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Why relational nominals make good concealed questions

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Abstract

Concealed questions are determiner phrases that are interpreted as if they were questions. For instance, *I found out Bill's age* can be paraphrased as *I found out what Bill's age is*.

It has long been observed by Löbner and others that DPs headed by inherently relational nouns such as *age* make excellent concealed questions, but simple DPs headed by sortal nouns such as *brick* do not: it is difficult or impossible to interpret ??*I found out the brick* as meaning anything, let alone as containing a concealed question.

I argue that this systematic restriction on concealed questions follows from the nature of questions in natural language. Questions generally contain two parts: a foreground, which identifies a set of alternatives, and a background, which distinguishes among those alternatives. For instance, the question *Who left?* identifies a set of relevant people (the foreground) and asks which of those objects have the property of leaving (the background).

My main claim is that in order to qualify as a concealed question, a DP must provide both a foreground and a background. For a DP headed by a relational noun, such as *Bill's age*, this is natural: the set of ages serves as the alternatives (the foreground), and the property of standing in the appropriate relation to the possessor (Bill) serves as the distinguishing property (the background). In contrast, simple sortal DPs provide only a set of objects (e.g., the set of bricks), without providing any property for distinguishing one brick from another. It is this lack of foreground/background structure that makes DPs headed by sortal nouns defective as concealed questions.

Keywords: Possessives; Relational nouns; Concealed questions; Questions; Structured meanings

1. Concealed questions require a relational head nominal

Baker (1968) observed that some DPs can be interpreted as if they were embedded interrogatives.

(1) a. Ann knows [Bill's age].
b. Ann knows [what Bill's age is].

For the purposes of this paper, a DP will count as an embedded question just in case it can be replaced with an interrogative clause with essentially the same meaning, as in (1a) and (1b). (See Nathan (2006) for an in-depth discussion of what should and shouldn't count as a concealed question.)

My starting point is an observation going back at least to Löbner (1981) (see also Löbner, 2011, ms.). Roughly put, the observation is that, by and large, a DP that serves as a concealed question must denote a 'functional concept'

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(*Fiunktionalbegriffe* for Löbner). DPs denoting a functional relational concept naturally arise from DPs headed by functional nouns such as *temperature*, *president*, *wife*, and *price*, but not from DPs headed by sortal nouns (Löbner's *Gattungsbegriffe*), including *linguist*, *rose*, and *brick*.

A similar observation is made by Caponigro and Heller (2007:262): "We propose that it is functional nouns (in the sense of Vikner and Jensen (2002)) that allow for concealed question interpretation, that is, nouns whose interpretation depend on an additional argument."

Explaining this systematic restriction on the set of acceptable concealed question DPs is one of the main goals of Nathan (2006), as discussed in section 7.

To illustrate the generalization, here are some often-repeated examples of concealed questions from Heim (1979):

(2) Ann knows [Bill's telephone number].
(3) [Ann's favorite drink] is obvious.
(4) They revealed [the winner of the contest].
(5) [The temperature of the lake] depends on [the season].

These DPs are all headed by relational nouns (according to the criteria discussed in section 4), and they can all be grammatically and accurately paraphrased by replacing the DP with an interrogative (e.g., *Ann knows what Bill's phone number is*).

In contrast, DPs headed by sortal nouns typically make terrible concealed questions:

(6) *Ann found out the brick.
(7) *Ann guessed Bill's rose.
(8) *Ann revealed everyone's linguist.
(9) *Ann's apple depends on Bill's brick.

As explored by Nathan (2006) and others, there are other DP types besides DPs headed by relational nouns that make good concealed questions. In particular, some relative clauses can head concealed-question DPs, as discussed in section 5.1.

Assuming we want to understand the relational/sortal contrast, two pressing questions arise immediately:

Why? What is it about the nature of asking questions that makes relational concepts so much better than sortal ones as concealed questions?

To sharpen this question, we will see below a simple (but incomplete) theory of concealed question meaning on which relational and sortal DP meanings are equally well-suited to giving rise to concealed question meanings. This will show that the contrast is not a matter of semantic coherence.

To give a brief preview, the answer I will give is that natural language conceptualizes questions as having two parts: a foreground and a background. The foreground characterizes a set of possible answers, what Hintikka (e.g., 1973) calls the "field of search" in his language games of seeking and finding; and the background distinguishes among those possibilities. So interpreting a DP as a question requires a meaning that delivers both a foreground and a background.

I will argue that relational DPs naturally cleave into appropriate parts. Sortal nouns, in contrast, are conceptually simple in the relevant respect, and do not naturally give rise to the required bipartite structure.

How? The second pressing question is this: given that we must make a distinction between DPs headed by relational and sortal nominals, how is that distinction to be built into an explicit grammar? The challenge is to find a way for differences internal to the DP to influence the external distribution of the DP, in violation of the usual notion of strict compositionality.

The answer I will give is that it must be possible to represent DPs as *structured descriptions*, much in the way that theories of focus interpretation represent clauses containing focused elements as consisting of a focus element and a background property. Instead of a structured proposition, however, we will have a structured individual.

Answering these larger questions in more detail will require addressing just what questions mean, leading to a first approximation of a theory of the meaning of concealed questions, followed by a discussion of the the sortal/relational distinction for nominals, and finally to a refined theory of concealed questions.

2. Two equally necessary perspectives on question meaning

Following the discussion in Krifka (2011), we can divide theories of question meaning into two main strategies: questions as functions on possible answers, which I will call the foreground/background perspective; versus questions as sets of propositions. We shall see that both perspectives are indispensable, not only for question meanings in general, but specifically with respect to concealed questions.

2.1. Question meanings as foreground/background structures

One way to motivate the foreground/background perspective is to note that movement in general, including wh-movement, is associated semantically with the formation of a function. In other words, movement creates foreground/background structures. This general observation is also true of (at least some kinds of) relative clauses (see section 5.1), of right-node raising, of topicalization, and the like. In each case, the denotation of the constituent from which something has been removed will be a function from the type of the removed expression (which will play the role of the foreground) to the normal pre-movement type of the constituent.

As Krifka (2011:1757) puts it, on the foreground/background approach, ''interrogatives are incomplete propositions, with the positions at which they are incomplete and the type of meanings that would make them complete specified by the wh-constituents.''

Loosely adapting the practice of Krifka and others with respect to representing focus structures, I will represent an expression with a foreground and a background as an ordered pair. On this perspective, the question *Who left?* will be a structured meaning represented as the ordered pair ⟨**person**, **left**⟩.

I will mention three well-known reasons here in support of the claim that the foreground/background perspective is indispensable.

The first reason is that tracking foreground/background articulation allows us to track question/answer congruence. For instance, in a context in which the question *Who left?* is under discussion, we can represent the focus/background structure of the answer *ANN left* (with focal stress in the form of a pitch accent on *Ann*) as the ordered pair ⟨**ann**, **left**⟩. The same answer but with pitch accent on *left* (i.e., *Ann LEFT*) will be represented as ⟨**left**, *λP.P*(**ann**)⟩. Only the first answer is an appropriate way to respond to the question *Who left?*. The generalization is that a question and a possible answer are congruent only if they share the same background element, in this case, the property **left**.

The second (related) advantage of tracking foreground/background structure concerns fragment answers. We can respond to the question *Who left?* by saying simply *Ann*, but not by saying *left*. The foreground element in the question representation specifies the syntactic category and the semantic type of a suitable fragment answer.

The third advantage is that tracking foreground/background structures allows us to see how different types of questions have different types of meanings. For instance, a single wh-question will correspond to an ordered pair whose background element is a property of individuals, but a multiple wh-question will correspond to an ordered pair whose second element is itself a foreground/background pair:

(10) (a) Who left? ⟨**person**, **left**⟩
(b) Who bought what? ⟨**person**, ⟨**thing**, **bought**⟩⟩

This difference in type accurately tracks the fact that in these examples only the double wh-question can felicitously be answered with a list of pairs. Likewise, congruent answers to single wh-questions need have only one constituent in focus, but answers to double wh-questions must usually have two foci corresponding to the two wh-phrases.

Thus articulation into a foreground and a background provides an excellent way to characterize question/answer congruence, as well as a way to predict when fragment answers and pair list readings will be licensed.

Based on these patterns, I will assume that explicit representation of foreground/background structure is a well-motivated component in the grammar of questions and answers.

2.2. Question meanings as partitions on the set of evaluation indices

To motivate the need for an additional perspective, note that predicates that embed questions can take either single wh-questions or multiple wh-questions:

(11) a. I know [who left].
b. I know [who bought what].

We saw above that on the foreground/background perspective, these two embedded questions have different semantic types. Given this difference in type, it would be reasonable to expect that there could be predicates that embed one class of wh-question but not the other. However, by and large, if a predicate embeds one type of interrogative, it embeds all of them. This is mysterious if the different flavors of multiple wh-questions all have different semantic types.

We could suppose that verbs that embed interrogatives are systematically polymorphic. But an even greater challenge is that different question types can be conjoined:

(12) Ann knows whether it will rain, [yes/no]
who called, [single wh]
and who will arrive when. [multiple-wh]

This strongly suggests that we need a general semantic type for question meanings that is neutral across the different foreground/background functional types.

This uniformity across question types has a convincing explanation on the set-of-propositions perspective.

Krifka (2011) identifies three major variants of the set-of-propositions approach. On one view, a proposition will be a member of the denotation set if it is a possible answer to the question (Hamblin, 1973), or in some versions only if it is a true answer (Karttunen, 1977). On another major variant (Inquisitive Semantics, Groenendijk and Roelofsen, 2009; Ciardelli et al., 2013), the propositions are interpreted as ways of resolving the issue raised by the question, and propositions are allowed to overlap. Even more restrictively, on the partition view (Groenendijk and Stokhof, 1982), the member propositions must divide up the context set into discrete cells. See, e.g., Krifka (2011) for a more detailed exposition and comparisons.

As far as I know, the main features of the proposal developed here are compatible with any of the three main varieties of the sets-of-propositions perspective. Therefore I'll concentrate here on the partition variant, since that makes the exposition simpler.

On the partition approach, two evaluation indices will be considered equivalent just in case they resolve the question in the same way.

(13) Who left?

In this diagram, each evaluation point can be thought of as corresponding to a possible world. The partition view groups together evaluation points that agree perfectly on what the answer to the question is. So two points will be in the same cell of the partition just in case exactly the same people are leaving in those two worlds.

We can easily convert a partition into a set of propositions, namely, the set of propositions in which each proposition contains all the worlds in exactly one of the equivalence classes.

Note that once we have converted a question meaning into a set of propositions, we have lost the information of what was in focus and what was backgrounded. It is precisely this leveling of information that allows the set-of-propositions perspective to generalize across question types.

(14) (a) Who left? λij . $\mathbf{left}_i = \mathbf{left}_j$
(b) Who bought what? λij . $\mathbf{buy}_i = \mathbf{buy}_j$

In the informal notation here, '$\mathbf{left}_i$' represents the extension of the property denoted by *left* when evaluated at *i*, i.e., the set of people who left in world *i*, and '$\mathbf{buy}_i$' represents the extension of the buying relation at point *i*, i.e., the set of ordered pairs of buyers and bought objects in world *i*. As shown in (14a), two indices will stand in the equivalence relation denoted by *Who left?* just in case the same people left in the worlds corresponding to the indices. Likewise, in (14b), two indices will stand in the relation denoted by the question *Who bought what?* just in case each person bought the same things at both indices.

This approach allows us to reduce all sorts of question types (including yes/no questions, single wh questions, and multiple wh-questions) to the same type of semantic object, namely, a set of propositions. If we suppose that question-embedding verbs require only that their complement denote a set of propositions, we can now understand why they accept all kinds of questions indiscriminately. By the same token, we also understand how it is possible to conjoin different question types: what matters is whether the conjuncts have the same semantic type, not what variety of question they correspond to.

2.3. Both perspectives are indispensable

We have seen that the foreground/background view is essential in order to understand question/answer congruence and the distribution of pair-list answers and fragment answers; but at the same time, the sets-of-propositions view is essential in order to understand the systematic tendency of most interrogative-embedding predicates to accept all sorts of interrogative clauses, as well as the ability to coordinate different types of questions.

As Krifka points out, the foreground/background approach is the most general, in the sense that a suitable sets-of-propositions denotation can always be computed based on the functional representation, but not vice-versa. This is because there can be more than one way to divide up a given proposition into a foreground and a background, even when they induce an identical partition.

(15) a. Who left? $\langle$**person**, **left**$\rangle$
b. Who didn't leave? $\langle$**person**, $\lambda x.\neg$(**left**(x))$\rangle$

The simplest way to see this is to note that a yes/no question and its negation have distinct background properties, but give rise to the same partition on the set of indices.

Therefore, like Krifka, I will assume that the foreground/background denotation is basic, but that the sets of propositions view is equally indispensable. In particular, both views will play a crucial role in explaining the main contrast under study in this paper.

More formally, we can convert from foreground/background interpretations to partitions over the set of indices as follows. Let '*F*' and '*B*' be expressions characterizing a foreground and a background, respectively:

$$[\![\langle \mathrm{F}, \mathrm{B}\rangle]\!]^i \equiv \{\langle x, [\![\mathrm{B}]\!]^i(x)\rangle | x \in [\![\mathrm{F}]\!]^i\}$$
$$[\![\langle \mathrm{F}, \langle \mathrm{F}', \mathrm{B}\rangle\rangle]\!]^i \equiv \{\langle x, \langle y, [\![\mathrm{B}]\!]^i(x)(y)\rangle\rangle : x \in [\![\mathrm{F}]\!]^i, y \in [\![\mathrm{F}']\!]^i\}$$

Purely for the sake of expository simplicity, these definitions work by cases rather than giving a fully general recursive definition for all question types. For example, assume that at index *i*, person *a* left, but person *b* did not:

$$\begin{aligned}[\![\langle \mathbf{person}, \mathbf{left}\rangle]\!]^i &= \{\langle x, \mathbf{left}_i(x)\rangle | x \in \mathbf{person}_i\} \\ &= \{\langle a, \mathbf{left}_i(a)\rangle, \langle b, \mathbf{left}_i(b)\rangle\} \\ &= \{\langle a, \mathit{true}\rangle, \langle b, \mathit{false}\rangle\} \\ &\cong \text{the set of people who left in } i\end{aligned}$$

For an example of a multiple wh-question, assume *a* and *b* are the people at index *i*, and *c* and *d* are the things. Furthermore, assume that at index *i*, only *a* left; *a* bought *c*, and *b* bought *d*.

$$\begin{aligned}&[\![\langle \mathbf{person}, \langle \mathbf{thing}, \mathbf{buy}\rangle\rangle]\!]^i \\ &= \{\langle x, \langle y, \mathbf{buy}_i yx\rangle\rangle | x \in \mathbf{person}_i, y \in \mathbf{thing}_i\} \\ &= \{\langle a, \langle c, \mathit{true}\rangle\rangle, \langle a, \langle d, \mathit{false}\rangle\rangle, \langle b, \langle c, \mathit{false}\rangle\rangle, \langle b, \langle d, \mathit{true}\rangle\rangle\} \\ &\cong \text{the set of pairs of people and the things they bought in i}\end{aligned}$$

In order to turn this denotation into a question meaning, we need Groenendijk and Stokhof's 1984 '**?**' operator, which turns a function on indices (i.e., an intension) into a partition on the set of indices.

(16) $[\![\mathbf{?}\langle \mathrm{F}, \mathrm{B}\rangle]\!] \equiv \lambda ij.([\![\langle \mathrm{F}, \mathrm{B}\rangle]\!]^i = [\![\langle \mathrm{F}, \mathrm{B}\rangle]\!]^j)$

Then *Who left?* will judge two indices *i* and *j* as equivalent just in case the same people left in *i* as in *j*. Likewise, *Who bought what?* will judge *i* and *j* equivalent just in case each person bought the same things in *i* and in *j*. Note that as far as the definition in (16) is concerned, the question operator is only well-defined when it is applied to a foreground/background pair. At a technical level, this restriction can be implemented by giving **?** the type $((\mathtt{e} \to \mathtt{t}) * (\mathtt{e} \to \mathtt{t})) \to \mathtt{s} \to \mathtt{s} \to \mathtt{t}$, where '*' forms product types (i.e., the type of an ordered pair). As I'll discuss further below, the **?** operator could have been defined with a more general type, since nothing in the definition here hinges on having access to the internal structure of the foreground/background pair. Thus restricting the **?** operator to foreground/background pairs is a substantive hypothesis about how natural language conceptualizes questions.

2.4. A note on intensions

The INTENSION of an expression is a function that specifies how the denotation of that expression varies depending on the choice of the index against which it is evaluated. Thus intensions are functions whose domain is the set of evaluation indices, that is, a function whose type begins with "$\mathtt{s} \to \ldots$", where $\mathtt{s}$ is the type of an evaluation index.

For instance, assume that the basic denotation of the DP *the President of the United States* is an individual of type $\mathtt{e}$. Then the intension of this DP is a function from indices to individuals that tells you who is the president at each index, a function such as $\begin{bmatrix} i \mapsto \mathbf{Bush} \\ j \mapsto \mathbf{Obama} \end{bmatrix}$. Following much of the literature on concealed questions (in turn following Montague), we have:

(17)

Expression	Intension	Terminology	Example
clause	$s \to t$	proposition	Ann left.
referential DP	$s \to e$	individual concept	the President
interrogative	$s \to (s \to t)$	relation over indices	Who left?

In Montague's (1974) Intensional Logic, and many approaches inspired by Montague, intensions are available systematically throughout the grammar. The way that this is accomplished is by building intensionality into the ordinary function/argument combination rule, as in, e.g., Heim and Kratzer's (1998:308) rule of Intentional Functional Application. So if an embedded non-interrogative clause denotes, say, a truth value, this Montague-style composition rule delivers to the verb that embeds that clause the intension of a truth value, that is, a function from indices to truth values, what I will call here a 'proposition'. Likewise, assuming that referential DPs denote individuals, Montague's composition rule will deliver the intension of a individual, that is, an individual concept.

The EXTENSION of a semantic value is the result of applying its intension to a specific index: this is what the expression denotes when evaluated against a particular circumstance. In the Montagovian system, all predicates uniformly take intensions as their official semantic arguments; nevertheless, a predicate is said to be 'extensional' if it depends only on the extension of its complement, and ignores the extra information provided by the intension.

For example, the verb *pinch* is extensional in this sense: whether or not a pinching relation obtains depends only on what is going on at the world of evaluation, and what is going on at other indices is not relevant. This means that as far as pinching is concerned, we can replace a referential DP whose extension varies across indices with one that does not vary (i.e., is a 'rigid designator') without affecting truth. That is, at an index where Obama is president, *Ann pinched the President* entails *Ann pinched Obama*, even though the intension of *the President* is different from the intension of *Obama*. In contrast, for verbs that are properly intensional, such as *seek*, the corresponding inference does not go through: *Ann seeks the President* does not entail *Ann seeks Obama*, since she might not know who happens to be the President.

2.5. Reducing knowing-who to knowing-that

Note in the chart in (17) that the *extension* of a question is the same type as the *intension* of a non-interrogative clause, namely, $s \to t$. On the partition view, then, a question extension is semantically equivalent to a proposition. This is supposed to explain why predicates that embed interrogatives always also allow non-interrogative clauses as complements, since the extension of the one is the same type as the intension of the other. (Well, almost always—see the discussion of *wonder* in the next paragraph.)

(18) a. Ann knows who left.
b. Ann knows that Bill and Cam left.

In fact, the connection is even closer. Assume we have an index *i* at which Bill left and Cam left (and no one else left). Then the extension of the question *who left* on the partition view will be λj . $\mathbf{left}_i = \mathbf{left}_j$, that is, the set of indices in which the set of leavers is the same as at index *i*. Since Bill and Cam are the leavers in *i*, the extension of the question is the set of indices in which Bill left and Cam left. But taking the intension of the clause *Bill and Cam left* will produce the same result, namely, the set of indices in which Bill and Cam are the leavers. So the partition theory is one on which the semantics of an extensional interrogative-embedding verb reduces to the semantics of a proposition-embedding verb.

Other interrogative-embedding verbs, such as *wonder*, however, are not extensional. Such verbs do not license replacement with non-interrogative clauses. Thus if Ann wonders who left, there is no entailment that she wonders anything specific about Bill and Cam, even if Bill and Cam are the (only) leavers in the world of evaluation. The inability to reduce wondering-who to wondering-that correlates with the fact that *wonder*, unlike *know*, does not allow non-interrogative complements (**Ann wonders that Bill left*).

Intriguingly, *wonder* also does not allow concealed questions (**Ann wonders the capital of Italy*). Nathan (2005, 2006) shows that there is a correlation between verbs that embed non-interrogative clauses and verbs that allow concealed questions, although the correlation is not perfect (the behavior of *ask* is particularly troublesome). He suggests that the general pattern holds because concealed questions systematically denote question extensions (i.e., propositions), the same kind of objects denoted by non-interrogative clauses. Since one of my main claims is that the operator that forms concealed question meanings is exactly the same general function defined by Groenendijk and Stokhof for forming question meanings, and since the question operator must in general deliver intensions, it follows that concealed question meanings must be intensional as well. We could still implement Nathan's generalization in the form of a meaning postulate governing verbs that take concealed questions, if desired, but that would be somewhat at odds with the spirit of Nathan's explanation.

I should mention that whether or not it is ultimately possible to reduce knowing-who to knowing-that is controversial (see, e.g., George, 2013). We don't need to take a stand on this issue; the point of discussing the possibility of reduction here is merely to get clear on intensions and extensions in a simple partition theory of question meaning.

2.6. Interim summary

At this point, I have argued that questions denote a structure consisting of a foreground and a background, and I've shown using standard techniques how this structure can be collapsed onto a set of propositions by means of the **?** type-shifter.

3. A simple but incomplete theory of concealed questions

How do concealed question DPs give rise to question meanings?

(19) Ann knows Bill's age.

We're making the Montagovian assumption that the grammar delivers the intension of every argument expression, so *know* will relate Ann to the intension of the individual-denoting DP *Bill's age*. The intension of an individual is an individual concept, that is, a function of type $s \to e$. What we need in order to have a question meaning is a partition over the set of evaluation indices, that is, a function of type $s \to (s \to t)$.

On some theories of concealed questions, predicates take individual concepts directly (e.g., Heim, 1979; Romero, 2005). This requires each predicate that accepts concealed questions to have a distinct meaning that deals in individual concepts instead of proper question meanings. Following a long line of previous work (including Nathan, 2006; Aloni, 2008; Aloni and Roelofsen, 2011; Percus, 2014), the strategy adopted here will be to provide instead a single meaning for each question-embedding verb, and to convert concealed-question DPs into question meanings via a type-shifter.

The way in which I will proceed is by temporarily relaxing the restriction of the **?** type-shifter to foreground/background pairs. If we allow the shifter to apply to arbitrary intensions, we immediately have an analysis of the meaning of concealed questions, as explained in Fig. 1.

$$?[\![\mathit{Bill's\ age}]\!] = \lambda ij.([\![\mathit{Bill's\ age}]\!]^i = [\![\mathit{Bill's\ age}]\!]^j)$$

Since **know** is extensional with respect to interrogative complements (see previous section), to know Bill's age at an index *i* is to know the proposition given by $\lambda j.([\![\mathit{Bill's\ age}]\!]^i = [\![\mathit{Bill's\ age}]\!]^j)$. This question meaning extension is the set of all indices in which Bill's age is the same as it is in *i*, the evaluation world. If Bill is 30 in *i*, then to know Bill's age entails knowing that Bill's age is 30. This is a reasonable account of the truth conditions of a predicate embedding a concealed question.

3.1. Why this simple theory is not complete

The problem with this simple theory is that it overgenerates. For one thing, **?** can turn the intension of quite literally any expression into a concealed question: adjectives, verbs, prepositions, determiners, etc.

(20) *I know in the fridge ≠ I know what is in the fridge
(21) *I found out expensive ≠ I found out what is expensive

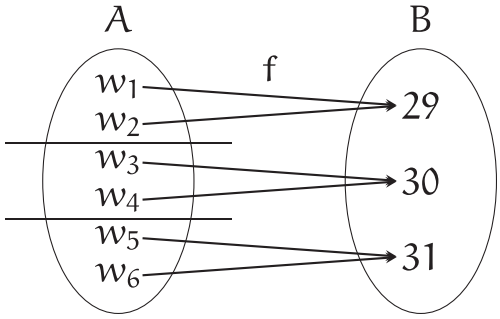

Fig. 1. How a function induces an equivalence relation on its domain. Given a function $f: A \to B$, two elements of *A* will be equivalent just in case *f* maps them to the same value in *B*. Here, *f* is the individual concept that maps each world to Bill's age in that world. The three cells in the partition correspond to the propositions that Bill's age is 29, that Bill's age is 30, and that Bill's age is 31.

For whatever reason, English (and other languages) limit concealed questions to DPs; presumably, this is at least in part a syntactic limitation on the kinds of expressions that can serve as direct arguments of a predicate. If the hypothesis defended below is correct, then at least part of the syntactic restriction follows from the need for the expression to denote a foreground/background pair. On the assumption that only interrogatives and certain DPs can denote such pairs, the restriction is explained.

But even limiting attention to DPs, Nathan (2006:28) allows that a **?**-like theory ''assigning question denotations to DPs is possible, and... they adequately capture the meaning of CQs. However,... this theory of CQ meanings must be supplemented with an explanation of CQ distribution.'' That is, since the intension of literally any referential DP meaning can be shifted into a perfectly coherent question meaning, we should seek an explanation for why some DP types make good concealed questions while others do not. In particular, there is no explanation for why the question meaning derived from a DP containing a relational head nominal such as **?** ⟦*Bill's age*⟧ makes for a good concealed question, but the question meaning derived from a DP containing a sortal head nominal such as **?** ⟦the rose⟧ does not. So we have not yet arrived at a complete picture.

4. Sortal versus relational nouns

In preparation for the main proposal, we should pause to consider the semantic difference between relational and sortal nouns.

It is widely assumed (see, e.g., Barker, 1995; Partee, 1997[1982]) that some nominals denote one-place relations ('sortal' nominals), and others denote two-place relations (properly 'relational' nominals). There are dissenting voices; see in particular Le Bruyn et al. (2013), who make a case for treating all nominals as syntactically and semantically sortal. To the extent that the analysis proposed in this paper succeeds in explaining a syntactic contrast in acceptability as following from a grammaticized sortal/relational contrast, this paper constitutes a new argument in favor of viewing the sortal/relational distinction as grammatical and relevant for linguistic explanation.

The sortal/relational contrast plays out at the conceptual, syntactic, and semantic levels. This may be familiar ground for some readers (see, e.g., Barker, 2011), but because it is essential to the story below, it is worth sketching the main ideas again here.

(22)

SORTAL	RELATIONAL
day	birthday
horse	steed
animal	pet
person	child

In these minimal pairs, the sortal concept corresponds to a class of entities that have certain properties. The relational concept in addition requires the existence of a distinct entity that stands in a particular relation to the described entity. Thus a day counts as a birthday only in relation to some person whose birthday it is; a horse counts as a steed only in relation to a rider; an animal counts as a pet only in relation to an owner; and a person counts as a child only in relation to a parent. This is despite the fact that, by and large, every day is someone's birthday, and every person is a child.

In order to argue that the conceptual sortal/relation contrast is grammaticized, we need to borrow the concept of transitivity from the syntax of verbal expressions.

(23)
a. Ann dined (*the steak).
b. Ann ate (the steak).
c. John devoured *(the steak).

Conceptually, the verbs *dine*, *eat*, and *devour* all require the existence of an eater and something that is eaten. It is a quirk of English syntax that the eaten participant cannot be expressed as a simple direct object for *dine*, can optionally be expressed or not for *eat*, and must obligatorily be expressed for *devour*. We say that *dine* is obligatorily intransitive, *eat* is optionally transitive or intransitive, and *devour* is obligatorily transitive.

Similar contrasts occur with conceptually relational nominals:

(24)
a. the stranger (*of Ann), *Ann's stranger
b. the child (of Ann), Ann's child
c. the sake *(of Ann), Ann's sake

Since someone who is a stranger to Ann might not be a stranger to Bill, *stranger* is an essentially relational concept. Yet the person with respect to whom the described individual is unknown cannot be overtly expressed, at least, not using a possessive *of* phrase or a prenominal possessive. The nominal *child*, argued above to be relational, can either have the other participant specified (*the child of Ann*) or not (*the child*). The vast majority of nominals in English fall into this category. For a few relational nominals, including *sake*, *detriment*, and one of the senses of *fault*, the possessor must obligatorily be expressed. On the basis of this parallelism, I will extend the terms 'intransitive' and 'transitive' to apply to nominals.

One argument that relational nominals are syntactically and semantically different from sortal nominals is that only relational nominals can occur with a postnominal possessive *of* phrase.

(25)

SORTAL	RELATIONAL
*the day of Ann	the birthday of Ann
*the animal of Ann	the pet of Ann
*the person of Ann	the child of Ann

Following Barker (1995) and Partee 1997[1982], I will assume that a postnominal possessive *of* phrase requires a relational head nominal. This will provide an operational test below for whether a nominal is grammatically relational or not.

Incidentally, sortals are often grammatical in a similar but distinct construction called the double-genitive. For instance, although **a brick of Ann* is ungrammatical, *a brick of Ann's* is perfectly fine. I follow Barker (1998) in assuming that the *of* in the double-genitive construction is a partitive *of*, and not a possessive, and so irrelevant for present purposes.

As further evidence that grammaticality with the postnominal *of* phrase depends on the head noun being relational, Barker (1995), and Partee and Borschev (1999) observe that *favorite* can shift a sortal concept into a relational one. That is, *brick* is a mere sortal, but *favorite brick* denotes a relation between an evaluating agent and a brick that they have an approving attitude towards.

(26)
a. the favorite day of the policeman
b. the favorite animal of John
c. the favorite person of Ann

As (26) shows, adding *favorite* significantly improves the grammaticality of the sortal examples given above in (25).

4.1. The relational/sortal distinction in concealed questions

The way that the sortal/relational distinction fits into the larger story here is that DPs whose head nominals are relational make good concealed questions, but DPs whose head nominals are sortals generally do not.

(27)
a. the age of everyone [this shows *age* is relational]
b. Ann knows everyone's age.

(28)
a. *the brick of everyone [this shows *brick* is sortal]
b. *Ann knows the brick
c. *Ann knows everyone's brick

Note that sortal head nominals are no good as concealed questions whether or not they occur in a possessive construction.

As mentioned in the introduction, the contrast between sortal and relational nouns has been noted before, notably in Löbner (1981) and Nathan (2006).

In order to confirm that the difference really is the sortal/relational distinction, we can try modifying a sortal with *favorite*. As argued above, *favorite* shifts sortal nominals into (properly) relational nominals. If *favorite* does turn a sortal nominal into a relational one, and that is the crucial factor for licensing a concealed question, the prediction is that modifying a sortal with *favorite* should enable it to serve as a concealed question:

(29)
a. *Ann knows Bill's brick.
b. Ann knows Bill's favorite brick.

(30)
a. *Ann found out Bill's person.
b. Ann found out Bill's favorite person.

And indeed, adding *favorite* to a sortal dramatically improves its ability to serve as a concealed question. I will assume that it really is the presence of the (unmodified) sortal that is interfering with the ability of a possessed sortal to serve as a concealed question.

5. Constraining concealed questions

The simple but inadequate theory of concealed question meaning given in the previous section makes heavy use of the partition perspective on question meaning, but ignores the foreground/background perspective completely. I will suggest that recognizing the relevance of both strategies for interpreting questions will lead to an explanation for at least some restrictions on the distribution of DPs in concealed questions.

We saw in section 2.1 that the foreground/background perspective on question meaning divided questions into a wh-part, constraining the set of possible answers, and a background, evaluating those alternatives. The central proposal of this paper is that in order to make a successful concealed question, a DP must respect this bipartite articulation by providing non-trivial content to each component. For relational DPs, this is natural, but not so for sortals.

To see how this works, assume we want to articulate a relational DP into a foreground and a background. It is clear how we would do it: the sortal requirements placed on the referent will constitute the foreground, characterizing the set of possible answers; and the content of the relation, along with the identity of the second relatum (usually, a possessor), will characterize which of the potential answers is the right answer. I take it that Löbner (1981:486) has something similar in mind when he comments, speaking of the meaning of a relational concealed question, that ''the range of alternative referents or possible function values is naturally included in a functional noun, just as a question determines the range of possible answers.''

In contrast, if we consider a sortal DP, articulation into a foreground and a background is not so easy. There just aren't enough linguistically distinct parts to manipulate. On the one hand, we could suppose that the sortal characterizes the set of possible answers, but that would leave no substantive contribution to the content of the background property. On the other hand, we could suppose that the sortal constituted the background property, but then the set of possible answers would have to be unconstrained. The heart of my hypothesis, then, is that natural language requires that in order to constitute a natural question, a question meaning must provide both a foreground and a background.

5.1. DPs containing relative clauses

So far, I have been careful to talk about DPs headed by *simple* sortals. More complex DPs can provide just the kind of bi-partite structure needed to give rise to a natural question. In particular, Nathan shows that sortals modified by a relative clauses can be used to form a grammatical concealed question.

(31) a. Ann knows [the street the restaurant is located on].
b. Ann knows [which street the restaurant is located on].

The close correspondence between the structure of some relative clauses and overt wh-questions is well-known. On movement theories of relative clause formation, this parallelism is explained by deriving them in a similar manner. Evidence in support of a movement theory of relative clause formation includes idiom licensing, quantificational binding, and other so-called reconstruction facts (see Sportiche, 2006). In the current context, the syntactic parallel suggests that the head nominal of the DP should correspond to the foreground property (the set of streets), while the relative clause provides the background property (things the restaurant is located on).

To prevent misunderstanding, (31b) is not intended as a candidate for a paraphrase of the concealed question above it; rather, it is intended to suggest the close syntactic and semantic parallels between relative clause formation and wh-fronting. As discussed in the next section, the official denotation for (31b) is the one provided by applying **?** to the denotation of *the street that the restaurant is located on*.

5.2. Integrating the perspectives on question meaning

I want to emphasize that the partition meaning delivered by the **?** type-shifter is still a fully accurate picture of the denotation of concealed questions. Furthermore, the partition view is still necessary in order to account for the semantic similarity across question meanings.

One way to see that the partition approach (more generally, the set-of-proposition perspective) remains essential is to note (along with Aloni and Roelofsen, 2011, among others) that not only can wh-questions be coordinated with multiple wh-questions, concealed questions can be coordinated with either type of question as well.

(32) Ann found out [Bill's phone number] and [where he lives].
(33) Our accountant needs to know [everyone's budget] and [who bought what].

The question type-shifter explains these facts by mapping each of these expressions, no matter whether they are single or multiple wh questions, or whether they are concealed-question DPs, to the same kind of partition on the set of indices.

For the sake of concreteness, I'll assume for the purposes of this paper that when a question is a complete utterance, it expresses a foreground/background structure suitable for gauging question/answer congruence and fragment answers, but whenever a question is embedded under a verb or coordinating conjunction, the foreground/background structure must shift via **?** into a set of propositions.

6. Some implementation details

By hypothesis, relational nouns denote foreground/background structures.

(34) a. $[\![\text{birthday}]\!] = \langle \textbf{day}, \textbf{born-on} \rangle$
b. $[\![\text{birthplace}]\!] = \langle \textbf{location}, \textbf{born-at} \rangle$

In each case, the foreground is a property characterizing the set of referents (days in (34a) versus places in (34b)), and the background is the condition a referent has to meet in order to qualify as the described entity.

The postnominal possessive *of* (likewise, the prenominal possessive construction) supplies an argument to the background element.

(35) John's birthday = birthday of_{POSS} John =
$\text{POSS}(\textbf{john}, \langle \textbf{day}, \textbf{born-on} \rangle) = \langle \textbf{day}, \textbf{born-on}(\textbf{john}) \rangle$

If we assume that the possessive *of* requires a foreground/background structure for its nominal argument, this accounts for the fact that the postnominal genitive construction is restricted to relational nominals, as discussed above.

For the purposes of this paper, I'll approximate the contribution of the definite determiner *the* by assuming that it merely checks to make sure that its complement identifies a unique object. For non-relational nominals, this requires checking that the property is true of exactly one object. For relational nouns, this amounts to checking that the background part of the foreground/background structure is true of exactly one element in the foreground set. As long as the evaluated DP denotations deliver a set containing exactly one individual, standard pointwise function application (as advocated in Kratzer and Shimoyama, 2002a,b) will incorporate the referent into the larger denotation in an appropriate way. Alternatively, Nathan (2005:294) suggests that the definite determiner shifts a singleton set to its unique member.

Then using the exact rules for evaluating foreground/background structures developed above in section 2.3 for interrogatives, we have the following relational DP meaning:

$$\begin{aligned}[\![\text{John's birthday}]\!]^i = \; & [\![\text{the birthday of John}]\!]^i = \\ & [\![\langle \textbf{day}, \textbf{born-on}(\textbf{john}) \rangle]\!]^i \\ & = \{\langle a, f a \rangle | a \in \textbf{day}_i, f \in \textbf{born-on}_i(\textbf{john}_i)\} \\ & = \{\langle \textbf{1}\text{–Jan}, \textit{true} \rangle, \langle \textbf{2}\text{–Jan}, \textit{false} \rangle, \ldots\}\end{aligned}$$

In predicational or specificational contexts, this denotation can serve as a property meaning more or less directly (*John's birthday is today, isn't it?*; see Mikkelsen, 2011). In contexts requiring a referential expression, we will need to replace the denotation with the unique object mapped to TRUE (in this case, 1 January).

The explanation of the contrast between sortal and relational nominals, then, is that we should insist on restricting the type-shifter **?** as originally defined in (16), so that it is only well-defined if its argument is a foreground/background structure. If so, we have

$$\begin{aligned}& [\![\text{John's birthday}]\!] \\ & = [\![\text{the birthday of John}]\!] \\ & = [\![\textbf{?}\langle \textbf{day}, \textbf{born-on}(\textbf{john}) \rangle]\!] \\ & = \lambda ij.([\![\langle \textbf{day}, \textbf{born-on}(\textbf{john}) \rangle]\!]^i = [\![\langle \textbf{day}, \textbf{born-on}(\textbf{john}) \rangle]\!]^j)\end{aligned}$$

Two indices *i* and *j* will stand in this relation just in case John's birthday in *i* is the same as John's birthday in *j*, which is the correct concealed-question meaning.

So DPs headed by relational nominals work out as desired.

What about sortals? Sortals denote simple properties. This assumption is required independently in order to explain why sortals can't combine with a postnominal possessive *of* phrase (**person of Ann*). As a result, an attempt to apply the question-forming type-shifter will fail: **?** ⟦*theperson*⟧ = **?** {*x*|**person**(*x*)} This is undefined, since **?** is limited by hypothesis to apply only to objects of the form ⟨*F*, *B*⟩.

We are now in a position to see how adding the adjective *favorite* allows a sortal to contribute to a grammatical concealed question. We know that *favorite* turns a sortal meaning into a relational one. Since our hypothesis is that relational meanings consist of foreground/background structures, we have

$$[\![favorite\ \ day]\!] = \langle \mathbf{day}, \mathbf{favorite}(\mathbf{day})\rangle$$

This synthetic relational nominal combines with a possessor in the way described above, so that

$$[\![John's\ \ favorite\ \ day]\!]\langle \mathbf{day}, \mathbf{favorite}(\mathbf{day})(\mathbf{john})\rangle$$

This denotation is suitable for undergoing the **?** type-shifter, so we now have an explanation for why **I found out Ann's brick* is ungrammatical, but *I found out Ann's favorite brick* is dramatically better.

6.1. Relative clauses

As for relative clauses, they also contribute a foreground/background structure. I suggested above that in view of the syntactic parallels between wh-interrogative formation and (at least some kinds of) relative clauses, on a fully worked out syntactic and semantic analysis (whose details are straightforward, but not included here for reasons of space; see, e.g., chapter 7 of Barker and Shan (2014) for complete compositional details), the foreground/background articulation for a relative clause should arise in a manner parallel to the independently-motivated case of wh-interrogatives. For the sake of concreteness, I'll simply stipulate here that the relative clause operator REL introduces the appropriate structure. For the DP *the street that the restaurant is located on*, we have

(36) REL(⟦ *that the restaurant is located on* ⟧)(⟦ *street* ⟧)
= ⟨**street**, **on**(**the-restaurant**)⟩

This gives the appropriate concealed-question meaning.

Finally, note that there is no reason to suspect that pronouns or proper names give rise in general to a foreground/background structure, correctly predicting that as a general rule they cannot serve as concealed questions.

(37) *Ann found out him.
(38) *Ann found out Bill.

Nevertheless, a referee points out that in the context of a game show contest in which contestants are given a list of names and must guess which country that person leads, it is possible to say *Ann only knew Obama*. Apparently, if the context is rich enough, it can provide a field of search (the set of countries) and a background property (being led by a given person) even for a proper name.

6.2. Greenberg's observation

Heim (1979) attributes to Bill Greenberg the observation that the following two sentences are not semantically equivalent.

(39) a. Ann found out Bill's murderer.
b. Ann found out who Bill's murderer is.

The concealed question in (39a) conveys only the thought that Ann found out which person murdered Bill. The embedded question in (39b) has in addition an interpretation on which Ann may have already known which person murdered Bill, and found out something else about her, such as that she is the captain of the hockey team. Aloni and Roelofsen (2011) call these readings *direct* and *indirect*.

On the account here, this contrast is expected. The only way to construct a concealed question as in (39a) is to shift the structure ⟨**volitional-entity**, **murder**(**bill**)⟩. This gives a question meaning in which the field of search is the set of entities capable of murder, and the background property is the property you hold if you participated in an event of murdering Bill. The reason (39b) has an additional reading is because copular clauses are ambiguous across a specificational or a

predicational reading (see Mikkelsen, 2011), so the embedded question in (39b) inherits the same ambiguity (see Frana, 2010b).

6.3. Additional restrictions are needed

The correlation between being relational (where being relational includes nominals modified by a relative clause) and being able to serve as a concealed question is imperfect. While being relational appears to be a necessary condition, it is not sufficient. There are clearly relational predicates that make lousy concealed questions. Nathan offers *carburetor*:

(40) *Ann found out the truck's carburetor.

M. Kaufmann comments in Schwager (2008) that objects that don't have names independent of their classifying nominals are often hard to contextualize as concealed questions, which she argues supports a view on which conceptual covers play a crucial role in the semantics of concealed questions (see section 8.5).

Clearly some relational nouns are better than others as concealed questions. Abstract relational nouns (*age*, *speed*) are better than concrete nouns, though some concrete nouns are excellent, such as *winner* or *capital*; relational nouns whose codomains are sets of degrees make good concealed questions (*weight*, *age*); and relational nouns whose values can vary over time make better questions than ones that are more stable (*age*, *capital* versus *nose*, *mother*). Familial relational nouns and part/whole relational nouns are not so good as concealed questions, though Löbner offers

(41) ?Ann's mother has not yet been determined.

Although the existence of relational nominals that don't give rise to concealed questions shows that the story here is incomplete, such examples do not threaten the main hypothesis, which is that concealed questions require a foreground/background structure.

In fact, because the theory here depends on the lexical interpretation of relational nouns, it is perfectly feasible to assign the foreground/background denotation that gives rise to concealed questions to a proper subset of the class of relational nouns.

7. The answer to the *Why?* question

Chapter 4 of Nathan (2006) seeks to account for which DPs make good concealed questions, the main goal of this paper. Furthermore, Nathan's analysis and the one developed here are similar in important technical respects. In particular, both rely on a typeshifter whose application is restricted to relational noun meanings. As a result, the answer Nathan gives to the *How?* question is highly similar to the answer given here.

However, although Nathan's approach can lead to a fragment that makes reasonable predictions, it leaves the *Why?* question unaddressed (a point made by Percus, 2014:45). For instance, why is there no parallel type-shifter that creates concealed question meanings for DPs headed by sortal nominals? The answer proposed here is that natural language questions in general require a foreground/background structure, and relational nouns, but not sortals, give rise to a suitable foreground/background articulation.

To give a bit more detail, Nathan (2006):109 proposes the following type shifter, which I will call $\mathbf{Q}_r$:

(42) $[\![\mathbf{Q}_r(\mathrm{R})]\!]^w = \lambda y \lambda p(\exists x.p = \lambda w'.[\![\mathrm{R}]\!]^{w'}(y)(x))$

Here, R is a relational nominal meaning of type $\mathtt{e} \to (\mathtt{e} \to \mathtt{t})$, y is an individual-denoting expression of type $\mathtt{e}$, and p is a proposition of type $\mathtt{s} \to \mathtt{t}$. Applying $\mathbf{Q}_r$ to the meaning of a relational noun builds a propositional meaning (interpreted as the extension of a question denotation) for the DP that contains it. On this view, sortals can't give rise to concealed-question DPs, as a simple matter of semantic types: $\mathbf{Q}_r$ requires a relational argument, and a sortal predicate doesn't satisfy that requirement.

However, there is no reason why $\mathbf{Q}_r$ couldn't be adapted to apply to sortals. For instance, here is a type-shifter given in Nathan (2005:294) (I'll call it $\mathbf{Q}_s$) that can apply to sortals in the same spirit as $\mathbf{Q}_r$:

(43) $[\![\mathbf{Q}_s(\mathrm{P})]\!]^w = \lambda p(\exists x.p = \lambda w'.[\![P]\!]^{w'}(x))$

where P is a sortal nominal meaning of type $\mathtt{e} \to \mathtt{t}$.

So accounting for the distribution of concealed question DPs depends on stipulating that $\mathbf{Q}_r$ is available, but not $\mathbf{Q}_s$.

It is worth considering whether the **Q** solution might contain within it elements that could be identified as corresponding to a foreground or a background. However, it is far from clear how to divide up (42) into a foreground part and a background part.

Thus it appears that the **Q** approach and the approach advocated in this paper are substantially different in terms of their explanatory claims.

Nathan (2006:119) also discusses relative clauses. Recall that adding a relative clause to a sortal head nominal can allow a DP to be interpreted as a concealed question (e.g., *Ann found out the street *(that the restaurant was located on)*). Nathan provides a second type-shifter that constitutes in effect a new mode of semantic combination, parallel to but distinct from Heim and Kratzer's (1998) Predicate Modification. At the level of the *How?* question, this solution is similar to the one given above, where the relativization process is stipulated to create the kind of structure needed in order for the **?** type shifter to apply.

But at the level of the *Why?* question, the accounts once again differ in an important way. Why should relative clauses give rise to a special mode of combination, but not other instances of Predicate Modification, such as prenominal adjectival modification? On the account here, the special status of relative clause formation stems from the deep resemblance between relative clause formation and wh-question formation. Both can involve displacement of material to form a foreground/background structure. In the relative clause cases, the head nominal corresponds to the foreground, and the relative clause corresponds to the background. This resemblance explains why nominals that have relative clauses resonate with a construction that requires content to align with the general conceptual requirements of question formation.

Finally with respect to Nathan's analysis, note that the $\mathbf{Q}_r$ typeshifter was purpose-built to deliver the desired contrast between relational nominals and sortal nominals, without any independent motivation. The **?** typeshifter used here, in contrast, is the same type-shifter proposed by Groenendijk and Stokhof completely independently of concealed questions. Furthermore, the importance of making a foreground/background distinction also has abundant independent motivation in the analysis of question meaning, as discussed above in section 2.

8. Individual concepts are orthogonal to the main contrast

An individual concept is a function from worlds to individuals (type $\mathtt{s} \rightarrow \mathtt{e}$). Many theories of concealed questions crucially rely on individual concepts in one way or another. I will argue that adding individual concepts or not is independent of the core issue investigated here.

There are two ways that individual concepts figure into discussions of concealed questions: as a candidate for the denotation of the concealed question DP itself, and as elements in the extension of the nominals from which concealed question denotations are built. I'll discuss each strategy in turn.

8.1. Concealed questions as individual concepts

On one of the proposals floated by Heim (1979), concealed question DPs denote individual concepts. For instance, if *f* is the individual concept that maps each world to the capital of Italy in that world, Ann will know the capital of Italy just in case *f* maps each world in her belief set onto Rome.

In this paper, I have chosen to emphasize the resemblance between concealed question DPs and embedded question clauses by giving them the same type of denotation, namely, sets of propositions. However, this is not an essential difference: it is easy to shift from individual concepts to an appropriate set of propositions. In fact, the partition induced by an individual concept (see Fig. 1) will partition a set of worlds into equivalence classes that agree on the capital of Italy, and the usual question-embedding sense of *know* (or *find out*, or *reveal*, etc.) will deliver appropriate truth conditions.

Because of this easy equivalence, we can help ourselves to treating concealed questions as sets of propositions without that decision by itself committing us to a stance on whether concealed questions might also denote individual concepts.

8.2. Meaningfully sorted concepts

Building on Nathan (2006), Frana (2010a, 2013) (see especially section 3.2 of Frana, 2013) addresses the difference between relational and sortal nominals. She considers two type shifters (based on Nathan): one that shifts a sortal property into an individual concept, and one that shifts a relation into an individual concept. She calls individual concepts that arise from relations *meaningfully sorted*. It is not clear precisely what it takes to qualify as a meaningfully sorted concept, apart from being a relation that has been shifted by a particular type shifter. In any case, Frana observes that only meaningfully sorted concepts can serve as concealed question meanings in a way that matches intuitions.

A referee asks whether meaningfully sorted concepts could provide the basis for an answer to the *Why?* question. Unfortunately, requiring concealed questions to be meaningfully sorted concepts only pushes the question back one level: what explains why they must be meaningfully sorted concepts? Until there is an answer to this deeper question, meaningfully sorted concepts do not resolve the issue at the heart of the present paper.

8.3. Can noun extensions contain individual concepts?

The other way in which the semantics of concealed questions can depend on individual concepts is by allowing nouns to have individual concepts in their extensions instead of plain individuals.

To see how this can be useful, Heim (1979) suggests that there are two distinct ways to know a price.

(44) Ann knows the price that Bill knows.

Assume that Bill knows the price of milk (and nothing else). Then either Ann knows the price of milk, and may not even know of Bill's existence; or else Ann knows which commodity Bill knows the price of, without necessarily knowing herself how much milk costs.

Building on Heim, Romero (2005) explains this ambiguity based on the assumption that the predicate denoted by *price* has individual concepts in its extension. The idea is that we can think of a price as an intensional object, as a function from indices to what some object costs at that index. If so, then the *extension* of the DP *the price that Bill knows* will already be a function on the set of indices. Romero proposes that the **?** type-shifter can shift the extension of the DP directly, arriving at the interpretation on which Ann knows how much milk costs. The other interpretation arises in the normal way, by applying **?** to the intension of the DP, which will be a function from indices to individual concepts. This interpretation will produce a partition in which equivalent worlds pick out the same individual concept. There is no technical reason why this analysis couldn't be adopted here, if desired.

Lasersohn (2005) argues that the lexical meanings of nouns never have individual concepts in their extension. There is extensive discussion of this issue specifically with respect to concealed questions in Romero (2005, 2006, 2010), Nathan (2006, chapter 4), Schwager (2007, 2008) and Frana (2010a, 2013).

Percus (2014) goes one step further and supposes that *price* can denote not sets of individual concepts, but sets of questions.

8.4. Quantified concealed questions

Heim (1979) observes that (45a) is ambiguous.

(45) a. Ann found out every phone number.
b. Ann found out every member of the Italian team.
c. Ann found out every book that Mary read.
d. *Ann found out every book.

It either means that Ann knows a set of phone numbers, without knowing whose they are (what Roelofsen and Aloni, 2008 call the 'set' reading); or else it means that for each person in some relevant domain, Ann knows that person's phone number (the 'pair-list' reading).

Frana (2010a, 2013) argues that whether a quantified concealed question has a list-pair reading depends on whether the head nominal is relational or sortal. Thus (45a) contains a relational nominal, and it is ambiguous between a pair-list reading and a set reading; but (45b), in which a relational nominal has its internal argument saturated, and (45c), a sortal with a relative clause modifier, have only a set reading.

However, the main contrast under study here is the contrast between DPs built from relational nominals (45a, 45b), or from sortal nominals combined with a relative clause (45c), versus DPs built from unmodified sortals (45d). The account in Frana (2013) of (45c) involves copy raising and higher-order traces, without depending on the presence of the relative clause. As a result, the account applies equally well to the ungrammatical (45d), leaving the main contrast under investigation here unaddressed. Likewise, the analysis in Aloni and Roelofsen applies equally well to DPs built from relational and sortal nominals, and so also does not address our main issue.

8.5. A note on conceptual covers

Many studies of concealed questions worry about a class of problems that have a de re/de dicto flavor to them, including Heim (1979), Frana (2006), Schwager (2007, 2008), Aloni (2008), and Aloni and Roelofsen (2011). Some of

these authors recommend relativizing interpretation to conceptual covers, which are sets of individual concepts that satisfy certain constraints. In particular, Aloni and Roelofsen (2011) show how conceptual covers give a particularly fine-grained picture of the various readings of the quantified concealed questions discussed in the previous section.

I am sympathetic to the notion that conceptual covers are relevant for the interpretation of concealed questions, but I don't currently see how they bear on the contrast between relational versus sortal DPs. As a result, I have left more careful consideration of conceptual covers and related issues for future work.

9. Some problematic cases

There are some perfectly idiomatic examples of concealed questions in which the head nominal appears to be an unmodified sortal.

(46) Ann wants to know the time.

The problem is that *time* is arguably not relational according to the operational test given above (**the time of now*, though there is a related sense *the time of the meeting*). Nevertheless, *time* is conceptually relational—a time always has to be the time of something. I will assume that *time* (and related items, such as *season*, *month*, etc.) are conceptually relational, but syntactically intransitive. One clear factor in favor of *time* as a concealed question is its direct dependence on the index of evaluation. Yet why not then expect *place*, which has an equally close dependence on index, to make a similarly good concealed question, contrary to fact (**Ann asked the place*)?

In addition, Svetlana Godjevac (personal communication) suggests that when trying to meet a friend at a theater performance, it makes sense to say

(47) Ann found out Bill's row.

Yet *row* is not relational by the operational test given here, since **the row of Bill* is not grammatical. But **row** is arguably relational with respect to a different class of possessors, since *the row of Bill's ticket* is much better. There may be some indirection going on here, that is, some deferred reference in the sense of Nunberg (1995).

9.1. Extrinsic possessives, functional relations, and definiteness

A referee asks why the prenominal (Saxon) possessive doesn't create a suitable foreground/background structure.

To set up the question, we've seen that relational nouns naturally provide a foreground and a background (*I know Bill's age*). Sortal nouns, understandably, do not (**I found out the brick*): sortals simply don't have enough internal parts to map them onto a foreground and a background. But what about a possessed sortal? That is, why can't the possessive description *Bill's brick* function as a concealed question in **Ann found out Bill's brick*? More specifically, why can't we analyzed *Bill's brick* as **?** ($\langle$**brick**, π(**ann**)$\rangle$), where π is a pragmatically-supplied possession relation (as motivated in, e.g., Barker, 2011)?

On a technical level, there is no difficulty correctly predicting that possessed sortals are ungrammatical: we simply stipulate that, unlike relative clause formation, the prenominal possessive does not create a foreground/background structure. But: why?

Here is one route to a more satisfying explanation. Because the value of the possession relation is not supplied by the lexical content of the head nominal, it must be supplied by the pragmatic context. As a result, we have two options for building the intensional function mapping each world to the referent of *Bill's brick* in that world. The first option is that we can resolve the pragmatic indeterminacy before taking the intension, in which case we arrive at a rigid intension that maps every world to the same object, namely, whatever serves as the referent of the description *Bill's brick* at the relevant point in the conversation in which it occurs. But this gives rise to a trivial question meaning, since every evaluation point will be in the same equivalence class, which we can easily imagine would constitute a defective concealed question meaning. In a similar spirit, Löbner (1981) suggests that in order to be a suitable meaning for a concealed question, a function must vary across time.

Or we can suppose that the pragmatic indeterminacy is not resolved before taking the intension. Then in order for the intension to not once again be a degenerate constant function, we must imagine that the circumstances of the conversation vary from index to index, so that *Bill's brick* picks out one object at one index, and another object at another index. But natural language does not allow the circumstances of the conversation to vary across indices in this way. For instance, if I say *If we were in Sienna, Bill's brick would be a reddish tan*, I am not saying that if we were in Italy, the referent of the expression *Bill's brick* would be a different object; rather, I can only be claiming that if we were in Italy, the very object referred to in our current conversation (say, the brick in Bill's hands) would have different properties.

One clue in support of this line of attack comes from the observation (Löbner, 1981; Caponigro and Heller, 2007; Percus, 2014) that definite DPs headed by functional relational nouns such as *capital*, *winner*, and *speed* make good concealed questions, but definite DPs headed by non-functional nominals such as *colony*, *citizen*, and *dimension* do not (e.g., **Ann found out France's citizen*). When the head noun is functional, there is no difficulty arriving at a unique value for the intension at each evaluation index (uniqueness is required by the definiteness in combination with the singular marking on the head noun). But when the head noun is not functional, the only way we can find a unique object to serve as the value of the intension at a given index is by relying on pragmatic information to narrow the domain, which is once again at odds with the requirement that the value of the intensional function vary from index to index in order to avoid a trivial question meaning.

9.2. Quantified sortals

Aloni and Roelofsen (2011:444) attribute the following example to Matthijs Westera:

(48) Ann knows every prime number.

This example suggests that providing a foreground and a background is not so cut and dried as the analysis here would suggest.

(49) a. Ann found out every prime number that is under 100.
b. Ann found out every prime number under 100.
c. Ann found out every prime number.
d. ?Ann found out every number.

Note that this example contains a quantificational determiner (*every*); quantificational concealed questions are also discussed above in section 8.4.

The variant in (49a) contains a relative clause, and so falls comfortably within the range of the official analysis here. The variant in (49b) contains a prepositional phrase modifier instead of a full relative clause, though it is synonymous with (49a). We can suppose either that the prepositional phrase should be analyzed as a reduced relative clause, or else that the ability to give rise to a foreground/background structure should be generalized from relative clauses to certain other modifier constructions.

The variant in (49c) is the original example, and (49d) shows that removing the adjective seriously degrades acceptability. To the extent that the example can be paraphrased as 'Ann found out which numbers in some relevant domain (foreground) are prime (background)', the required conceptual structure is present. But it would be a mistake to generalize the ability to create a foreground/background structure to all adjectives, since the prime number example is somewhat exceptional. Other choices of noun and adjective do not work nearly as well.

(50) a. Ann guessed the right number.
b. Ann revealed the expensive wine.
c. ?Ann knows the red apple.
d. ??Ann found out the salty pasta.

The concealed question interpretation of (50a) is impeccable. Focus stress on the adjective helps in (50b), but not in (50c) or (50d).

What these examples suggest is that although relational nouns and relative clauses provide foreground/background structures systematically and uniformly as a matter of their grammar, foreground/background articulation may be available in other constructions, but predicting when requires additional study.

10. Conclusions

As argued in section 2, we need the **?** shifter independently of concealed questions. The main hypothesis is that the **?** operator only applies to arguments that have been divided into a foreground and a background. This restriction expresses the claim that natural question meanings must always be articulated into a field of search and a classifying property.

Nathan (2006) also provides an account of the correlation between the internal structure of DPs and their ability to serve as concealed questions. He does this by providing a type-shifter that applies only to relational nouns, as well as a type-shifter that applies to relative clauses.

The main advance here has been to address the *Why?* question: Why are relational nouns particularly well-suited to concealed questions? The answer I have suggested here is that it is because relational nouns naturally align with the articulation of questions into a foreground and a background. On the assumption that this is an essential, fundamental property of the way that natural languages conceptualize questions, we have the beginnings of a deeper understanding of the larger cognitive requirements that constrain the distribution of concealed questions.

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