Resolving Concealed Questions[*]

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Abstract

Concealed questions are determiner phrases that are naturally para-phrased as embedded questions (e.g., John knows *the capital of Italy* ≈ John knows *what the capital of Italy is*). This paper offers a novel account of the interpretation of concealed questions, whose central as-sumption is that an entity-denoting expression α may be type-shifted into an expression $?z.P(\alpha)$, where P is a contextually determined property, and z ranges over a contextually determined domain of indi-vidual concepts. Different resolutions of P and the domain of z yield a wide range of concealed question interpretations, some of which were not noted previously. On the other hand, principled constraints on the resolution process prevent overgeneration. The paper closes with some remarks on the distribution of concealed questions, in compari-son with that of interrogative and declarative complement clauses.

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1 Introduction

Concealed questions (CQs) are determiner phrases (DPs) which are naturally paraphrased as questions.[1]

(1)   John knows *the capital of Italy*.
       ≈ John knows what the capital of Italy is.

(2)   They revealed *the winner of the contest*.
       ≈ They revealed who the winner of the contest was.

Concealed questions arise not only with definite determiner phrases, but also with indefinite and quantified ones.

(3)   John knows a doctor who could help you.   (Frana 2006)

(4)   John knows every phone number.   (Heim 1979)

Heim (1979) observed that quantified CQs exhibit an interesting ambiguity. If no particular context is given, the most salient reading of (4) is probably what we will call the *specificational* reading:

(5)   John knows that Ann's number is 503, that Bill's number is 431, etc.

But if John's task is to assign to every newly installed phone a number that is not yet taken by any other phone, then he doesn't need to "know every phone number" in the sense of knowing which phone number is whose, but merely in the sense of knowing which numbers are somebody's at all (Heim, 1979, p.60). We call this the *predicational reading*:[2]

(6)   John knows of every phone number whether it is a phone number.

Predicational readings are particularly salient when the CQ noun is non-relational. This is illustrated by the following variant of Heim's original example, provided by Matthijs Westera (p.c.):

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[1]Sentence (1) and many of the other examples to be discussed below have, besides the described CQ reading, also an acquaintance reading. In languages like Italian and Dutch, where epistemic *know* and acquaintance *know* are lexically distinct, the CQ reading can be forced by using the verb for epistemic *know* (*sapere* in Italian and *weten* in Dutch).

[2]In (Roelofsen and Aloni, 2008) we referred to specificational and predicational readings as *pair-list* and *set*-readings, respectively. The intended interpretation of the terms has not changed; we have just come to find *specificational* and *predicational* more appropriate.

(7)   John knows every prime number.

Apart from the basic definite, indefinite and quantified CQs exemplified in (1)-(4), there are also structurally more involved cases like:

(8)   John knows the capital that Fred knows.

Heim (1979) observed that such CQ-containing CQs (CCQs) are ambiguous. In particular, she noted that (8) has the following two readings, which are generally referred to in the literature as Reading A and Reading B:[3]

(9)   Reading A:

        There is exactly one country x such that Fred can name x's capital; and John can name x's capital as well.

(10)   Reading B:

        John knows which country x is such that Fred can name x's capital (although John may be unable to name x's capital himself).

Suppose Fred knows that the capital of Italy is Rome. Then on Reading A, (8) entails that John also knows that the capital of Italy is Rome. On Reading B, (8) lacks this entailment. It only follows that John knows that Fred can name the capital of Italy.

     Of course, CCQs may also be indefinite or quantified:

(11)   John knows a doctor that Fred knows.

(12)   John knows every capital that Fred knows.

This paper provides a unified account of the interpretation of definite, indefinite, and quantified CQs and CCQs. In developing such an account, we will considerably widen the empirical domain. In particular, among other things, we will show that the A and B readings described above are just two among many readings that may arise for CCQs.

     Previous work has not only been concerned with the interpretation of CQs, but also with their distribution. One of the main challenges in this area is to characterize the range of verbs that select for CQ complements, as compared to the range of verbs that select for full-fledged declarative or

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[3]For simplicity, we disregard the distinction between what is presupposed and what is asserted in paraphrasing these readings. We will continue to do so throughout the paper.

interrogative complement clauses. Baker (1968) observed a striking correlation between CQs and interrogative complement clauses: verbs that select for CQ complements also select for interrogative complement clauses.

(13)   a.   John knows/remembers the capital of Italy.
        b.   John knows/remembers what the capital of Italy is.

However, this generalization only holds in one direction. As observed by Grimshaw (1979), there are verbs that select for full interrogative complement clauses, but not for CQs:

(14)   a.   John wonders/inquires what the capital of Italy is.
        b.   *John wonders/inquires the capital of Italy.

So the distribution of CQs does not fully coincide with the distribution of interrogative complement clauses. It also differs from the distribution of declarative complement clauses:

(15)   a.   John believes/regrets that Rome is the capital of Italy.
        b.   *John believes/regrets the capital of Italy.

We will outline a possible semantic account of Baker's generalization and of the differences in distribution between CQs and full-fledged interrogative and declarative complement clauses. While this account will rely on certain stipulations that stand in need of further explanation, it shows that it is in principle possible to develop a semantic account of the relevant distributional facts that is compatible with our overall theory of CQ interpretation.

The paper is organized as follows. Section 2 provides a brief overview of the theoretical options that have been explored in the recent literature, and points out what we think is the most promising direction to take. Section 3 identifies some outstanding problems, and section 4 develops a new account of the interpretation of CQs. Finally, section 5 briefly considers the distribution of CQs, and section 6 concludes.

2   Recent Approaches

As depicted in figure 1, recent approaches differ along two dimensions. Along the vertical dimension, which we call the TYPE dimension, theories differ in that they assign different semantic *types* to concealed questions. Some take

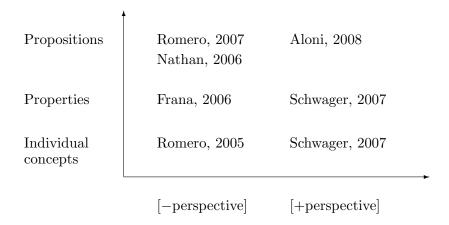|	[−perspective]	[+perspective]
Propositions	Romero, 2007 / Nathan, 2006	Aloni, 2008
Properties	Frana, 2006	Schwager, 2007
Individual concepts	Romero, 2005	Schwager, 2007

Figure 1: An overview of recent approaches.

CQs to denote propositions, while others take them to denote properties or individual concepts. Along the horizontal dimension, which we call the PERSPECTIVAL dimension, theories differ in that some take the interpretation of CQs to be dependent on a particular perspective that is taken on the individuals in the domain of discourse, while others do not (what this means exactly will be explained right below).[4]

Along the TYPE dimension, there are two basic arguments. The first involves *coordination*. Concealed questions can be coordinated with full-fledged declarative and interrogative complement clauses, as in (16) and (17).

(16)   They revealed the winner of the contest and that the President of the association would hand out the prize in person.

(17)   I only knew the capital of Italy and who won the Worldcup in 1986.

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[4]After this paper was submitted for publication (in November 2009) the *individual concept* approach of Romero (2005) was further developed by Frana (2010) and Romero (2010), while Percus (2010) proposed an account on which CQs denote sets of propositions. All these accounts belong in the [−perspective] column. An earlier contribution that is missing from the chart is that of Harris (2007). Harris' work certainly belongs in the [+perspective] column, but it does not belong in any of the rows in the chart. Harris analyzes CQs as functions from individual concepts to identity questions, or, equivalently, as functions from world-pairs to sets of individual concepts. Aloni's (2008) work can be seen as an attempt to simplify Harris' analysis.

If CQs are taken to denote propositions, then these coordination facts can be straightforwardly accounted for. This is immediately clear in the case of (16), which involves coordination of a CQ with a declarative complement clause. Declarative complement clauses are standardly taken to denote propositions. Thus, if CQs are also taken to denote propositions, the meaning of the coordinate structure in (16) is straightforwardly derived.

The CQ in (17) is coordinated with an interrogative complement clause. If CQs are taken to denote propositions, and if interrogative complement clauses are taken to denote propositions as well, as for instance assumed by Groenendijk and Stokhof (1984) and Aloni (2008), then the meaning of the coordinate structure in (17) is again straightforwardly derived. If instead interrogative complement clauses are taken to denote sets of propositions, as for instance assumed by Karttunen (1977a), the meaning of the coordinate structure in (17) could still be derived in a rather straightforward way, assuming the existence of an operator that takes an interrogative clause and delivers the true exhaustive answer to the question expressed by that interrogative clause in the world of evaluation (e.g., the ANS_2 operator in Heim 1994). Under the assumption that interrogative complement clauses denote sets of propositions, such an operator would be independently needed to derive the meaning of sentences like:

(18)   Julia remembers what Ben ate and that he didn't like it.

Thus, if CQs are taken to denote propositions, the meaning of sentences like (16) and (17) can be derived without stipulating *ad hoc* type-shifting operators. Evidently, this is *not* the case if CQs are taken to denote properties or individual concepts, rather than propositions.

The other argument along the TYPE dimension is one of *parsimony*. All CQ-embedding verbs also embed full-fledged interrogative and/or declarative clauses. Thus, if CQs are taken to denote propositions, CQ-embedding verbs can be composed with their CQ-complements just as they would be composed with their full-fledged interrogative and/or declarative complements. If CQs are not taken to denote propositions but, say, individual concepts, then CQ-embedding verbs must be associated with at least two distinct lexical items: one which embeds proposition denoting expressions and one which embeds individual concept denoting expressions. Clearly, such stipulations should be avoided whenever possible. Thus, both arguments along the TYPE dimension favor approaches that take CQs to denote propositions.

Now let us turn to the horizontal dimension in figure 1. Along this dimension, theories differ in that some take the interpretation of CQs to be dependent on a particular *perspective* that is taken on the individuals in the domain of discourse, while others do not. What this means exactly is best explained by means of an example.

Suppose that in front of you lie two face-down cards. One is the Ace of Hearts, the other is the Ace of Spades, but you don't know which is which. You have to choose one card: if you choose the Ace of Hearts you win €10, if you choose the Ace of Spades you lose €10. Now consider the following sentence:

(19)   You know the winning card.

Is this sentence true or false in the given situation? On the one hand, the sentence is true: you know that the Ace of Hearts is the winning card. On the other hand, the sentence is false: as far as you know, the winning card may be the card on the left, but it may just as well be the card on the right. Intuitively, there are two ways in which the cards may be identified in this situation: by their position (the card on the left, the card on the right) or by their suit (the Ace of Hearts, the Ace of Spades). Whether (19) is judged true or false depends on which of these perspectives is adopted. If identification by suit is adopted, the sentence is judged true. But if identification by position is adopted, the sentence is judged false. Some theories of CQs account for such perspective-related ambiguities, others do not. Clearly, other things being equal, the ones that do are to be preferred.

This leads us to the preliminary conclusion that Aloni's (2008) theory, which takes CQs to denote propositions and accounts for perspective-related ambiguities, is the most promising theory among those proposed in the recent literature. Several problems remain however. In the next section, we discuss Aloni's theory and the problems it faces.

3   Concealed Questions under Cover

Aloni's theory of concealed questions builds on the theory of questions developed in (Aloni, 2001). This in turn is an extension of Groenendijk and Stokhof's (1984) theory of questions, one which is especially geared at capturing the perspective-sensitive nature of questions and other operators in

natural language. We will first review Aloni's approach to questions in general. Then we will turn to her account of concealed questions in particular, and point out some of its shortcomings.

3.1   Conceptual Covers

Consider again the card situation discussed in the previous section. In front of you lie two face-down cards. One is the Ace of Spades, the other is the Ace of Hearts. You don't know which is which. There are two different ways of identifying the two cards in this scenario: by their position on the table (the card on the left, the card on the right) and by their suit (the Ace of Spades, the Ace of Hearts). Aloni (2001) proposes to formalize such *methods of identification* in terms of *conceptual covers*. A conceptual cover is a set of individual concepts which exclusively and exhaustively covers the domain of individuals: each individual is identified by exactly one concept in each world. More formally:

Definition 1. [Conceptual covers] Given a set of possible worlds W and a domain of individuals D, a *conceptual cover* CC based on (W, D) is a set of functions $W \to D$ such that:

$$\forall w \in W : \ \forall d \in D : \ \exists! c \in CC : c(w) = d$$

Illustration.   To formalize the card situation discussed above we need a model with two worlds, w_1 and w_2, and a domain consisting of two individuals, $\heartsuit$ and $\spadesuit$. As illustrated in the diagram below, either $\heartsuit$ is the card on the left (in w_1) or it is the card on the right (in w_2).

$$w_1 \ \mapsto \ \heartsuit \quad \spadesuit$$
$$w_2 \ \mapsto \ \spadesuit \quad \heartsuit$$

There are only two possible conceptual covers definable over such a model, namely the set A which identifies the cards by their position and the set B which identifies the cards by their suit:

A = {the card on the left, the card on the right}

B = {the Ace of Spades, the Ace of Hearts}

C below is a set of concepts which does *not* constitute a conceptual cover:

C = {the card on the left, the Ace of Hearts}

For C to be a conceptual cover, every individual should instantiate exactly one concept in every world. But this is not the case. In w_1 for example, $\heartsuit$ instantiates two concepts, while $\spadesuit$ does not instantiate any concept at all.

3.2   Quantification under Cover

We start with a language of first-order logic enriched with a ι-operator and a question operator ?. A model for this language is a quadruple (W, D, I, C) where W is a set of possible worlds, D a set of individuals, I a world dependent interpretation function, and C a set of conceptual covers based on (W, D). Sentences are evaluated relative to a model, a world in that model, and an assignment function. Normally, an assignment function g simply maps a variable x to some individual $d \in D$. However, in Aloni's framework, variables do not range over individuals *simpliciter*, but rather over the elements of some pragmatically determined conceptual cover. The conceptual cover that a variable x ranges over is determined by a *cover resolution function* $\mathcal{R}$. This function maps every variable x to some conceptual cover in C.[5]

Definition 2. [Cover resolution functions] Given a set of variables V and a model (W, D, I, C), a cover resolution function $\mathcal{R}$ is a function that maps every variable x in V to some conceptual cover in C.

Now, given a certain cover resolution function $\mathcal{R}$, an assignment function $g_{\mathcal{R}}$ maps every variable x to some individual concept in $\mathcal{R}(x)$.

Definition 3. [Assignment functions] Given a set of variables V, a model (W, D, I, C), and a cover resolution function $\mathcal{R}$, an assignment function $g_{\mathcal{R}}$ is a function that maps every variable x in V to some individual concept in $\mathcal{R}(x)$.

Thus, a variable x is assigned a value in two steps. First, $\mathcal{R}$ determines the conceptual cover that x ranges over, and then $g_{\mathcal{R}}$ maps x to some individual concept in $\mathcal{R}(x)$. Quantification, then, works as follows:

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[5]We diverge slightly from Aloni's original terminology and notation here, purely for presentational purposes.

Definition 4. [Quantification under conceptual cover]

- $[\![\exists x.\varphi]\!]_{M,w,g_{\mathcal{R}}} = 1$ iff $\exists c \in \mathcal{R}(x) : [\![\varphi]\!]_{M,w,g_{\mathcal{R}}[x/c]} = 1$

- $[\![\forall x.\varphi]\!]_{M,w,g_{\mathcal{R}}} = 1$ iff $\forall c \in \mathcal{R}(x) : [\![\varphi]\!]_{M,w,g_{\mathcal{R}}[x/c]} = 1$

In words, $\exists x.\varphi$ is true in a world w relative to an assignment function $g_{\mathcal{R}}$ iff there is some individual concept c in $\mathcal{R}(x)$, i.e., the conceptual cover that x ranges over according to $\mathcal{R}$, such that φ is true in w relative to $g_{\mathcal{R}}[x/c]$. And similarly for $\forall x.\varphi$.

Apart from existential and universal quantification, our analysis of concealed questions will also make heavy use of the ι-operator, which is defined as follows.

Definition 5. [The ι-operator]

- If there is a unique $c \in \mathcal{R}(x)$ such that $[\![\varphi]\!]_{M,w,g_{\mathcal{R}}[x/c]} = 1$, then:

$$[\![\iota x.\varphi]\!]_{M,w,g_{\mathcal{R}}} = c(w)$$

- Otherwise, $[\![\iota x.\varphi]\!]_{M,w,g_{\mathcal{R}}}$ is undefined.

It should be noted that, even though variables range over the elements of a conceptual cover in this framework, rather than over individuals *simpliciter*, the denotation of a variable in a certain world is always an *individual*, not an individual concept.

Definition 6. [The denotation of variables] $[\![x]\!]_{M,w,g_{\mathcal{R}}} = g_{\mathcal{R}}(x)(w)$

The denotation $[\![x]\!]_{M,w,g_{\wp}}$ of a variable x with respect to a model M, a world w and an assignment function $g_{\mathcal{R}}$ is the individual $g_{\mathcal{R}}(x)(w)$, i.e., the value of the concept $g_{\mathcal{R}}(x)$ in world w. Thus, variables do not refer to concepts, but to individuals. However, they do refer in a non-rigid way: different individuals can be their value in different worlds.

3.3 Questions under Cover

Questions are analyzed in terms of their possible exhaustive answers, as in (Groenendijk and Stokhof, 1984). However, determining the denotation of

a question involves quantification over the elements of a conceptual cover rather than over individuals:[6]

Definition 7. [Questions under conceptual cover]

- $[\![?x.\varphi]\!]_{M,w,g_\mathcal{R}} = \{v \mid \forall c \in \mathcal{R}(x) : [\![\varphi]\!]_{M,w,g_\mathcal{R}[x/c]} = [\![\varphi]\!]_{M,v,g_\mathcal{R}[x/c]}\}$

Illustration. Consider again the card situation described above. In front of you lie two face-down cards. One is the Ace of Hearts, the other is the Ace of Spades. You don't know which is which. Furthermore, assume that one of the cards is the winning card, but you don't know which. This situation can be modeled as follows (the dot indicates the winning card):

$$
\begin{array}{rcl}
w_1 & \mapsto & \heartsuit \quad \spadesuit^\bullet \\
w_2 & \mapsto & \spadesuit \quad \heartsuit^\bullet \\
w_3 & \mapsto & \heartsuit^\bullet \quad \spadesuit \\
w_4 & \mapsto & \spadesuit^\bullet \quad \heartsuit
\end{array}
$$

Consider the following interrogative sentence:

(20)   a.   Which card is the winning card?
       b. $?z.\ z = \iota x.\text{WINNING-CARD}(x)$

The evaluation of this sentence depends on the conceptual cover that z ranges over. There are two possible resolutions: under $\mathcal{R}_1$, z ranges over the *position* cover, while under $\mathcal{R}_2$, z ranges over the *suit* cover:

$\mathcal{R}_1(z) = \{\text{the card on the left, the card on the right}\}$

$\mathcal{R}_2(z) = \{\text{the Ace of Spades, the Ace of Hearts}\}$

The question in (20) partitions the set of worlds in two different ways depending on the assumed cover resolution:

$$
\text{under } \mathcal{R}_1 : \quad
\begin{array}{|c|}
\hline
w_1 \\
w_2 \\
\hline
w_3 \\
\hline
w_4 \\
\hline
\end{array}
\qquad
\text{under } \mathcal{R}_2 : \quad
\begin{array}{|c|}
\hline
w_1 \\
w_4 \\
\hline
w_2 \\
\hline
w_3 \\
\hline
\end{array}
$$

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[6]For simplicity, we only define the semantics of single-constituent questions here (like *who called?*). See (Aloni, 2001) for a generalization, which also deals with multi-constituent questions (like *who called whom?*).

Under $\mathcal{R}_1$, (20) induces a partition which separates worlds where the winning card occupies a different position. Under $\mathcal{R}_2$, (20) induces a partition which separates worlds where the winning card is of a different suit. Since different resolutions result in different partitions, the fact that different answers are required in different contexts is accounted for. For instance, (21) counts as an appropriate answer to (20) only under $\mathcal{R}_2$:

(21)   The Ace of Spades is the winning card.

3.4   Knowledge Ascription

In order to translate sentences like *John knows which card is the winning card*, the language is extended with a knowledge operator K_a, for every agent a whose epistemic state we would like to describe. The above sentence is then translated as $K_j\,(?z.\ z = \iota x.\textsc{winning-card}(x))$. A model for the extended language is a quintuple (W, D, I, C, E), where W, D, I and C are as above and E is a function mapping individual-world pairs (a, w) into subsets of W. Intuitively, $E(a, w)$ represents the epistemic state of a in w. Sentences of the form $K_a(?z.\varphi)$ are interpreted as follows:

Definition 8. [Knowledge ascription]

- $[\![K_a\,(?z.\varphi)]\!]_{M,w,g_\mathcal{R}} = 1$ iff $E(a, w) \subseteq [\![?z.\varphi]\!]_{M,w,g_\mathcal{R}}$

$K_a\,(?z.\varphi)$ is true in w iff a's epistemic state is contained in the denotation of $?z.\varphi$ in w. Since the denotation of $?z.\varphi$ in w corresponds to the true exhaustive answer to $?z.\varphi$ in w, $K_a\,(?z.\varphi)$ is true in w iff a's epistemic state supports the true exhaustive answer to $?z.\varphi$ in w.

Illustration.   Consider again the card situation described above. Suppose now that John knows that the Ace of Spades is the winning card, but he doesn't know whether it is the card on the left or the one on the right. In this situation John's epistemic state corresponds to the set: $\{w_1, w_4\}$. Sentence (22) is then correctly predicted to be true under $\mathcal{R}_2$, but false under $\mathcal{R}_1$.

(22)   a.   John knows which card is the winning card.
         b. $K_j(?z.\ z = \iota x.\textsc{winning-card}(x))$

3.5 Conceptual covers and intensional operators

In order to understand many of the examples to be discussed below, it is useful to realize that the denotation of $\iota x.\varphi$, $\exists x.\varphi$, and $\forall x.\varphi$ does not depend on the conceptual cover that is assigned to x by $\mathcal{R}$, as long as x does not occur free in the scope of an intensional operator in φ.[7] This is perhaps easiest to see by considering a simple example. Consider the term $\iota x.P(x)$, where P is a simple one-place predicate. To determine $[\![\iota x.P(x)]\!]_{M,w,g_{\mathcal{R}}}$, we have to check whether there is a unique concept $c \in \mathcal{R}(x)$ such that $[\![P(x)]\!]_{M,w,g_{\mathcal{R}}[x/c]} = 1$. If we can find such a unique concept c, then the value of $[\![\iota x.P(x)]\!]_{M,w,g_{\mathcal{R}}}$ is $c(w)$. But since $\mathcal{R}(x)$ is a conceptual cover and the individual concepts in a conceptual cover are all instantiated by a unique individual in every world, we know that there is a unique concept $c \in \mathcal{R}(x)$ such that $[\![P(x)]\!]_{M,w,g_{\mathcal{R}}[x/c]} = 1$ just in case the extension of P in w consists of a unique individual $d \in D$. Moreover, in this case we have that $[\![\iota x.P(x)]\!]_{M,w,g_{\mathcal{R}}} = c(w) = d$. This means that, to determine $[\![\iota x.P(x)]\!]_{M,w,g_{\mathcal{R}}}$, we do not really need to know anything about $\mathcal{R}$. We just need to look at the extension of P in w, and check whether this extension consists of a unique individual d. If so, $[\![\iota x.P(x)]\!]_{M,w,g_{\mathcal{R}}} = d$. Otherwise, $[\![\iota x.P(x)]\!]_{M,w,g_{\mathcal{R}}}$ is undefined.

This reasoning also goes through if instead of $\iota x.P(x)$ we consider $\exists x.P(x)$ or $\forall x.P(x)$, or if instead of P we take an arbitrarily complex predicate φ, as long as x does not occur free in the scope of an intensional operator in φ. Below we will see many examples where x does occur in the scope of an intensional operator in φ (see for instance example (27) in the next subsection where x occurs free in the scope of a question operator). In these cases, it matters which conceptual cover x ranges over. But we will also see many examples where x does not occur free in the scope of an intensional operator. When considering such examples, always keep in mind that it does not really matter which conceptual cover x ranges over.

3.6 Concealed Questions under Cover

Aloni (2008) applies the above analysis of questions and knowledge ascription to the domain of concealed questions. She assumes that the interpretation of concealed questions involves a type-shifting operator $\uparrow_z$ which transforms

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[7]An operator Σ is called *intensional* if and only if the denotation of an expression $\Sigma\varphi$ in a world w depends on the denotation of φ in worlds other than w. In our formal language, the only intensional operators are the question operator and the knowledge operator.

an entity denoting expression α into the identity question $?z.\ z = \alpha$ (*which z is α?*), where z ranges over some contextually determined conceptual cover.

(23) $\uparrow_z \alpha \ =_{\text{def}} \ ?z.\ z = \alpha$

Illustrations.   First consider a 'plain' definite CQ:

(24)   a.   John knows the capital of Italy.
         b. $K_j(\uparrow_z \iota x.Px)$ $(= K_j(?z.\ z = \iota x.Px))$

When a proposition embedding verb like *know* applies to an entity denoting expression like *the capital of Italy*, the type-shifting operator $\uparrow_z$ must apply to avoid a type mismatch. The resulting sentence is then interpreted according to the analysis of knowledge ascription given in the previous section.

(25) $[\![K_j(?z.\ z = \iota x.Px)]\!]_{M,w,g_\mathcal{R}} = 1$ iff $E(j,w) \subseteq [\![?z.\ z = \iota x.Px]\!]_{M,w,g_\mathcal{R}}$

The intended reading is obtained if x and z are both taken to range over the *naming* cover:[8]

(26) $x, z \to \{\text{Berlin, Rome, Paris, } \ldots\}$

Under this resolution the embedded question $?z.\ z = \iota x.Px$ denotes in w the proposition that Rome is the capital of Italy, if Rome is indeed the capital of Italy in w. Sentence (24) then is true in w iff John's epistemic state in w supports this proposition.

Example (27) illustrates Aloni's analysis of quantified CQs:

(27)   a.   John knows every European capital.
         b. $\forall x.(\text{EUROPEAN-CAPITAL}(x) \to K_j(\uparrow_z x))$

The most natural cover resolution for x and z here is the following:

(28)   a. $x \to \{\text{the capital of Germany, the capital of Italy, } \ldots\}$
         b. $z \to \{\text{Berlin, Rome, } \ldots\}$

The sentence is then predicted to be true iff for each European country John can name the capital of that country. This captures the specificational reading of the sentence. Notice that contrary to the previous example, the

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[8]Notice that, as explained in section 3.5, it does not really matter which cover x is taken to range over, since x does not occur free in an intensional context.

quantified case crucially requires that x and z range over two different covers, otherwise the question $?z.\ z = x$ would be trivialized (i.e., it would denote a tautology in every world, relative to any assignment function).

Finally, we turn to Heim's CCQ ambiguity. As we mentioned in the introduction, Heim (1979) observed that sentences like (29) have the two readings paraphrased in (30) and (31).

(29)   John knows the capital that Fred knows.

(30)   Reading A:

        There is exactly one country x such that Fred can name x's capital; and John can name x's capital as well.

(31)   Reading B:

        John knows which country x is such that Fred can name x's capital (although John may be unable to name x's capital himself).

Aloni analyzes Heim's ambiguity as a *de re/de dicto* ambiguity:

(32)   John knows the capital that Fred knows.

$$\exists x.(x = \iota y.(\text{CAPITAL}(y) \wedge K_f(\uparrow_{z_1} y)) \wedge K_j(\uparrow_{z_2} x)) \qquad \text{[Reading A]}$$

$$K_j(\uparrow_{z_3} \iota y.(\text{CAPITAL}(y) \wedge K_f(\uparrow_{z_4} y))) \qquad \text{[Reading B]}$$

The intended readings are captured by assuming the following cover resolution for the variables:

(33)   a. $x, y, z_3 \rightarrow \{\text{the capital of Germany, the capital of Italy, } \dots\}$
        b. $z_1, z_2, z_4 \rightarrow \{\text{Berlin, Rome, } \dots\}$

On this resolution, Reading A says that there is a unique capital which Fred can identify by name, and that John can identify that capital by name as well. On Reading B, John can identify 'the capital that Fred knows' with one of the individual concepts in the conceptual cover associated with z_3. That is, there is some country x such that 'the capital that Fred knows' and 'the capital of x' denote the same city in all worlds in John's epistemic state.[9]

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[9]See Aloni (2008) for a more detailed description of how these readings are obtained.

3.7   Some outstanding issues

Aloni's account captures some of the basic semantic aspects of CQs. However, it leaves several issues unadressed. Below we briefly discuss five such issues.

Predicational readings of quantified CQs.   As noted above, quantified CQs like (34):

(34)   John knows every phone number.

are ambiguous between a specificational reading:

(35)   John knows that Ann's number is 503, that Bill's number is 431, etc.

and a predicational reading:

(36)   John knows of every phone number whether it is a phone number.

As shown in section 3.6, Aloni's theory accounts for the specificational reading. But it has no way of accounting for the predicational reading.

Ambiguity of quantified CCQs.   Recall that Aloni analyzes the A/B ambiguity of definite CQs such as:

(37)   John knows the capital that Fred knows.

as a *de re*/*de dicto* ambiguity. On the other hand, her account of quantified CQs assumes a *de re* representation. That is, quantified CCQs such as (38) must be represented *de re*.

(38)   John knows every capital that Fred knows.

But this means that the A/B ambiguity of quantified CCQs cannot be derived as a *de re*/*de dicto* ambiguity.[10]

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[10]Aloni's theory does provide for an alternative strategy to derive the A/B ambiguity, but only under certain rather unnatural assumptions about cover resolution (see Roelofsen and Aloni, 2008, for more discussion of this issue).

Greenberg's observation. The contrast between (39) and (40), first noted by Greenberg (1977), constitutes a third open issue for Aloni's account.[11]

(39)   John found out the murderer of Smith.

(40)   John found out who the murderer of Smith was.

Sentence (39) contains a concealed question, whereas (40) contains a full interrogative clause. Greenberg observed that there is a subtle difference in meaning between the two sentences: (39) necessarily entails that John solved the question of who murdered Smith (direct reading); (40) does not necessarily have this entailment—it may be used to report, for example, that John found out that his gardener was a much sought-after criminal known as *The Strangler* even if John did not find out that the guy actually murdered Smith (indirect reading). This contrast clearly stands in need of an explanation, especially on an approach that assimilates CQs to interrogative complement clauses.

CQ distribution. A fourth issue that Aloni's proposal leaves unaddressed is the distribution of CQs. In particular, since CQs are semantically treated as questions on this approach, an explanation is needed of the fact that there are verbs selecting for full interrogative clauses, but not for CQs:

(41)   a.   John wonders/inquires what the capital of Italy is.
       b.   *John wonders/inquires the capital of Italy.

Indeed, examples like (41) have been presented by Nathan (2006) and Frana (2010) as a general argument against approaches that treat CQs as questions. In our view, these examples do not really constitute such an argument. They just show that there are certain differences between CQs and full-fledged interrogative clauses that certain embedding verbs are sensitive to. To illustrate this point, consider the following contrast, first noted by Karttunen (1977b):

(42)   a.   I doubt whether they serve breakfast.
       b.   *I doubt what they serve for breakfast.

We cannot conclude from this contrast that the two embedded clauses must differ in semantic type. We can only conclude that there must be a certain

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[11]As Frana (2010) reports, most English speakers tend to dislike CQs with *find out*. However, the contrast can be reproduced by replacing *find out* with *discover*.

difference between the two clauses that the verb *doubt* is sensitive to. Similarly, we can conclude from the contrast in (41) that there must be a certain difference between CQs and full interrogative complement clauses that the verbs *wonder* and *inquire* are sensitive to. This could be a difference in semantic type, but that is not necessarily the case.

Nevertheless, the contrast in (41) does stand in need of an explanation, and Aloni (2008) does not provide such an explanation.

Basic and derived covers. Apart from these empirical issues, there is also a more technical issue with Aloni's proposal, having to do with the fact that, by definition, a conceptual cover is a set of individual concepts such that every concept picks out *exactly one* individual in every world. There are many examples of concealed questions which seem to require quantification over a domain of individual concepts that does not necessarily have this special property. Consider the following example:

(43)   John knows the price that Fred knows.

Heim's reading B of (43) says that John knows which price Fred knows (e.g., the price of milk, the price of butter, or the price of bread). This reading involves quantification over the following domain of individual concepts:

(44)   {the price of milk, the price of butter, the price of bread, ... }

Now, it is possible, of course, that the price of butter and the price of milk coincide in some world, which would mean that not every individual is picked out by a unique concept in that world. Thus, the required domain of quantification is *not* necessarily a conceptual cover.[12]

Notice that this problem does not arise for our original example, (8), just because it happens to be impossible for two countries to have the same capital city. The problem does arise, however, for analogous examples involving temperatures, scores, colors, dates of birth, etc.

To overcome this problem we will make a distinction between *basic* covers and *derived* covers. Basic covers are conceptual covers that satisfy the original requirement that in every world, every individual instantiates exactly one concept. Given a basic cover C and a function $f_{\langle s, \langle e, e \rangle \rangle}$, the derived cover based on C and f is defined as follows:

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[12] A closely related observation has been made by Schwager (2007a).

(45) $\{c \mid \exists c' \in C.\forall w.\ c(w) = f(w)(c'(w))\}$

For example, {the capital of Italy, the capital of Germany, ... } is a derived cover based on {Italy, Germany, ... } and the *capital-of* function. We will assume that domains of quantification may be derived covers, as well as basic covers, and that functional nouns like *price* and *capital* can make derived covers particularly salient.[13]

The empirical issues listed above will be addressed in the next two sections. Section 4 develops a detailed account of the interpretation of CQs. Section 5 outlines a possible account of their distribution.

4   Resolving concealed questions

4.1   Basic Proposal

We take as our point of departure the specificational/predicational ambiguity of quantified CQs. As pointed out above, Aloni's theory does not account for this ambiguity.[14] What is it that makes this case so challenging? Consider again the standard example:

(46)   John knows every phone number.

Let us assume (47) as a representation of the truth-conditional meaning of (46), without yet fixing the exact definition of the type-shifting operator ↑.

(47) $\forall x.(\text{PHONENUMBER}(x) \rightarrow K_j(\uparrow x))$

Now let us just see how ↑ *should* be defined to get the facts right. In order to capture the specificational reading, we need:

(48) $\uparrow x \rightsquigarrow ?z.\ z = x$

with:

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[13]Although this solution serves our present purposes, it is not without potential pitfalls. The appendix provides some further discussion of this issue.

[14]When this paper was submitted for publication (in November 2009) the specificational/predicational ambiguity of quantified CQs was problematic for all existing theories of CQs. In the meantime, Frana (2010) has proposed an account of the ambiguity that differs from the one to be proposed here. A detailed comparison of Frana's account with our own must be left for another occasion.

- $x \rightarrow \{$Ann's phone number, Bill's phone number, $\dots\}$

- $z \rightarrow \{5403,\ 5431,\ \dots\}$

In order to get the predicational reading, we want:

(49) $\uparrow x \rightsquigarrow\ ?\,\text{PHONENUMBER}(x)$

with:

- $x \rightarrow \{5403,\ 5431,\ \dots\}$

To capture this flexibility, we will assume that $\uparrow$ transforms an entity-denoting expression α into the question $?z.P(\alpha)$.

(50) $\uparrow_{(z,P)} \alpha\ =_{\text{def}}\ ?z.P(\alpha)$

The type-shift has two pragmatic parameters: z ranges over some contextually determined conceptual cover and P is a contextually determined property. We assume that by default P is resolved to the property of being identical to z, i.e., to the "identity property" $\lambda y.y = z$; or to the property expressed by the CQ noun phrase. In the latter case, the cover resolution of z becomes irrelevant. Indeed, if z does not occur free in P and α, then $?z.P(\alpha)$ is equivalent to $?P(\alpha)$, and we will avoid reference to z altogether. Finally, we assume that z by default ranges over a naming cover, a rigid cover (in case the individuals in the relevant domain can be identified by ostension, as in the card example discussion in section 2), or a derived cover based on a functional CQ noun (if such a cover is salient in the given context).

Thus, (46) is now analyzed as:

(51) $\forall x.(\text{PHONENUMBER}(x) \rightarrow K_j(?z.P(x)))$

The specificational reading results from the following resolution:

- $x \rightarrow \{$Ann's phone number, Bill's phone number, $\dots\}$

- $z \rightarrow \{5403,\ 5431,\ \dots\}$

- $P \rightarrow \lambda y.y = z$

which yields:

(52) $\forall x.(\text{PHONENUMBER}(x) \rightarrow K_j(?z.\ z = x))$

The predicational reading results from the following resolution:[15]

- $x \to \{5403,\ 5431,\ \dots\}$

- $P \to$ PHONENUMBER

which yields:

(53) $\forall x.(\text{PHONENUMBER}(x) \to K_j(?\,\text{PHONENUMBER}(x)))$

In the first case P is resolved to the "identity property", in the second case to the property expressed by the CQ noun phrase. The resolution of z is only relevant in the first case. Notice that, at least for this example, the proposed account does not overgenerate. The only available covers are the naming cover $\{5403,\ 5431,\dots\}$ and the derived cover $\{$Ann's phone number, Bill's phone number, $\dots\}$. The only salient properties are the identity property and PHONENUMBER. As a result, any resolution of x, z and P will yield either the specificational or the predicational reading described above.

4.2   CCQs

Let us now consider the case of CCQs. So far we have assumed that CCQs are two-way ambiguous between the A and B readings that Heim (1979) identified. The theory proposed here, however, predicts that there are several additional readings. And upon closer examination these readings are indeed available.[16] To illustrate this, let us consider the most general and most challenging case: quantified CCQs (the theory deals with definite and indefinite CCQs in an analogous way). Consider our initial example:

(54)   John knows every capital that Fred knows.

and its analysis:

(55) $\forall x.((\text{CAPITAL}(x) \land K_f(?z_1.\ P_1(x))) \to K_j(?z_2.\ P_2(x)))$

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[15]The cover resolution of z will be left unspecified whenever it is irrelevant, i.e., whenever P is not resolved to the identity property.

[16]During a recent workshop Heim (2009) herself also pointed out the existence of additional readings for CCQs. In particular, she discussed what we will call below the *predicational* A and B readings (she called them *individual-based* A and B readings). However, we will see that besides the 'original' A and B readings, and the predicational ones, there are even more.

It will be useful to make a distinction between two general types of readings. On the first type of reading, (54) says something about John's knowledge *in contrast/comparison* with Fred's knowledge. On the second type of reading, (54) is concerned with John's knowledge *about* Fred's knowledge. We will refer to readings of the first type as A readings, and to those of the second type as B readings. Notice that on this terminology, the two readings originally described by Heim (1979) are indeed A- and B-type readings, respectively. However, there are several additional A- and B-type readings as well. Let us first consider the A-type readings in more detail.

There are three different A-type readings that quite naturally arise. First, consider a context where John and Fred are given a list of cities, and are asked which of these cities are capitals. In this context, (54) can be taken to mean that for every city x such that Fred knows that x is a capital city, John also knows that x is a capital city (a predicational reading).

Second, consider a context where John and Fred are given a list of cities, and are asked to specify the countries that these cities are the capitals of. In this context, (54) can be taken to mean that for every capital x such that Fred can specify the country that x is the capital of, John can also specify the country that x is the capital of (a specificational reading).

Finally, consider a context where John and Fred are given a list of countries, and are asked to specify the capitals of these countries. In this context, (54) can be taken to mean that for every country y such that Fred can specify y's capital, John can also specify y's capital (another specificational reading).

These readings correspond to the following resolutions:[17]

Predicational A reading:

- $x \rightarrow \{\text{Rome, Berlin, Paris, ...}\}$

- $P_1, P_2 \rightarrow \text{CAPITAL}$

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[17]Given our semantic treatment of knowledge ascription, the two specificational readings turn out to be truth-conditionally equivalent. However, a more sophisticated treatment of knowledge ascription should be able to tease these two readings apart. To see this, suppose that neither John nor Fred is able to specify the capital of any country other than France. Additionally, Fred knows that Italy is the only country in the world whose capital starts with an 'R' and ends with an 'e'. John doesn't know this. Then, intuitively, John knows every capital that Fred knows in the [countries given, capitals asked] scenario, but not in the [capitals given, countries asked] scenario, since Fred can tell us which country Rome is the capital of, while John can't.

First specificational A reading: [capitals given, countries asked]

- $x \to \{$Rome, Berlin, Paris, ... $\}$

- $z_1, z_2 \to \{$the capital of Italy, the capital of Germany, ... $\}$

- $P_1 \to \lambda y.\ y = z_1$

- $P_2 \to \lambda y.\ y = z_2$

Second specificational A reading: [countries given, capitals asked]

- $x \to \{$the capital of Italy, the capital of Germany, ... $\}$

- $z_1, z_2 \to \{$Rome, Berlin, Paris, ... $\}$

- $P_1 \to \lambda y.\ y = z_1$

- $P_2 \to \lambda y.\ y = z_2$

Notice that for the predicational reading, P_1 and P_2 are both resolved to the property expressed by the CQ noun phrase, while for the two specificational readings P_1 and P_2 are both resolved to the identity property, and z_1 and z_2 are taken to range over the same cover. This 'parallelism effect' is expected since (54) is interpreted here as a contrastive statement (the parallelism effect of contrast on resolution is familiar from the literature on ellipsis, cf. Rooth, 1992; Heim, 1997; Fox, 1999; Roelofsen, 2008).

Now let us consider the B-type readings, which report John's knowledge *about* Fred's knowledge. Again, three readings quite naturally arise.

First, consider a context in which Fred is given a list of cities, and is asked which of these cities are capitals. John is asked to predict how Fred will respond. In this context, (54) can be taken to mean that for every capital x such that Fred knows that x is a capital, John knows that Fred knows that x is a capital (a predicational reading).

Second, consider a context in which Fred is given a list of capitals, and is asked to specify which countries these are the capitals of. Again, John is asked to predict how Fred will respond. In this context, (54) can be taken to mean that for every capital x such that Fred can specify the country that x is the capital of, John knows that x is a capital such that Fred can specify the country that x is the capital of. We will call this a 'mixed' reading because

it reports that John has 'predicational knowledge' about a range of concepts that are characterized in terms of Fred's 'specificational knowledge'.

Finally, consider a context in which Fred is given a list of countries, and is asked to specify the capitals of these countries. Again, John is asked to predict how Fred will respond. In this context, (54) can be taken to mean that for every country y such that Fred can specify y's capital, John knows that y is a country such that Fred can specify its capital (another mixed reading). These readings correspond to the following resolutions:

Predicational B reading:

- $x \rightarrow \{$Rome, Berlin, Paris, ...$\}$

- $P_1 \rightarrow$ CAPITAL

- $P_2 \rightarrow \lambda x.\text{CAPITAL}(x) \wedge K_f(?z_1. P_1(x))$

First mixed B reading: [capitals given, countries asked]

- $x \rightarrow \{$Rome, Berlin, Paris, ...$\}$

- $z_1 \rightarrow \{$the capital of Italy, the capital of France, ...$\}$

- $P_1 \rightarrow \lambda y.\ y = z_1$ (specificational)

- $P_2 \rightarrow \lambda x.\text{CAPITAL}(x) \wedge K_f(?z_1. P_1(x))$ (predicational)

Second mixed B reading: [countries given, capitals asked]

- $x \rightarrow \{$the capital of Italy, the capital of France, ...$\}$

- $z_1 \rightarrow \{$Rome, Berlin, Paris, ...$\}$

- $P_1 \rightarrow \lambda y.\ y = z_1$ (specificational)

- $P_2 \rightarrow \lambda x.\text{CAPITAL}(x) \wedge K_f(?z_1. P_1(x))$ (predicational)

There are two things to note here. First, the fact that mixed readings arise in this case is no surprise. As alluded to above, the absence of mixed A readings is due to the fact that A readings are *contrastive* in nature. B readings are

not contrastive, so mixed readings are in principle just as likely to arise here as purely specificational and purely predicational readings.

Second, notice that all the described B readings involve resolution of P_2 to the property $\lambda x.\text{CAPITAL}(x) \wedge K_f(?z_1.\ P_1(x))$. This is not accidental: it reflects the fact that these readings all concern John's knowledge *about* Fred's knowledge. This also explains why we do not get even *more* B readings: once the resolution of P_2 is fixed, the only freedom that remains is in resolving P_1 and the cover indices. If P_1 is resolved to CAPITAL, then any default cover resolution either yields the predicational B reading described above ($x \rightarrow$ naming), or a trivial meaning ($x \rightarrow$ capitals). If P_1 is resolved to the identity property, then any default cover resolution either yields one of the mixed B readings described above, or again a trivial meaning. Assuming that trivial meanings are generally avoided, it is predicted that, as long as we confine ourselves to default resolutions, the three B readings described above are the only ones that arise.

Thus, the complete range of CCQ readings is accounted for in a straightforward and perspicuous way, and as long as we stick to default resolutions the proposed theory does not overgenerate.

4.3   Further widening the empirical domain

Now let us turn to some further challenging cases. In particular, we will consider *Greenberg's observation*, which was already mentioned in section 3.7, and several related facts. Some of these will speak in favor of the proposed account, but others will reveal an issue of potential overgeneration. This will lead us to a more in-depth analysis of the constraints that play a role in the pragmatic resolution process.

Greenberg's observation.   Recall Greenberg's (1977) observation:[18]

(56)   John found out the murderer of Smith.

(57)   John found out who the murderer of Smith was.

Sentence (56) contains a concealed question, whereas (57) contains a full interrogative clause. Greenberg observed that there is a subtle difference in

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[18]As mentioned before, most English speakers tend to dislike CQs with *find out*, but the contrast can be reproduced by replacing *find out* with *discovered* (Frana, 2010).

meaning between the two: (56) necessarily entails that John solved the question of who murdered Smith (direct reading); (57) does not necessarily have this entailment—it may be used to report, for example, that John found out that his gardener was a much sought-after criminal known as *The Strangler* even if John did not find out that the guy actually murdered Smith (indirect reading). This observation has given rise to the generalization, which we will refer to as *Greenberg's generalization*, that CQs only allow for direct readings, while *wh*-complements allow both for direct and for indirect readings. We will show, however, that several exceptions to this generalization can be found.

First exception: Arequipa. Tomas is confronted with the following list of South American cities:

(58)   Caracas, Montevideo, Lima, Porto Alegre, Quito, Arequipa.

He is challenged to say which of these cities are capitals and which are not. His wife Tereza reports:

(59)   He only knew the city we visited on our honeymoon last year.

On its most natural reading, this sentence conveys that Tomas only knew of the city that he and Tereza visited on their honeymoon last year, say Arequipa, whether or not it was a capital city.[19] Crucially, Tereza does not report that Tomas only knew that Arequipa was the city that they visited on their honeymoon last year.[20]

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[19]Besides the described CQ reading, this sentence also has an acquaintance reading. An anonymous reviewer suggested that this acquaintance reading may in fact be the only reading available for (59). However, in languages like Italian and Dutch, where epistemic *know* and acquaintance *know* are lexically distinct, direct translations of (59) with the epistemic verbs *sapere* and *weten*, given below, clearly exhibit the relevant CQ reading.

(i)   a.   Ha saputo solo la città che abbiamo visitato l'anno scorso in viaggio di nozze.
       b.   Hij wist alleen de stad die wij vorig jaar op onze huwelijksreis bezocht hebben.

[20]This example also shows that $P(\alpha)$ should be within the scope of the question operator (*contra* Heim (1979) and Frana (2006)): Tereza reports that Tomas knew *whether* the city they visited on their honeymoon was a capital, not necessarily *that* it was a capital.

Second exception: the Obamas. Michelle Obama tells her daughters, Malia Ann and Sasha:

(60)   Today I went to visit a primary school in the neighborhood. At some point one of the children—I think his name was Billy—was asked to name the presidents of some American countries. But, poor kid, he only knew your father.

On its most natural reading, the underlined sentence says that Billy only knew that Barack Obama was the president of the United States. Crucially it does not entail that he knew that Barack Obama was Malia Ann's and Sasha's father.

Last exception. We have already seen another phenomenon which is in conflict with Greenberg's generalization: A-type readings of CCQs. Consider our initial example of a definite CCQ:

(61)   John knows the capital that Fred knows.

Taking Greenberg's generalization at face value, we should expect that the sentence entails that John knows of the capital that Fred knows that it is the capital that Fred knows. But we have already seen that this is not necessarily so. A-type readings of (61) say that John and Fred know the same capital, but do not necessarily entail that John knows anything about Fred.

These exceptions are hard, if not impossible, to explain on a *structural* account of Greenberg's generalization (e.g., Frana, 2006). The theory proposed here is flexible enough to deal with them. However, pragmatic accounts always run the risk of overgeneration. Greenberg's original observation, as well as the following example—due to Maribel Romero—clearly show that the pragmatic resolution process must be carefully constrained.

Romero's observation. Lucia just learned her first capital in Kindergarten: she learned that the capital of France is Paris. When her mother picks her up and hears the news from the care-takers, she decides to play a guessing game on her husband Ben in the evening: he will have to find out which capital Lucia learned that day. But incidentally Ben talks to one of the Kindergarten care-takers on the phone later that day and also hears the news. This means that Lucia's mother won't be able to play her guessing

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game anymore, because:

(62)   a.   Ben (already) knows the capital that Lucia knows.
        b. #Lucia knows the capital that Ben (already) knows.

Sentence (62b) does not convey the intended message in this situation. On our account, however, it is represented as in (63), and it is not hard to find a possible resolution such that (63) indeed entails that 'Ben already knows the capital that Lucia knows'.

(63) $\exists x_1.(x_1 = \iota x_2.(\text{CAPITAL}(x_2) \wedge K_b(?z_1.\ P_1(x_2))) \wedge K_l(?z_2.\ P_2(x_1)))$

Problematic resolution:

- $x_1, x_2 \rightarrow \{\text{the capital of Italy, the capital of France, } \dots\}$

- $z_2 \rightarrow \{\text{Rome, Berlin, Paris, } \dots\}$

- $P_1 \rightarrow \lambda y.\text{CAPITAL}(y) \wedge K_l(?z_2.\ P_2(y))$

- $P_2 \rightarrow \lambda y.\ y = z_2$

So, on the one hand, we need a flexible, context-sensitive account to deal with the 'exceptional' cases mentioned above, but on the other hand, the resolution process needs to be suitably constrained. The following section discusses some factors that we take to play a crucial role in this process.

4.4   Constraints on resolution

On the proposed account, the interpretation of a concealed question involves a type shift $\uparrow_{(z,P)}$, where P and the domain that z ranges over are contextually determined. As mentioned earlier, we assume that there are certain default choices for P and the domain that z ranges over. In particular, we assume that P is by default resolved to the property of being identical to z or to the property expressed by the CQ noun phrase, and that z by default ranges over the naming cover, the rigid cover (if the individuals in the relevant domain can be identified by ostension), or a derived cover based on a functional CQ noun (if such a cover is salient in the given context). But when exactly does an interpreter deviate from these default resolutions?

Our proposal is that deviation from the default properties/covers is possible, but costly, and only justified if it is needed in order to comply with

Gricean principles of conversation. More precisely, following Aloni (2001), we assume that resolution to a non-default salient property/cover is licensed only if it is needed in order to avoid trivial, contradictory or irrelevant meanings, and only if the obtained interpretation could not have been expressed by a more perspicuous/effective form. In sum:

Default resolutions for P and the domain of z:

- P is by default resolved to:

    - the property of being identical to z;
    - the property expressed by the CQ noun phrase.

- z is by default taken to range over:

    - the naming cover;
    - the rigid cover (if the individuals in the relevant domain can be identified by ostension);
    - a derived cover based on a functional CQ noun (if salient).

Deviation from default resolutions is licensed:

- only if necessary to avoid contradictory/trivial/irrelevant meanings

    [*quality, quantity, relevance*]

- and only if the meaning obtained by shifting to a non-default resolution could not have been expressed by a more perspicuous/effective form.

    [*manner* as **blocking**]

Below we will illustrate how these principles account for Greenberg's and Romero's observations, as well as the other cases discussed in section 4.3.

Greenberg's concealed question example. Greenberg's CQ example, repeated in (64), has two possible representations, given in (64a) and (64b):

(64)   John found out the murderer of Smith.
        a. $F_j(\uparrow_{(z,P)} \iota x.\text{MURDERER-OF-SMITH}(x)))$
        b. $\exists y.(y = \iota x.\text{MURDERER-OF-SMITH}(x) \wedge F_j(\uparrow_{(z,P)} y)$

In a neutral context, the possible resolutions for y, z and P are the following:

(65)   a.   *Covers:* naming
        b.   *Properties:* identity, MURDERER-OF-SMITH

Consider first the *de dicto* representation in (64a). In a neutral context, the predicted resolution for P is the identity property—the other salient property, MURDERER-OF-SMITH, yields a trivial meaning. The only possible cover for z is the naming cover—there are no other salient covers. This gives us a 'direct reading' of (64), which entails that John solved the question of who murdered Smith.

Now consider the *de re* representation in (64b). In this case, the predicted resolution for P is the property MURDERER-OF-SMITH rather than the identity property, which would yield a trivial meaning. The variable y must range over the naming cover, the only salient cover. This, again, gives us a direct reading of (64), entailing that John solved the question of who murdered Smith.

Hence, in a neutral context the resolution process is constrained in such a way that (64) can only be assigned a direct reading, in agreement with Greenberg's observation.

Summary of predicted resolutions:

- For (64a): $P \to$ Id & $z \to$ naming $[P \to$ MURD-OF-S $\Rightarrow$ trivial$]$

  'John learned to identify the murderer of Smith by name'

- For (64b): $P \to$ MURD-OF-S & $y, z \to$ naming $[P \to$ Id $\Rightarrow$ trivial$]$

  'Of the name of the murderer of Smith John found out whether it was the name of the murderer of Smith'

Greenberg's non-concealed question example.   Consider now the non-concealed question example from Greenberg, repeated in (66), and its two possible representations:

(66)   John found out who the murderer of Smith was.
        a. $F_j(?z.\ z = \iota x.\text{MURDERER-OF-SMITH}(x))$
        b. $\exists y.(y = \iota x.\text{MURDERER-OF-SMITH}(x) \land F_j(?z.\ z = y))$

Consider first the *de dicto* representation in (66a). In a neutral context, the only possible cover for z is the naming cover—as in the case of (64a). This gives us again a 'direct reading', which entails that John solved the question of who murdered Smith.

Now consider the *de re* representation in (66b). This case is crucially different from that of (64b). There we predicted a predicational reading which here, given the different logical form of the sentence, is not possible. The only way to avoid a trivial meaning for the embedded identity question in (66b) is to assign two different covers to y and z. These could be naming and the derived murderers cover (if salient) or, for example, naming and a cover like $A = \{$the much sought-after criminal known as *The Strangler*, the new criminal on the block, ... $\}$ (if salient). In the latter case we would obtain an indirect reading.

Crucially, even in a context where cover A is salient, the *de re* representation of Greenberg's CQ example, (64b), does not yield an indirect reading. This is because, in the case of (64b), a direct reading is obtained by means of a default resolution ($P \rightarrow$ MURDERER-OF-SMITH $\& \, z \rightarrow$ naming). Since this reading is consistent and non-trivial, a non-default resolution is not licensed. By contrast, the *de re* representation of Greenberg's non-concealed question example, (66b), yields a trivial meaning unless we allow for a non-default resolution. This licenses resolution to a non-default cover like A, which gives rise to an indirect reading.

Summary of predicted resolutions:

- For (66a): default resolution: $z \rightarrow$ naming

  'John learned to identify the murderer of Smith by name'

- For (66b): non-default resolution: $z \rightarrow$ naming $\& \, y \rightarrow A$, if A salient

  'John learned to identify by name the much sought-after criminal known as *The Strangler*, who in fact (but possibly to John's ignorance) murdered Smith'

Arequipa. Now consider the first exception to Greenberg's generalization, and its possible representations:

(67)   Tomas only knew the city we visited on our honeymoon.

     a. $K_t(\uparrow_{(z,P)} \iota x.\text{CITY-VISITED-ON-HONEYMOON}(x)))$

     b. $\exists y.(y = \iota x.\text{CITY-VISITED-ON-HONEYMOON}(x) \wedge K_t(\uparrow_{(z,P)} y)$

In the described context Tomas has to say which of the cities in a list are capitals and which are not. It is natural to assume that the following covers and properties are available in this context. We underline the values that would involve non-default resolution, in this case the property CAPITAL.

(68)   a.   *Covers:* naming

     b.   *Properties:* identity, CITY-VISITED-ON-HONEYMOON, <u>CAPITAL</u>

No matter whether we assume the *de re* or the *de dicto* representation of (67), the only resolution of P that yields a relevant meaning in this context is the non-default resolution to the property CAPITAL. Given this resolution the sentence could be interpreted as: 'Tomas only knew whether the city that he and Tereza visited on their honeymoon was a capital city or not' (*de dicto*), or 'Tomas only knew of the city that he and Tereza visited on their honeymoon whether or not it was a capital city' (*de re*). Before accepting a non-default resolution, however, we have to check whether there is a more perspicuous way to express the obtained meanings in the given context. This is not the case here. Therefore, the non-default resolution is licensed.[21]

Summary of predicted resolutions:

- For (67a): $P \rightarrow$ <u>CAPITAL</u>   [others trivial/irrelevant]

  'Tomas only knew whether the city that he and Tereza visited on their honeymoon was a capital city or not'

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[21]Intuitively, the presence of *only* in example (67) makes it particularly easy to establish a non-default resolution. This may be explained by the fact that, in the presence of *only*, default resolution of P to CITY-VISITED-ON-HONEYMOON yields the following meaning: 'only of the city visited on their honeymoon, Tomas knew that it was the city visited on their honeymoon'. This is not merely an irrelevant meaning, but moreover a meaning to which *only* does not make any essential contribution. For, if there is only one city visited by Tomas and Teresa on their honeymoon, of what other city could Tomas possibly know that it is the city that he and Teresa visited on their honeymoon? Plausibly, this is why the presence of *only* in (67) makes it particularly clear that a non-default resolution of P is intended.

- For (67b): $P \rightarrow$ CAPITAL & $y \rightarrow$ naming [others trivial/irrelevant]

  'Tomas only knew of the city that he and Tereza visited on their honeymoon whether or not it was a capital city'

- Blocking check: Is there another more effective way to express these meanings in the given context? No.

The Obamas. Consider the relevant sentence and its possible analyses:

(69)   Billy (only) knew your father.
   a. $K_b(\uparrow_{(z,P)} \iota x.\text{YOUR-FATHER}(x))$
   b. $\exists y.(y = \iota x.\text{YOUR-FATHER}(x) \wedge K_b(\uparrow_{(z,P)} y))$

In the described context there are two salient covers, the naming cover and the derived *presidents* cover: {the president of the United States, the president of Mexico, the president of Venezuela, ... }. Resolution to the latter cover would be exceptional, since the functional noun 'president' is not contained in the CQ. The available options for P on the other hand, are the identity property and the property expressed by the CQ noun phrase.

(70)   a.   *Covers:* naming, presidents
        b.   *Properties:* identity, YOUR-FATHER

Assuming the *de dicto* representation, (69a), any possible resolution yields a trivial meaning ($P \rightarrow$ YOUR-FATHER) or an irrelevant meaning ($P \rightarrow$ ID). As for the *de re* representation, the only resolution that provides a relevant meaning is the one that maps P to the identity property, y to the derived presidents cover, and z to the naming cover. This is a non-default resolution, so we need to check for the availability of a strictly more efficient way to express the obtained meaning in the given context. A natural candidate is the sentence 'Billy only knew the president of the US' which would convey the same meaning without the need for non-default resolution. However, for independent reasons, it is strongly dispreferred for Michelle Obama to refer to her husband as 'the president of the US' when talking to her daughters. 'Your father' is the preferred referential expression in this context (cf. Gundel *et al.*, 1993; Aloni, 2001). Therefore, the non-default resolution is licensed in this case.

Summary of predicted resolutions:

- For (69a): either trivial $[P \to \text{YOUR-FATHER}]$ or irrelevant $[P \to \text{ID}]$

- For (69b):
  $P \to \text{identity}$
  $z \to \text{naming}$
  $y \to \underline{\text{presidents}}$ [others trivial/irrelevant]

  'Billy could only identify the president of the US by name'

- Blocking check: Is there another more perspicuous way to express this meaning in the given context? No (since, for independent reasons, it is strongly dispreferred for Michelle Obama to refer to her husband as 'the president of the US' when talking to her daughters).

Notice that this example differs from the Arequipa example in that it involves non-default *cover resolution* rather than non-default resolution of P.

Finally, we turn to Romero's example, which is a case where non-default resolution is *blocked* by an alternative, more efficient form.

Romero. Consider Romero's example and its two possible representations:

(71) Lucia knows the capital that Ben (already) knows.
  - a. $K_l(\uparrow_{(z_1, P_1)} \iota x.(\text{CAPITAL}(x) \wedge K_b(\uparrow_{(z_2, P_2)} x)))$
  - b. $\exists y (y = \iota x.(\text{CAPITAL}(x) \wedge K_b(\uparrow_{(z_1, P_1)} x)) \wedge K_l(\uparrow_{(z_2, P_2)} y))$

The available covers and properties in the given context are:

(72)   a.   *Covers:* naming, capitals
       b.   *Properties:* identity, CAPITAL-B-KNOWS, <u>CAPITAL-L-KNOWS</u>

As in the previous example, the *de dicto* representation does not yield any relevant interpretation. As for the *de re* representation, the only resolution leading to a relevant meaning is the resolution mapping y to the derived capital cover, P_1 to CAPITAL-LUCIA-KNOWS, P_2 to the identity property, and z_2 to the naming cover. Given this resolution, the sentence conveys that Ben already knows the capital that Lucia knows. However, this interpretation involves non-default resolution, so we need to check whether it is blocked. And in this case there is indeed a more perspicuous way to express the relevant meaning, namely the sentence: 'Ben already knows the capital that

Lucia knows'. Therefore, the non-default resolution is discarded and the interpretation procedure fails to derive a relevant meaning.

Summary of predicted resolutions:

- For (71a): all either trivial or irrelevant

- For (71b):
  $P_1 \rightarrow$ CAPITAL-THAT-LUCIA-KNOWS
  $P_2 \rightarrow$ identity
  $y \rightarrow$ capitals
  $z_2 \rightarrow$ naming   [others trivial/irrelevant]

  'Ben (already) knows the capital that Lucia knows'

- Blocking check: Is there another more effective way to express this meaning in the given context? **Yes.**
  $\Rightarrow$ the interpretation process fails to derive a relevant meaning

Thus, the proposed constraints on resolution, which were motivated by ideas familiar from Gricean pragmatics, account for Greenberg's and Romero's observations, while preserving enough flexibility to deal with the Arequipa example and the Obama case.

5   Remarks on the distribution of CQs

We will end the paper with some remarks on the distribution of CQs. We mentioned in the introduction that one of the challenges in this domain is to characterize the range of verbs that select for CQ complements, as compared to the range of verbs that select for *wh-* and/or *that*-complements. It turns out that this task is far from straightforward. A representative sample of the relevant data, mostly drawn from Baker (1968), Grimshaw (1979), and Nathan (2006), is given in table 1.[22]

One generalization that emerges from this table is that any verb that selects for CQs also selects for *wh*-complements (Baker's 1968 generalization).

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[22]One verb that we intentionally did not include in the table is *ask*. At first sight, it seems that *ask* selects for CQ-complements (e.g., *Alex asked me the price of milk*). However, Nathan (2006, pp.140–145) argues that such examples are deceptive and that *ask* does in fact not select for CQ-complements. This claim has remained controversial, but we will not address this issue here.

	that-complement	*wh*-complement	CQ-complement
hope believe suspect	✓	∗	∗
agree inform be certain	✓	✓	∗
know remember forget	✓	✓	✓
be related to depend on	∗	✓	✓
wonder inquire	∗	✓	∗

Table 1: A representative sample of the data concerning selection.

Otherwise, however, there are no clear correlations between the verbs that select for CQs and the verbs that select for *wh*- and/or *that*-complements.

Below we will outline a semantic account of Baker's generalization and of the differences in distribution between CQ-, *wh*-, and *that*-complements. We should emphasize up front that this account will rely on certain stipulations that stand in need of further explanation. Our main point here is just to show that a semantic account of the relevant data can in principle be given.

The account to be developed below has three components. First, we will make certain assumptions about the semantic characteristics of CQs, *wh*-complements, and *that*-complements. Second, we will adopt a type-shifting operator, ANS, which maps the denotation of a *wh*-complement in a particular world to the true exhaustive answer to the question expressed by that *wh*-complement in the given world. And finally, we will specify certain selectional criteria for the verbs appearing in table 1.

Semantic characteristics of CQ-, *wh*- and *that*-complements. We have been assuming that CQs denote propositions. But this is not the only

semantic feature of CQs that may be relevant for selection. Another potentially relevant semantic feature of CQs is that they typically denote different propositions in different worlds. That is, the denotation of CQs is *world-dependent*. CQs crucially differ in this respect from *that*-complements. That is, *that*-complements denote propositions as well, but their denotation is the same in every world. Thus, the denotation of *that*-complements is *world-independent*. Finally, we will assume that *wh*-complements denote propositional concepts rather than propositions. More specifically, we will assume that *wh*-complements denote functions from possible worlds to true exhaustive answers, or equivalently partitions of the logical space in the sense of Groenendijk and Stokhof (1984). Recall, though, that Groenendijk and Stokhof originally assumed that the *intension* of a *wh*-complement is a propositional concept (or equivalently a set of propositions partitioning logical space), while the *extension* (i.e., the denotation) of a *wh*-complement in a particular world is a proposition. Here, a *wh*-complement is taken to *denote* a propositional concept, namely the propositional concept that Groenendijk and Stokhof take to be its intension.[23] This means that the denotation of a *wh*-complement is *world-independent*.[24] Our assumptions are summarized in table 2.

	Denotation	World-dependency
CQ-complement	proposition	+
that-complement	proposition	−
wh-complement	propositional concept	−

Table 2: Semantic characteristics of CQ-, *wh*- and *that*-complements.

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[23]One way of implementing this would be to represent a *wh*-complement like *who has the property P* as $^\wedge?x.P(x)$, using the $^\wedge$ operator from Montague grammar.

[24]Alternatively, we could follow Karttunen (1977a) in assuming that the denotation of an interrogative clause in a given world is the set of propositions that correspond to the most basic *true* answers to that interrogative clause in that world. In this case, the denotation of an interrogative clause would be world-dependent. Or we could follow Hamblin (1973) in assuming that the denotation of an interrogative clause in a given world is the set of propositions that simply correspond to the most basic answers (not necessarily *true* answers) to the given interrogative clause. In this case, the denotation of an interrogative clause would again be world-independent. If we were to adopt Hamblin's or Karttunen's analysis of interrogative clauses, we would have to adapt the definition of the ANS operator given in (75) below, and the selectional criteria of *agree*-type and *wonder*-type verbs.

The ANS operator.   We are assuming that *wh*-complements differ in semantic type from *that*- and CQ-complements. However, as mentioned in section 2, *wh*-complements can be coordinated with *that*-complements and with CQ-complements; the relevant examples are repeated below.

(73)   Julia remembers what Ben ate and that he didn't like it.

(74)   I only knew the capital of Italy and who won the Worldcup in 1986.

To derive the meaning of such sentences we will assume, following Heim (1994) and others, an operator ANS which applies to an interrogative clause and delivers the true exhaustive answer to that interrogative clause in the world of evaluation. The operator is defined as follows.

(75)   For any expression φ of type $s(st)$: $[\![\text{ANS } \varphi]\!]^{M,w,g_{\mathcal{R}}} = [\![\varphi]\!]^{M,w,g_{\mathcal{R}}}(w)$

$[\![\text{ANS } \varphi]\!]^{M,w,g_{\mathcal{R}}}$ is a proposition that embodies the true exhaustive answer in w to the question that φ expresses. Notice that $[\![\text{ANS } \varphi]\!]^{M,w,g_{\mathcal{R}}}$ typically differs from world to world. This means that the denotation of ANS φ is world-dependent.

The ANS operator allows us to account for the coordination facts mentioned above. Moreover, it also allows us to assume a single lexical entry for verbs that select for both *that*-complements and *wh*-complements. For instance, to deal with sentences like (76) and (77), we just need to assume a single lexical entry for *tell*:

(76)   Max told us who called.

(77)   Max told us that Bill called.

Without the ANS operator, we would have to assume two lexical entries for *tell*, one that takes *that*-complements and one that takes *wh*-complements.

Selectional criteria for embedding verbs.   The selectional criteria that we assume for the verbs in table 1 are specified in table 3 below.

Illustration of predictions.   Under the given assumptions, the observed distributional patterns are suitably accounted for. To see this, let us consider one verb from each of the five rows in table 1. First consider the verb *believe*, from the first row, which only selects for *that*-complements:

Verb	Selects for complements that denote
hope believe suspect	a world-independent proposition
agree inform be certain	a world-independent (proposition or propositional concept)
know remember forget	a proposition
be related to depend on	a world-dependent proposition
wonder inquire	a propositional concept

Table 3: Selectional criteria for the verbs in table 1.

(78)   Alex believes that he paid / *who paid / *the price of milk.

We are assuming that *believe* selects for complements that denote a world-independent proposition. This criterion is indeed satisfied by *that*-complements, but not by CQ- or *wh*-complements, even after application of ANS.

Next consider the verb *agree*, which selects for *that*- and *wh*-complements, but not for CQ-complements:

(79)   They agreed that he would pay / who would pay / *the price of milk.

We are assuming that *agree* selects for complements that denote a world-independent proposition or propositional concept. This criterion is satisfied by *that*-complements and by *wh*-complements (without application of ANS), but not by CQ-complements.

Next consider *remember*, which selects for all three types of complements:

(80)   Alex remembered that he paid / who paid / the price of milk.

We are assuming that *remember* selects for complements that denote a proposition, world-dependent or -independent, and this criterion is indeed satisfied by all three types of complements. In the case of a *wh*-complement, application of ANS is necessary before the complement combines with the verb.

Now consider *depend on*, which selects for *wh*- and CQ-complements:

(81)   Alex's mood depends on *that he paid / who paid / the price of milk.

We are assuming that *depend on* selects for complements that denote a world-dependent proposition, and this criterion is indeed satisfied by CQ- and *wh*-complements, after application of ANS, but not by *that*-complements.

Finally, consider the verb *wonder*, which only selects for *wh*-complements:

(82)   Alex is wondering *that he paid / who paid / *the price of milk.

We are assuming that *wonder* selects for complements that denote a propositional concept. This criterion is satisfied by *wh*-complements, without application of ANS, but not by *that*- or CQ-complements. Thus, all the relevant data are accounted for.

6   Conclusion

We have proposed an account of concealed questions whose central assumption is that an entity-denoting expression α may be type-shifted into an expression $?z.P(\alpha)$, where P is a contextually determined property, and z ranges over a contextually determined conceptual cover. Thus, depending on the resolution of P and the domain of z, a concealed question either denotes the true exhaustive answer to the identity question *which z is α*, or to the polar question *whether α has the property P*.

As a final remark, we would like to point out that the account presented here is related to the theory of anaphora proposed in Roelofsen (2008). One of the basic claims of that theory is that the interpretation of NP and VP anaphora, just like that of concealed questions, crucially involves the contextual resolution of a property P. Moreover, P is by default resolved to the property expressed by some overt NP or VP in the surrounding discourse, or to the property of being identical to some bound variable. This is in exact analogy with the default resolution of P in the interpretation of concealed questions.

7 Appendix: two open issues

Derived covers. An anonymous reviewer pointed out a problem arising for *de dicto* representations of definite CCQs, exemplified in (83).

(83) a. John knows the price that Fred knows.
      b. $K_j(\uparrow_{(z_1, P_1)} \iota x.(\text{PRICE}(x) \wedge K_f(\uparrow_{(z_2, P_2)} x)))$

Consider the following resolution:

- $x, z_1 \to \{\text{price of milk, price of wine, price of butter, } \ldots \}$

- $z_2 \to \{\text{\euro}1, \text{\euro}2, \text{\euro}3, \ldots \}$

- $P_1 \to \lambda y.\ y = z_1$

- $P_2 \to \lambda y.\ y = z_2$

Under this resolution, the truth-conditions for (83b) are too weak: (83a) is predicted to be true in certain scenarios where it is intuitively false. To see this, consider the two scenarios in (84). While sentence (82a) is intuitively false in scenario A, but true in scenario B, (82b) fails to distinguish between the two scenarios and predicts the sentence to be true in both cases.

(84) **Scenario A**: Milk and butter both cost €2, and nothing else costs €2. John does not know how much milk or butter costs, but he knows that they cost the same. Fred knows that the price of milk is €2, but he does not know what the price of butter is. John is aware that the price that Fred knows the euro-value of is either the price of milk, or the price of butter, but John cannot determine which one of those two it is.

Scenario B: Just like scenario A, but now John knows that Fred knows the price of milk.

As a formal representation of the two scenarios, consider a model consisting of the following four worlds:

	milk	butter
w_0	2	2
w_1	1	1
w_2	1	2
w_3	2	1

and assume the following specifications for John's and Fred's epistemic states:

(85) **Scenario A**:

    a. $E(j, w_0) = \{w_0, w_1\}$ (in w_0 John doesn't know the price of milk or butter, but he knows that they are the same)

    b. $E(f, w_0) = \{w_0, w_2\}$ (in w_0 Fred knows the price of butter)

    c. $E(f, w_1) = \{w_1, w_2\}$ (in w_1 Fred knows the price of milk)

(86) **Scenario B**:

    a. $E(j, w_0) = \{w_0, w_1\}$ (as above)

    b. $E(f, w_0) = \{w_0, w_3\}$ (in w_0 Fred knows the price of milk)

    c. $E(f, w_1) = \{w_1, w_2\}$ (as above)

It is easy to see that (83b) is predicted to be true in w_0 in both scenarios. In particular, the analysis wrongly predicts that in scenario A, John knows in w_0 which price Fred knows. The problem is that, even though intuitively in the two epistemic alternatives for John in w_0, namely w_0 and w_1, Fred knows different prices (the price of butter in w_0 and the price of milk in w_1), these two concepts (the price of butter and the price of milk) have exactly the same values in both alternatives in John's epistemic state (he believes that they are extensionally equivalent), and therefore they count as one; so John knows of that one concept, which is an element of the price cover, that Fred knows its euro-value.

The source of the problem seems to be that our system allows for *derived covers*, which typically contain overlapping individual concepts like 'the price of butter' and 'the price of milk' (these concepts are *overlapping* in the sense that in some worlds they have exactly the same value). In certain epistemic states such concepts will be indistinguishable, because they have the same value in all relevant worlds.

One way to avoid this problem would be to construe a derived cover not just as a set of individual concepts, but rather as a more structured object, for instance a pair consisting of a basic cover and an intensional function that maps, say, every object in every world to the price of that object in that world, if any. This way, the elements of a derived cover will always be clearly distinguishable: even though their values may overlap in certain worlds, we would always be able to detect that these values were obtained in different ways (e.g., by applying the *price*-function to butter, or by applying

the *price*-function to milk). However, a full implementation of this solution must be left for another occasion.

It is also worth remarking that the spurious reading discussed here arises from a *de dicto* treatment of CCQ noun phrases, and that, in the analysis presented in this paper, *de dicto* representations are not really necessary to obtain any of the observed readings. In particular, they are not really needed to obtain B-readings of CCQs.

Below is a *de re* representation of the B reading of our sentence, together with a resolution of the relevant covers and properties, which yields the right predictions for both scenarios (because now we can no longer ignore the values of the relevant concepts in worlds outside of John's epistemic state):

(87)   a.   John knows the price that Fred knows.

        b. $\exists y.(y = \iota x.(\text{PRICE}(x) \wedge K_f(\uparrow_{(z_1, P_1)} x)) \wedge K_j(\uparrow_{(z_2, P_2)} y))$

(88)   Resolution

        a. $x, y \rightarrow \{$price of milk, price of wine, price of butter, $\dots\}$

        b. $z_1 \rightarrow \{$€1, €2, €3, $\dots\}$

        c. $P_1 \rightarrow \lambda y.\ y = z_1$

        d. $P_2 \rightarrow \lambda x.[\text{PRICE}(x) \wedge K_f(?z_1.\ P_1(x))]$

Thus, another way to avoid the spurious reading discussed above would be to ban *de dicto* representations altogether. But can this be justified in the grammar? Is there a principled way to prevent CQ noun phrases from being interpreted *in situ*? Again, we must leave these questions for another occasion.

Non-factive verbs.   Another potential issue for our analysis, also pointed out by an anonymous reviewer, concerns predicational readings of quantified CQs under non-factive verbs like *agree on*. For example, according to the reviewer, a sentence like (89) would be true on its predicational reading in a scenario like (90), while on our analysis it would come out false, because quantified CQs need to scope out of the verb, and (89) would therefore be analyzed as 'for most actual phone numbers, John and Mary agree on whether they are phone numbers', which is false in the given scenario.

(89)   John and Mary agree on most phone numbers.

(90)   Scenario:

    a.   Salient list of potential phone numbers:
        101, 102, 103, 104, 105

    b.   Actual phone numbers:
        101, 102, 103

    c.   Numbers that John believes to be phone numbers:
        101, 103, 104, 105

    d.   Numbers that Mary believes to be phone numbers:
        102, 103, 104, 105

Intuitions on this example are far from clear. Does the CQ in (89) really quantify over salient numbers (as assumed by the reviewer) rather than actual phone numbers (as predicted by our analysis)? Consider the following case. Two lunatics, John and Mary, believe that some of their friends, namely Sue, Bill and Fred, are werewolves, and that there are no other werewolves. It seems appropriate to describe this situation with (91a), but not with (91b).

(91)   a.   John and Mary agree on which of their friends are werewolves.
       b.   John and Mary agree on every werewolf.

One potential reason for the awkwardness of (91b) is that the quantified CQ in this sentence quantifies over *actual* werewolves (as predicted by our analysis), and therefore violates a principle against vacuous quantification. However, further investigation of this issue must be left for another occassion.

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