CONCEALED QUESTIONS ARE STRUCTURED
INDIVIDUALS

Abstract. Questions in natural language typically consist of a proposition articulated into a foreground part, which evokes a set of alternatives, and a background part, which provides a function for distinguishing among those alternatives. For instance, the question *Who left?* asks which of the people that *who* quantifies over (the foreground) have the property of leaving (the background).

Concealed questions are DPs that can be interpreted as if they were interrogatives. For instance, *I found out Bill’s age* means roughly the same thing as *I found out what Bill’s age is*, so the DP *Bill’s age* is functioning here as a concealed question. It has long been observed by Lübner and others that DPs containing 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 the same thing as *I found out which object the brick is*.

I propose that, just like ordinary clausal questions, concealed-question DPs must be articulated into a foreground and a background. For a DP headed by a relational noun, such as *Bill’s age*, the possible referents serve as the set of alternatives (that is, the set of ages), and the background property corresponds to standing in the relation denoted by the head noun to the possessor (Bill). In contrast, simple sortal DPs provide only a set of alternatives (e.g., the set of bricks), without providing any non-trivial property for distinguishing one brick from another. It is this lack of foreground/background structure that prevents DPs headed by sortal nominals from serving as concealed questions.

If so, then the denotations of definite descriptions must have internal structure in the way that has long been argued for propositions.

1. Concealed questions and the sortal/relational contrast

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, Löbner ms.). Roughly put, the observation is that, by and large, a DP that serves as a concealed question must denote a ‘functional concept’ (*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, and is taken up also in some detail by Frana 2013.

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 below in section 4), and they can all be grammatically and accurately paraphrased by replacing the DP with an interrogative (e.g., *Ann found out what Bill’s phone number is*).

In contrast, DPs headed by sortal nouns 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 below in section 5.1.

Assuming we want to find an explanation for the relationa/sortal
contrast, two pressing questions arise immediately:

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

To sharpen this question, we will see below a simple (but incom-
plete) theory of concealed question meaning on which relational and
sortal DP meanings are equally well-suited to giving rise to con-
cealed 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 lan-
guage conceptualizes questions as having two parts, a foreground
and a background. The foreground characterizes a set of possible
answers, and the background distinguishes among those possibili-
ties. If so, then interpreting a DP as if it were a question requires
articulating its meaning into 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 rele-
vant 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 in-
fluence the external distribution of the DP, in violation of most notions
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 in-
terpretation represent clauses containing focused elements as con-
sisting 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 ad-
ressing just what questions mean, leading to a theory of the mean-
ing of concealed questions, followed by a discussion of the the sort-
al/relational distinction for nominals, and finally to a refined theory of
concealed questions.
2. TWO EQUALLY NECESSARY PERSPECTIVES ON QUESTION MEANING

For our purposes, following the discussion in Krifka 2011, we can divide theories of question meaning into two main strategies: questions as functions on possible answer meanings, which I will call the foreground/background perspective; versus questions as sets of propositions. This dichotomy does not provide two incompatible ways to handle questions so much as two different but related perspectives on questions. We shall see that both perspectives are indispensable, both for question meanings in general, and 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. 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 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. The question Who left? will be represented from the foreground/background perspective as the ordered pair ⟨person, left⟩.

The foreground/background articulation captures two important generalizations about the grammar of questions and answers. The first generalization concerns question/answer congruence. We can represent the focus/background structure of the answer Ann left (with pitch accent on Ann) as the ordered pair ⟨ann, left⟩. The same answer but with pitch accent on left will be represented as ⟨left, λP.P(ann)⟩.

But only the first candidate 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 have the same background (in this case, the property left).
The second (related) generalization concerns reduced (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.

On the foreground/background approach, 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:

\[
\begin{align*}
\text{(a) Who left?} & \quad \langle \text{person, left} \rangle \\
\text{(b) Who bought what?} & \quad \langle \text{person, \langle thing, bought \rangle} \rangle
\end{align*}
\]

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 we need articulation into a foreground and a background at the very least in order to characterize question/answer congruence, and in order to license fragment answers and pair list readings.

2.2. Question meanings as partitions on the set of evaluation indices. To motivate the need for a second strategy, note that predicates that embed questions can take either single *wh*-questions or multiple *wh*-questions:

\[
\begin{align*}
\text{(11) a. I know [who left].} \\
\text{b. I know [who bought what].}
\end{align*}
\]

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 even more challengingly, different question types can be conjoined:
Ann knows whether it will rain, [yes/no]
who called, and [single wh]
who will arrive when. [multiple-wh]

This strongly suggests that we need a 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 sets-of-proposition approach.

Krifka 2011 identifies three major variants of the sets-of-propositions view. 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 2008, Groenendijk and Roelofsen 2009), the members of the set of propositions are in addition required to not stand in a subset relation with each other. Even more restrictively, on the partition view (Groenendijk and Stokhof 1982), the member propositions must divide up the context set (roughly, the evaluation points in the common ground) 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 it will make certain formal details simpler.

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

(13) Who left?

Each evaluation point is one possible situation (one possible world). The partition view groups together evaluation points that agree on what the answer to the question is. So two points will be in the same cell of the partition just in case the same people are leaving and not leaving in those two worlds.
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 inter-
rogative clauses.

As Krifka points out, the foreground/background approach is the
most general, in the sense that a suitable sets-of-propositions de-
notation can always be computed based on the functional represen-
tation, 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 the corresponding partition is the same.

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 ex-
plaining the main contrast under study in this paper.

More formally, we can convert from foreground/background inter-
pretations to partitions over the set of indicies as follows:

\[
\begin{align*}
[F, B]_i & = \{ \langle x, [B]_i^i(x) \rangle | x \in [F]_i \} \\
[F, (F', B)]_i & = \{ \langle x, (y, [B]_i^i(x)(y)) \rangle : x \in [F]_i, y \in [F']_i \}
\end{align*}
\]

For example,
\(\llbracket\langle\text{person}, \text{left}\rangle\rrbracket_i = \{\langle x, \text{left}_i(x)\rangle | x \in \text{person}_i\}\)
\(= \{\langle a, \text{left}_i(a)\rangle, \langle b, \text{left}_i(b)\rangle\}\)
\(= \{\langle a, \text{TRUE}\rangle, \langle b, \text{FALSE}\rangle\}\)
\(= \text{the set of people who left}\)

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 \(d\).

\(\llbracket\langle\text{person}, \langle\text{thing}, \text{buy}\rangle\rangle\rrbracket_i = \{\langle x, \langle y, \text{buy}_i(x)\rangle \rangle | x \in \text{person}_i, y \in \text{thing}_i\}\)
\(= \{\langle a, \langle c, \text{TRUE}\rangle\rangle, \langle a, \langle d, \text{FALSE}\rangle\rangle, \langle b, \langle c, \text{FALSE}\rangle\rangle, \langle b, \langle d, \text{TRUE}\rangle\rangle\}\)
\(= \text{the set of pairs of people and the things they bought}\)

In order to turn this denotation into a question meaning, we need Groenendijk and Stokhof’s \(\mathfrak{q}\) operator, which turns a function on indices (i.e., an intension) into a partition on the set of indices.

\[\mathfrak{q}(F, B) = \lambda i. (\llbracket (F, B) \rrbracket_i = \llbracket (F, B) \rrbracket_j)\]

Then \textit{Who left?} will judge two indices \(i\) and \(j\) as equivalent just in case the same people left in \(i\) as in \(j\). Likewise, \textit{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 I have stipulated that the question operator is only well-defined when it is applied to a foreground/background pair. This is not necessary for semantic reasons; in particular, the nothing in the definition here takes advantage of the access to the internal structure of the foreground/background pair. Thus restricting the \(\mathfrak{q}\) operator to foreground/background pairs is a substantive hypothesis about how natural language conceptualizes questions.

2.4. A note on intensions. The \textsl{intension} of an expression is a function that reveals 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 “\(s \rightarrow \ldots\)”, where \(s\) is the type of an evaluation index.

For instance, assume that the basic denotation of the DP \textit{the President of the United States} is an individual of type \(e\). 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 \(\begin{bmatrix} i & \mapsto & \text{Bush} \\ j & \mapsto & \text{Obama} \end{bmatrix}\).
Following much of the literature on concealed questions (in turn following Montague), we have:

(16) | Expression | Intension | Terminology | Example |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>clause</td>
<td>s \rightarrow t</td>
<td>proposition</td>
<td>Ann left.</td>
</tr>
<tr>
<td>referential DP</td>
<td>s \rightarrow e</td>
<td>individual concept</td>
<td>the President</td>
</tr>
<tr>
<td>interrogative</td>
<td>s \rightarrow (s \rightarrow t)</td>
<td>relation overindices</td>
<td>Who left?</td>
</tr>
</tbody>
</table>

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 (though see section 8.1 for a possible exception involving concealed questions). So if an embedded non-interrogative clause denotes, say, a truth value, Montague’s 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, called here a ‘proposition’. Likewise, assuming that referential DPs denote individuals, Montague’s composition rule will always deliver the intension of an individual, that is, an individual concept. (I’m assuming, by the way, that referential DPs denote individuals, not generalized quantifiers, in the spirit of, e.g., Heim and Kratzer 1998.)

The extension of a semantic value is an intension applied 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 semantic arguments, since the system guarantees that all arguments are intensional; nevertheless, a predicate is said to be ‘extensional’ if it ignores the extra information provided by an intensional function.

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, as long as they have the same extension with respect to the world of evaluation. For instance, at an index where Obama is president, *Ann pinched the President* entails *Ann pinched Obama*. In contrast, for verbs that are intensional rather than extensional, such as *seek*, the corresponding inference does not go through: *Ann seeks the President* does not entail *Ann seeks Obama*. 
2.5. Reducing knowing-who to knowing-that. Note that the extension of a question is the same type as the intension of a non-interrogative clause, namely, $s \rightarrow t$. On the partition view, then, a question extension is semantically equivalent to a proposition. This is supposed to explain why predicates that embed interrogatives almost always also allow non-interrogative clauses as complements, since the extension of the one is the same type as the intension of the other.

(17) 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 $\lambda j. \text{left}_i = \text{left}_j$, 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. Some 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. This non-equivalence is supposed to explain the fact that wonder, unlike know, does not allow non-interrogative complements (*Ann wonders that Bill left), and therefore certainly not concealed questions (*Ann wonders the capital of Italy).

3. A SIMPLE BUT INCOMPLETE THEORY OF CONCEALED QUESTIONS

   How do concealed question DPs give rise to question meanings?

(18) 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, function of type $s \rightarrow e$. What we need in order to have a question meaning is a
Figure 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. 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.

\[
\begin{array}{c}
\text{partition over the set of evaluation indices, that is, a function of type} \\
\text{s \to (s \to t).}
\end{array}
\]

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 or propositions. The strategy adopted here will be to have unitary meanings for question-embedding verbs, and to convert concealed-question DPs into question meanings.

The way in which we will accomplish this 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 Figure 1.

\[
\begin{align*}
?([\text{Bill’s age}]) &= \lambda ij.([\text{Bill’s age}]^i = [\text{Bill’s age}]^j)
\end{align*}
\]

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 \( \lambda j.([\text{Bill’s age}]^j = [\text{Bill’s age}]^i) \). 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.

A technical note: for all functions \( f \), \( ?f \) is a fixed point for \( ? \), that is, \( ?(?f) = f \). This is because \( ?f \) is a function that maps each index \( i \) onto the set of indices that are in the same equivalence class. So \( ?f \) maps any two equivalent indices to the same value. Therefore \( ?(?f) \) maps two indices to the same value just in case they are already equivalent with respect to \(?f\).

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.

\[
(19) \quad (20) \quad *I \, know \, in \, the \, fridge \neq I \, know \, what \, is \, in \, the \, fridge \\
(21) \quad *I \, found \, out \, expensive \neq I \, found \, out \, what \, is \, expensive
\]

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, there is no 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.

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 since Barker 1995 and 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 Bryun et al. 2013 for 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. That is, the relational terms are essentially relational at least conceptually (and, as we will see, arguably syntactically and semantically as well).

In order to argue that the conceptual sortal/relational 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. 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 Borchev 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 examples given above in (25).

The way that the sortal/relational distinction fits into the larger story here is that when concealed question DPs are possessives, they strongly prefer a relational head noun.

(27)  a. the age of everyone (age is relational)  
      b. Ann knows everyone’s age.

(28)  a. *the brick of everyone (brick is sortal)  
      b. *Ann knows everyone’s brick

The contrast between sortal and relational nouns has been noted before, in Lübner 1981, Nathan 2006, Frana 2006, 2013, and elsewhere.

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:

      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 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 a 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 the hypothesis, then, is that natural language requires that in order to constitute a natural question, a question meaning must provide a set of alternatives to choose among, as well as property to use to distinguish among the alternatives.

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 a DP containing a relative clause and a wh-question 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, e.g., Barker and Shan 2014 chapter 7). 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 subsection, the official denotation for (31a) is the one provided by ? applied to the intension 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 type-shifting perspective remains essential is to note, as, e.g., Aloni and Roelofsen 2011 emphasize, 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 types of questions, whether they are single or multiple wh, or whether they are concealed-question DPs, to the same kind of partition on the set of indices.

6. Sketch of an implementation

By hypothesis, relational nouns denote foreground/background structures.
(34) \[ \text{[\textit{birthday}]} = \langle \text{day}, \text{born-on} \rangle \\
\text{[\textit{birthplace}]} = \langle \text{location}, \text{born-at} \rangle \]

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

The postnominal possessive of and the prenominal possessive construction both supply an argument to the background element.

(35) John’s birthday \equiv \text{birthday of}_{\text{POSS}} \text{John} \equiv \\
\text{POSS}([\text{\textit{john}}, \langle \text{day}, \text{born-on} \rangle]) = \langle \text{day}, \text{born-on(\text{\textit{john}})} \rangle

The fact that the possessive of requires a foreground/background structure accounts for its restriction to relational nominals.

For the purposes of this paper, I’ll assume that the definite determiner \textit{the} 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, pointwise function application will incorporate the referent into the larger denotation in an appropriate way.

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:

John’s birthday \equiv \text{the birthday of } \text{John} \equiv \\
[\langle \langle \text{\textit{day}}, \text{\textit{born-on(\text{\textit{john}})} } \rangle \rangle^i] \\
= \{ \langle a, f a \rangle | a \in \text{day}_i, f \in \text{born-on}_i(\text{\textit{john}}_i) \} \\
= \{ \langle 1\text{-Jan}, \text{TRUE} \rangle, \langle 2\text{-Jan}, \text{FALSE} \rangle, \ldots \}

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 restore the restriction of the type-shifter ? so that it is only well-defined if its argument is a foreground/background structure. If so, we have
John’s birthday 
= the birthday of John 
= \(\lambda i,j.(\langle \text{day, born-on}(\text{john}) \rangle^i = \langle \text{day, born-on}(\text{john}) \rangle^j)\)

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 means they can’t combine with a postnominal possessive of phrase. This means that the semantics of the prenominal possessive introduces a pragmatically-controlled possession relation, represented here by the unbound relation-denoting variable \(\pi\):
\[
[\text{John’s day}] = \{x | \text{day}(x) \land \pi(\text{john})(x)\}
\]

Since this DP meaning is not a foreground/background structure, it is not in the domain of the \(?\) operator, so it is correctly predicted to not give rise to a concealed question meaning.

The contrast between *Ann found out John’s birthday versus *Ann found out Bill’s day just explained shows that ability to serve as a concealed question does not depend on the presence versus the absence of an overt possessor.

As argued above in section 4, the adjective favorite turns a sortal nominal into a relational nominal:
\[
[\text{favorite day}] = \langle \text{day, favorite(day)} \rangle
\]

This synthetic relational nominal combines with a possessor in the way described above, so that
\[
[\text{John’s favorite day}] = [\text{favorite day of John}] = \langle \text{day, favorite(day)}(\text{john}) \rangle
\]

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, 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 here, I’ll simply stipulate that the relative clause operator REL introduces the appropriate structure. For the DP *the street that the restaurant is located on*, we have
\[
\text{REL}([\text{that the restaurant is located on}])([\text{street}]) = \langle \text{street, on(\text{the-restaurant})} \rangle
\]
This gives the appropriate concealed-question meaning.

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

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

Incidentally, the hypothesis here explains the restriction to functional relational concepts noted by Löbner 1981 and Caponigro and Heller 2007. That is, DPs headed by functional relational nominals such as capital, winner, and speed make good concealed questions, but non-functional nominals such as colony, citizen, and dimension do not (e.g., *Ann found out France’s citizen). The reason is that the type-shifter only delivers a partition if its semantic argument is a function. If the argument is a non-functional relation, it maps a single input (say, France) to multiple outputs. The relational indeterminacy makes it impossible to decide whether two indices ought to count as equivalent.

6.1. 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:

(38)  *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 8.3 below).

Clearly some classes of 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

(39)  Ann’s mother has not yet been determined.
Because the theory here depends on the lexical interpretation of relational nouns, it is perfectly feasible to give the sort of interpretation that gives rise to concealed questions to a proper subset of the class of relational nouns. So it is much more important for the account here that all concealed question DPs be relational nouns, rather than that all relational nouns make good concealed questions.

However, there may be some sporadic examples of concealed questions in which the head nominal is not obviously a relational noun.

(40) Ann wants to know the time.

In some sense, time is relational, and means something like *now’s time. 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 a theater performance, it makes sense to say

(41) 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.

But these potential counterexamples notwithstanding, it seems clear that the overwhelming majority of concealed questions involve relational nominals, a correlation for which the current paper offers an explanation.

7. Conclusions: structured individuals can explain restrictions on concealed question DPs

The crucial assumption here is that the ? operator requires a foreground/background structure as an argument. This restriction expresses the hypothesis that natural question meanings must always be articulated into a foreground and a background. We need the ? shifter independently of concealed questions, and the fact that it is restricted to foreground/background structures automatically explains
why concealed questions are restricted to DPs headed by relational
nominals and DPs containing relative clauses.
Nathan 2006 provides an account of the correlation between the
internal structure of DPs and their ability to serve as concealed ques-
tions. He does this by providing a type-shifter that applies to re-
lational nouns, and a different type-shifter that applies to relative
clauses. In the absence of a detailed theory of relative clause forma-
tion, the account here is stipulative to a comparable degree. What,
then, has been accomplished beyond what Nathan already achieved?
There are differences that bear emphasizing. The main potential
advance is supplying an answer to the Why? question: Why are re-
lational 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, fun-
damental property of the way that natural languages conceptualize
questions, we have the beginnings of a deeper understanding of the
distribution of concealed questions.
In the implementation given here, some DPs denote ordered pairs
consisting of a foreground and a background. The semantic evalua-
tion rules guarantee that this bipartite structure collapses into a set
of ordinary denotations. Nevertheless, in order to check whether the
restriction imposed by the question operator ? to apply only to struc-
tured meanings, it is necessary to assume that even some referential
DPs must have internal structure, just as theories of focus structure
and theories of structured propositions assume for other expression
types.

8. Appendix: miscellaneous notes

There are a number of issues in the literature of concealed ques-
tions that I have not addressed. I’ll mention a couple here.

8.1. The price ambiguity. Heim 1979 suggests that there are two
distinct ways to know a price.

(42) Ann knows the price that Bill knows.

Assume that Bill knows the price of milk (and nothing else). Then ei-	her Ann knows the price of milk, and may not even know of Bill’s
existence; or else Ann might know what commodity it is that Bill
knows the price of, without necessarily knowing herself how much
milk costs.
Romero 2005 provides a solution based on the assumption that
the predicate denoted by *price* has individual concepts in its exten-
sion, rather than plain individuals. The idea is that a price is a func-
tion from indices to what some object costs at that index. If so, then
the extension of the *price that Bill knows* will already be a function on
the set of indices, before intensionalization. Romero proposes that
in such circumstances, in terms of the analysis proposed here, 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 shifting the intension of
the DP. So at least one solution for the ambiguity translates smoothly
into the approach given here.

Lasersohn 2005 shows some of the difficulties that can arise when
nouns are allowed to have individual concepts in their extension
(though see Romero 2006 and Schwager 2009), and in Schwager
2008, M. Kaufmann gives a solution to the *price* puzzle on which it
has ordinary individuals in its extension. Her solution depends on
conceptual covers (see below).

8.2. Quantified concealed questions. There are two ways to intro-
duce quantification into a concealed question DP.

(43) Ann knows everyone’s phone number.

(44) Ann knows every phone number.

In (43), the possessor is a quantificational DP. Frana 2013 proposes
that when the quantifier takes scope, it can leave behind a trace that
has the type of an individual concept, rather than of a plain individ-
ual. Then, adopting Romero’s assumptions described in the previ-
ous subsection, the individual concept trace can be shifted into a
question meaning directly. This requires a number of changes to the
standard semantics of scope-taking (e.g., Heim and Kratzer 1998),
but could certainly be adapted to the approach here.

On the approach here, a simpler explanation is possible, as long
as the quantificational possessor phrase is allowed to take scope
outside at least the ? type-shifter, and presumably over the embed-
ing verb as well. Then the analysis of (43) can be

$$\forall x. \text{know}(\text{?phone-number } x))(\text{ann}),$$

which gives reasonable truth conditions. This would require allowing
a quantifier to take scope outside of the DP in which it occurs, which
is usually forbidden (e.g., Büring 2004); unfortunately, this issue is
too complicated to address in detail here.
As for the quantified relational DP in (44), following suggestions of Heim 1979, Frana claims that this example is ambiguous. It either means that Ann knows a set of phone numbers without knowing whose they are (what Frana calls the ‘set’ reading); or else it means that for each person in some relevant domain, Ann knows that person’s phone number in the usual concealed-question way. Frana proposes to capture this second meaning by allowing the relational noun phone number to have in its target set individual concepts rather than individual number sequences. In order to accomplish this, she adapts a type-shifter proposed by Nathan in order to explain how relational nominals give rise to concealed-question meanings. Since the explanation given above does not rely on Nathan’s type-shifter, such a solution would not have independent motivation here, though it could certainly be adopted. If the second interpretation is indeed systematically available with quantified relational DPs, more work is needed to understand how it works from the point of view of the current proposal. See Romero 2010 for a quantificational strategy similar to the one needed here.

8.3. Conceptual covers. Aloni and Roelofsen 2011 observe that whether a sentence involving a concealed question is true or false can depend on the epistemic state of the attitude holder. Imagine there are two playing cards, face down on the table.

(45) Ann knows the winning card.

This can be true if Ann merely knows which of the cards will complete a winning hand (say, the Ace, but not the Jack), even if she doesn’t know which of the cards is the Ace. On a different interpretation, (45) can be true if Ann knows which of the face-down cards will result in a win, even if she doesn’t know whether the Ace or the Jack is the desired card. Aloni suggests that truth depends on conceptual covers, which associate attitude holders with properties for categorizing objects in various ways.

It’s not clear that this variability in interpretation requires any adjustment to our theory of concealed questions.

(46) The Ace is the winning card.
(47) The card on the left is the winning card.

The occurrences of the winning card are not concealed questions. Their interpretations correspond to two distinct individual concepts:
Presumably any theory that delivers this ambiguity for the DP independently of the concealed-question construction will give the right result when the DP is interpreted as a concealed question.

8.4. A kind of hyperintensionality. Löbner 2011 suggests that in order to qualify as a functional concept (which he claims is required in order to serve as a concealed question), an individual concept must vary across indicies, that is, cannot be a rigid designator. On the current proposal, there is no such requirement.

(49) Ann knows the square of 2.

The square of 2 is 4 at every index, yet (49) is perfectly fine as a concealed question. This is consistent with the account here, as long as we recognize that square is a properly relational concept that delivers its semantic contribution in the form of a foreground (the property of being a number) and a background (the property of being some number multiplied by itself).

(50) Ann knows the square root of 16.

What remains mysterious here is how (49) can be true at the same time that (50) can be false (which I take to be entirely possible, if Ann’s powers of arithmetic are at a certain rudimentary level). If know operates purely on question extensions, then this is a hyperintensionality puzzle parallel to standard propositional attitudes.

(51) Ann knows that 4 is the square of 2.

(52) Ann knows that 4 is the square root of 16.

The standard judgment is that (51) and (52) can differ in truth value, despite the fact that the intension of the embedded clauses are the exact same (constant) function from indicies to truth values.

One well-known approach to this kind of hyperintensionality (e.g., Soames 2014, King 2007) is to suppose that propositions are articulated into a structure that distinguishes at least a subject and a predicate. Since the predicates of the two propositions are distinct (being the square of 2 versus being the square root of 16), it is possible to correctly predict that the truth values of these attitude reports can differ. There is still work to be done here in order for the truth value of a concealed question to depend on the structure internal
to the foreground/background articulation, but the analysis proposed here provides exactly the right sort of information for addressing the kind of hyperintensionality illustrated in the contrast between (49) and (50).

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