (95) paraphrasable to *Who among the people Ann thinks came are such that they (actually) came?*.

(95) Who does Ann think came?

(96) $\lambda p.\ \exists x.\ p = \mathsf{came}(x) \wedge \mathsf{think}(x)\mathsf{ann}(w)$

That this sentence lacks this reading can be seen by the fact that (95) cannot be answered by a sentence like *Beth did* to imply that Beth came and Ann thinks Beth came.

The only way I see to constraint the distribution of interrogative with intruders within the present approach would be to stipulate that both matrix interrogatives and interrogatives embedded by rogative predicates require the ?-operator to apply at the level of $C_{[+wh]}$. This constraint, would, however, be completely unmotivated.

4.3 Concealed questions intruders

4.3.1 Introducing concealed question intruders

Concealed questions (CQs) — the main topic of chapter 3 — are DPs that can be naturally paraphrased as embedded questions (Baker 1968). Some illustrative examples are given below in (97).

(97) a. Ann knows **Filipe's birthday**.
≈ *Ann knows what Filipe's birthday is.*

b. Beth predicted **every Academy Award winner**.
≈ *Beth predicted who every Academy Award winner would be.*

c. **One of Cleo's secrets** is shocking.
≈ *It's shocking what one of Cleo's secrets is.*

A standard account of the phemenon, due to Heim (1979), is that the meaning of CQ-embedding verbs involves a relation between an individual and an IC. For example, CQ-embedding *know* is be true of an individual x and an IC u at w if x knows that the actual value of u is the individual $u(w)$:

(98) $[\![\text{know}_{\text{IC}}]\!]^{w} := \lambda x_{\mathsf{e}}.\lambda u_{\mathsf{se}}.\ \mathsf{know}(\lambda w'_{\mathsf{s}}.\ u(w) = u(w'))(x)(w)$

Under this analysis, sentence (97a) could thus be analyzed as in (99): it is predicted to be true whenever the extension of *Filipe's birthday* in Ann's belief worlds is the same as its extension in the actual world.

(99) $[\![\text{Ann knows Filipe's birthday}]\!]^{w}$
$= [\![\text{know}_{\text{IC}}]\!]^{w}(\lambda w'.\ [\![\text{Filipe's birthday}]\!]^{w'})([\![\text{Ann}]\!]^{w})$
$= \mathsf{know}(\lambda w'.\ [\![\text{Filipe's birthday}]\!]^{w} = [\![\text{Filipe's Birthday}]\!]^{w'})(\mathsf{ann})(w)$

Among other things, such proposal captures the fact that the argument in (100) is invalid. The puzzle is that even though *Filipe's birthday* and *Caracalla's birthday* are stated to be identical, substitution of one for the other is not truth preserving.

(100) Ann knows Filipe's birthday.
Filipe's birthday is (also) Caracalla's birthday.
$\not\therefore$ Ann knows Caracalla's birthday.

If each sentence of (100) is translated as in (101), the invalidity is expected: *know* combines with the **intension** of its internal argument and the identity copula only states that the **extension** of the two DPs is the same.

(101) a. $\exists x.\ \mathsf{know}(\lambda w'.\ x = \mathsf{filipes\text{-}birthday}(w'))(\mathsf{ann})(w)$

b. $\mathsf{filipes\text{-}birthday}(w) = \mathsf{caracallas\text{-}birthday}(w)$

c. $\exists x.\ \mathsf{know}(\lambda w'.\ x = \mathsf{caracallas\text{-}birthday}(w'))(\mathsf{ann})(w)$

The invalid argument in (100) thus shows that the the **form** of CQ determines how the CQ is interpreted.

Concealed question intruders

Just like interrogative clauses, CQs can also have intruders. For example, sentence (103) is true in the bat scenario, repeated in (102):

(102) **Bat scenario** A bat is inside Ann and Ben's apartment but they can't find it. Ben tells Ann that the bat is hiding in the living room, but she's not convinced. Neither is aware that the bat is actually hiding in the bathroom.

(103) Ann disagrees with Ben the room he thinks the bat is hiding in.

Given the meaning for CQ-embedding *disagree* given in (104), sentence (103) should be translated into (105): it should convey that Ann and Beth disagree on the extension of *the room he thinks the bat is hiding in*.

(104) $$[\![\text{disagree}]\!]^{w} \coloneqq \lambda x.\lambda u.\lambda y.\ \exists z.\ \mathsf{believe}(\lambda w'.\ z = u(w'))(x)(w) \\ \wedge\ \mathsf{believe}(\lambda w'.\ z = u(w'))(y)(w)$$

(105) $$\exists z.\ \mathsf{believe}(\lambda w'.\ z = [\![\text{the room Ben thinks the bat is hiding in}]\!]^{w'})(\mathsf{ben})(w) \\ \wedge\ \mathsf{believe}(\lambda w'.\ z = [\![\text{the room Ben thinks the bat is hiding in}]\!]^{w'})(\mathsf{ann})(w)$$

Although this is indeed a possible reading of this sentence, in the bat scenario, both Ann and Ben know that Ben thinks the bat is hiding in the living room. Thus, this analysis predicts the sentence to be false. Instead, under the true reading of the sentence, the disagreement is about the extension of *the room the bat is hiding in* — *he thinks* is acting like an intruder.

Against pragmatic accounts

One might be tempted to resort to pragmatics to account for these particular examples — both Heim (1979) and Aloni and Roelofsen (2011), for example, have proposed pragmatic theories of CQs. For concreteness, I briefly present the pragmatic proposal of Heim, where CQ-embedding *know* would be interpreted as a relation between **individuals** but its meaning would make reference to a property-denoting variable whose meaning is contextually determined:

(106) $[\![\text{know}^{N}_{\text{IC}'}]\!]^{w} \coloneqq \lambda x_{\mathsf{e}}.\lambda y_{\mathsf{e}}.\ \mathsf{know}(\lambda w'.\ N(w')(x))(y)(w)$

The sentence *Ann knows the capital of France* would be analyzed as in (107): *know* composes with the extensions of *the capital of France* and *Ann*, and its property-denoting variable has the NP *capital of France* as its value. The sentence is predicted to be true only if Ann knows that Paris is the capital of France.

(107) $[\![\text{know}^{N}_{\text{IC}'}]\!]^{w}([\![\text{the capital of France}]\!]^{w})([\![\text{Ann}]\!]^{w})$
$= \mathsf{know}(\lambda w'.\ N(w')(\mathsf{the\text{-}capital\text{-}of\text{-}france}(w)))(\mathsf{ann})(w)$
where $N \mapsto \lambda w'.\lambda x.\ \mathsf{capital}(\mathsf{france})(x)(w')$

Intruders could be analyzed as follows: the value of the property-denoting value in (103) is resolved to the property denoted by *room that the bat is hiding in* instead of *room that he thinks the bat is hiding in*, as shown in (108).

(108) $[\![\text{Ann disagrees with Ben the room he thinks the bat is hiding in}]\!]^{w}$
$= [\![\text{disagree}]\!]^{w}(\lambda w'.\ N(w')([\![\text{the room he thinks the bat is hiding in}]\!]^{w}))(\mathsf{ann})$
where $N \mapsto \lambda w'.\lambda x.\ \mathsf{room\text{-}the\text{-}bat\text{-}is\text{-}hiding}(x)(w')$

In general, however, it is hard to reconcile pragmatic theories with the invalid argument in (100), as it's not clear why context wouldn't be able to allow the argument to be validated. In any case, here I will show specific properties of CQs with intruders that suggest that a fully pragmatic account would fail to explain the phenomenon — crucially, I argue that linguistic form of plays an important role in the interpretation of CQs even when it contains intruders.

First, observe that the following argument is invalid, even if *Ann thinks* is interpreted as an intruder:

(109) The person Ann thinks won surprises her.
The person Ann thinks won is also the person Beth think lost.
$\not\therefore$The person Beth thinks lost surprises Ann.

The intuition is that this follows from the facts that (i) *the person Ann think won surprises her*, under its intruder reading, conveys that Ann was surprises at who won, and (ii) that *the person Beth thinks lost surprises Ann* cannot convey this same information.

Thus, even though *Ann thinks* acts an intruder, the rest of CQ plays a role in determining what Ann is surprised about.

Further evidence can be found in the contrast between the sentences in (110). Suppose Ann mistakenly thinks her son Bob was hired. Sentence (110) but not sentence (110b) has an intruder reading — even though the DPs *the man Ann thinks was hired* and *the man whose mom thinks was hired* is contextually equivalent in the given scenario.

(110) a. The man Ann^1 thinks was hired surprises her$_1$.

b. The man whose mom^1 thinks was hired surprises her$_1$.

If the two DPs are contextually equivalent, the only way to account for the distinction between these two sentences would be to claim that the distinction between them is semantic rather than pragmatic.

4.3.2 A scopal theory of concealed questions

In this chapter, I adopt a simplified version of the theory of CQs presented in Chapter §3. Crucially, in this theory, the inner structure of DPs interpreted as CQs mirrors the inner structure of interrogative clauses. This will allows to give a unified analysis of the phenomenon of intrusion.

Concealed question embedding

I assume that the meaning of CQ-embedding predicates is defined in terms of their meaning as proposition-embedding predicates as follows:

(111) $[\![V_{\text{CQ}}]\!]^w \coloneqq \lambda u_{\text{se}}.\lambda x_{\text{e}}.\ \exists x.\ [\![V]\!]^w(\lambda w'.\ x = u(w'))(x)$

The schema above yields the same results as the theory of CQs proposed by George (2011), which is itself an extension of the theory of question embedding of Spector and Egré (2015).

Some sample translations are given in (112) and (113):

(112) a. Ann is certain of the room the bat is in.

b. $\exists x.\ \mathsf{certain}(\lambda x.\ x = [\![\text{the room the bat is in}]\!]^i)(\mathsf{ann})(w)$

(113) a. Ann knows the room the bat is in.

b. $\exists x.\ \mathsf{know}(\lambda x.\ x = [\![\text{the room the bat is in}]\!]^i)(\mathsf{ann})(w)$

Sentence (112a) is true whenever there's a particular room that Ann is certain is the room that the bat is in, and sentence (113a) is true whenever there's a particular room that Ann knows is the room that the bat is in. Notice that, because *know* is factive, (113b) requires Ann to know the room the bat is in.

Structuring concealed questions

Following Montague (1973), I assume that DPs sometimes involve quantification over ICs. Specifically, I take natural language quantificational determiners are systematically ambiguous between entries that involve quantification over individuals and entries that involve quantification over ICs:

(114)
$$\begin{aligned} [\![\text{every}_\alpha]\!]^w(A_{\alpha t})(B_{\alpha t}) &:= \forall a_\alpha.\, A(a) \rightarrow B(a) \\ [\![\text{a}_\alpha]\!]^w(A_{\alpha t})(B_{\alpha t}) &:= \exists a_\alpha.\, A(a) \wedge B(a) \\ [\![\text{the}_\alpha]\!]^w(A_{\alpha t}) &:= \iota a_\alpha[A(a)] \end{aligned}$$

where $\alpha = \mathsf{e}$ or $\alpha = \mathsf{se}$

This entry for determiners assumes that their restrictor denotes a predicate of ICs. Given that I assume that NPs denote predicate of individuals, I propose that they can be shifted into predicates of ICs via the silent operator $\uparrow_{\mathsf{se}}$, whose building blocks are two type-shifting operations from Partee 1986, iota and ident:

(115) a. $\mathsf{iota}_\alpha := \lambda f_{\alpha t}.\, \iota x_\alpha[f(x)]$

b. $\mathsf{ident}_\alpha := \lambda a_\alpha.\lambda b_\alpha.\, a = b$

(116) $[\![\uparrow_{\text{IC}}]\!]^w := \mathsf{ident}_{\mathsf{se}}(\lambda w'.\, \mathsf{iota}_{\mathsf{e}}(N(w')))$

$= \lambda N_{\mathsf{set}}.\lambda u_{\mathsf{se}}.\, u = (\lambda w'.\, \iota x[N(i)(x)])$

To show how the theory works, I analyze the following simple sentence:

(117) The person that was hired surprised Ann.

In principle, *surprise*$_{\text{IC}}$ could combined directly with the intension of *the*$_{\mathsf{e}}$ *person that was hired*. However, within the present proposal, it is also possible for us to analyze this description as having an IC as its **extension**. To do so, we must shift the NP *person that was hired* into a predicate of ICs via $\uparrow_{\mathsf{se}}$ and then compose the result with *the*$_{\mathsf{se}}$:

(118) a. the$_{\mathsf{se}}$ [$\uparrow_{\mathsf{se}}$ [person that was hired]]

b. $\iota u_{\mathsf{se}}[u = \textbf{the}(\mathsf{hired})]$

where $\textbf{the}(A_{\mathsf{est}}) := \lambda w.\, \iota x[A(x)(w)]$

Sentence (117) can then be analyzed as in (119): it is true whenever Ann is surprised that x was the person that was hired, for some x.

(119) a. the$_{\mathsf{se}}$ [$\uparrow_{\mathsf{se}}$ [person that was hired]] surprised Ann

b. $\exists x.\ \mathsf{surprise}(\lambda w'.\ x = \iota u_{\mathsf{se}}[u = \mathbf{the}(\mathsf{hired})](w'))(\mathsf{ann})(w)$
$= \exists x.\ \mathsf{surprise}(\lambda w'.\ x = \mathbf{the}(\mathsf{hired})(w'))(\mathsf{ann})(w)$

There are many similarities between this analysis of the inner structure of CQs and the analysis of interrogative clauses proposed by Karttunen (1977). Just as the ?-operator determines the form of the answers to a question, $\uparrow_{\mathsf{se}}$ determines the form of the IC in the NP. Note that there is even a semantic connection between the two operators, since ?-operator is an instantiation of ident. Given these similarities, one could imagine that the analysis of intruders advanced in the previous section can be extended to CQ intruders. We will see, however, that it is not simple to do so.

4.3.3 Accounting for concealed question intruders

Sentence (121) can be true in scenario (120): the sentence has an interpretation where the proposition that surprises Ann is the one denoted by *Beth was hired* rather than *Beth is the person Ann thinks was hired*. Under this interpretation, *Ann thinks* is an intruder.

(120) **Scenario** Ann mistakenly thinks Beth got the job. This surprises her.

(121) The person Ann thinks was hired surprises her.

The following sentence, with an interrogative, has an intruder reading too, as it can also be true in scenario (120):

(122) It surprises Ann who she thinks was hired.

In this subsection, I propose an account of the phenomenon of intrusion that can account for both of these examples.

Intruders via clausal QR?

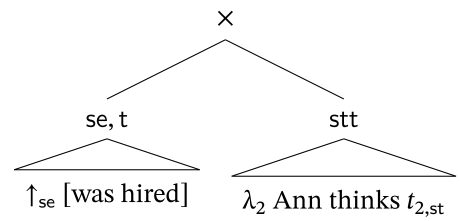
Intruders in embedded interrogatives are derived by having the ?-operator take low scope within the embedded interrogative. The natural idea to pursue here, then, is to have $\uparrow_{\mathsf{se}}$ scope low within the relative clause:[11]

[11] For ease of exposition, I will ignore the NP *person*. Everything I discuss in this subsection would be the same if we had entertained LFs in which *person* reconstructs into the relative clause.

(123) the [Ann thinks [$\uparrow_{se}$[was hired]]]

We have the same issue that we had with interrogatives — the LF in (123) is not interpretable as it is: *think* must take a proposition as its complement, but its sister in (123) denotes a predicate of ICs. However, in this case, QR of the embedded clause will not create an interpretable LF:

(124)

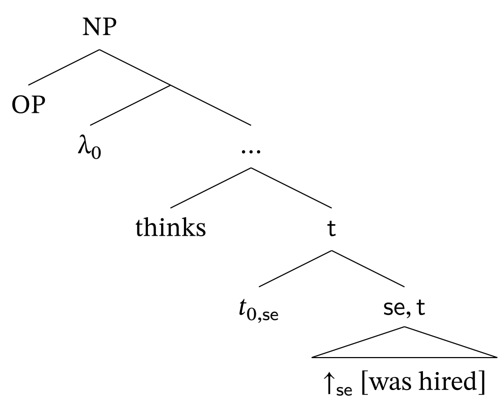


Differently from what we had with interrogatives, the moved constituent doesn't have the same type as the constituent created by movement: the constituent headed by $\uparrow_{se}$ denotes a predicate of ICs, but the predicate created by movement is a predicate of propositions. We must, therefore, pursue a different analysis.

A second attempt

Here's a proposal that initially will not work. Suppose we fix the type mismatch between *think* and the $\uparrow_{se}$-constituent by having a null operator leave a trace of type se right in between them:[12]

(125)



This interpretable structure is translated into the following predicate of ICs:

(126) $\lambda u_{se}.\ \exists z.\ \mathsf{think}(\lambda w'.\ u = \mathbf{the}(\mathsf{hired}))(\mathsf{ann})(w)$

[12]This structure could have been generated via successive-cyclic movement.

The problem is that the complement of *think* is a non-contingent proposition — it will either map every world to true (a tautology) or every world to false (a contradiction). Under the assumption Ann doesn't have contradictory beliefs, we could simplify this formula into (127), which is equivalent to not having *Ann thinks* in the structure at all.

(127) $\lambda u_{\mathsf{se}}.\ \exists z.\ u = \mathbf{the}(\mathsf{hired})$

We'd find ourselves in a similar situation had we tried the same strategy with the interrogative clauses:

(128) a. who λ_0 [OP λ_1 [Ann thinks [$t_{1,\mathrm{st}}$ [? $t_{0,\mathrm{e}}$ was hired]]]]

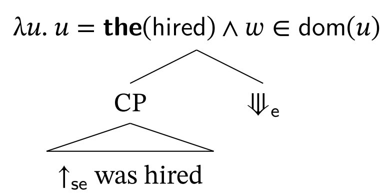
b. $\lambda p.\ \exists x.\ \mathsf{think}(\lambda w'.\ p = \mathsf{hired}(x))(\mathsf{ann})(w)$
$= \lambda p.\ \exists x.\ p = \mathsf{hired}(x)$

Rather than giving up on this strategy altogether, I propose that the following null operator can be used to turn our non-contingent propositions into contingent ones:

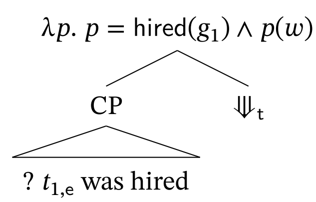
(129) $$[\![⟱_{\alpha}]\!]^{w}(a_{\mathsf{s}\alpha}) := \begin{cases} a(w) & \text{if } \alpha = \mathsf{t} \\ (w) \in \mathsf{dom}(a) & \text{if } \alpha = \mathsf{e} \end{cases}$$

When $⟱$ applies to a proposition at index *i*, it returns the value of that proposition at *i*; when it applies to an IC at *i*, it returns true if, and only if, the IC is defined at *i*.

I propose that, as a last resort operation, $⟱$ can modify constituents shifted by $\uparrow_{\mathsf{se}}$ and ?. Modifying an NP shifted by $\uparrow_{\mathsf{se}}$ with $⟱$ yields the function true of those ICs in the NP that are defined in the world of evaluation:[13]

(130)


Modifying a clause shifted by ? with $⟱$ yields a set of true answers:

(131)


[13]Because the set of ICs of the form *the hired (person)* is only true of a single IC, this new predicate will either be empty or be true of the same IC, depending on the given state of affairs.

Observe that having a ?-constituent be modified by ⟱ is equivalent to using Karttunen's actual proto-question operator, which turns propositions into sets of **true** propositions:

(132) $[\![?_{\mathrm{K}}]\!]^{w} := \lambda p.\lambda q.\ p = q \wedge p(w)$

Now that we have ⟱, we can then rewrite the LFs (125) and (128a) as follows:

(133) a. the [OP λ_0 Ann thinks [$t_{0,\mathrm{st}}$ [[$\uparrow_{\mathrm{se}}$ [was hired]] $⟱_{\mathrm{e}}$]]]

b. who λ_1 [OP λ_0 [Ann thinks [$t_{0,\mathrm{st}}$ [[? [t_1 was hired]] $⟱_{\mathrm{t}}$]]]]

These LFs will be translated into the formulas in (134) : the NP in (133a) is translated into the predicate true of the IC *the hired (one)* when Ann believes a unique person was hired; and the CP in (133b) is translated into the predicate true of propositions of the form *x was hired*, for any *x* Ann believes to have been hired.

(134) a. $\lambda u_{\mathrm{se}}.\ \mathsf{think}(\lambda w'.\ u = \mathbf{the}(\mathsf{hired}) \wedge w' \in \mathsf{dom}(u))(\mathsf{ann})(w)$

$\lambda u_{\mathrm{se}}.\ \mathsf{think}(\mathsf{dom}(u))(\mathsf{ann})(w) \wedge u = \mathbf{the}(\mathsf{hired})$

$= \lambda u_{\mathrm{se}}.\ \mathsf{think}(\lambda w'.\ \exists! x.\ \mathsf{hired}(x)(w'))(\mathsf{ann})(w) \wedge u = \mathbf{the}(\mathsf{hired})$[14]

b. $\lambda p.\ \exists x.\ \mathsf{think}(\lambda w'.\ p = \mathsf{hired}(x) \wedge p(w'))(\mathsf{ann})(w)$

$= \lambda p.\ \exists x.\ \mathsf{think}(p)(\mathsf{ann})(w) \wedge p = \mathsf{hired}(x)$

The question in (134b) is identical to the one we'd derive via the mechanism proposed in the previous section (i.e., via clausal QR), therefore it should be clear how the LF in (133b) will deliver the correct interpretation of (122). Therefore, I will only show that we correctly account for the intruder reading of (120). If that sentence's CQ has the LF in (133a), it is translated as follows:

(135) $\exists x.\ \mathsf{surprise}(x = \iota u_{\mathrm{se}}[\mathsf{think}(\mathsf{dom}(u))(\mathsf{ann})(w) \wedge u = \mathbf{the}(\mathsf{hired})(w')](\mathsf{ann})(w))$

As desired, the proposition that is fed to surprise is a proposition of the form *x is the hired (one)*, given some *x* — the intruder *Ann thinks* is able to outscope the CQ-embedding verb *surprise*.

We have thus an analysis of the phenomenon of intrusion that can account for both embedded question intruders and CQ intruders in a uniform way. However, this comes at a cost: the crucial ingredient of this analysis is an otherwise unmotivated operator, ⟱. It is therefore in many ways less appealing than the analysis of intruders that was offered in the previous section.

[14]The meaning of this NP is not quite accurate — the proposition Ann believes is perhaps too weak. This could be fixed with the theory of so-called **set readings** of CQs developed in chapter 3.

4.4 Conclusion

In the present paper, I discussed a new puzzle involving the interpretation of embedded interrogative clauses. What I call *intruders* are strings containing an intensional propositional operator and its core arguments (and modifiers) that appear to somehow escape the scope of the question-embedding predicate. I proposed an account of the phenomenon within the semantic analysis of interrogatives proposed in Karttunen 1977. The key idea was that the ?-operator – Karttunen's proto-question formation rule – is able to take scope at different constituents within an interrogative. Two compositional analysis were proposed, each with its own faults and virtues. The first naturally accounts for intruders in embedded interrogatives, but it has over-generation issues and cannot not be extended to intruders in concealed questions. The second analysis can give a uniform account of intruders in both embedded questions and concealed questions, but it relies on an otherwise unmotivated phonologically null operator.

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