1

know-how: A compositional approach

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1.1 *de se* know-how[1]

Consider John Perry's (1977) friend Rudolph Lingens, an amnesiac lost in the Stanford Library. Lingens is very intelligent and exceptionally well-read, and has access to all kinds of propositional information about a fellow named Rudolph Lingens. In the library, among other things, he has read that Rudolph Lingens is in aisle five, floor six, of the Main Library, Stanford. Moreover, (1) is true of the amnesiac Lingens:

(1) The poor fellow knows that Rudolph Lingens can get out of the Stanford Library by going down to the first floor, turning right at the circulation desk, and exiting straight ahead.

But unfortunately, the poor fellow doesn't know that he* is Rudolph Lingens (in the sense of *he** due to Hector-Neri Castañeda 1966). David Lewis embroiders the story a bit. Suppose that Lingens has narrowed down his identity to one of two individuals, one of whom, Rudolph Lingens, is located on the sixth floor of the Stanford Library, and the other, Lester Reynolds, is located on the lowest level of the Widener

[1]This paper grew out of invited comments on a paper by Barbara Abbott that was presented at the Pacific Meetings of the American Philosophical Association in March, 2006. Thanks to the conference organizers and to Barbara Abbott for this stimulating opportunity. The analysis proposed here is based on unpublished work by David Dowty and Polly Jacobson, and I thank them for generously sharing it with me. I am also grateful to Polly Jacobson and an anonymous reviewer, who provided very valuable, detailed comments on a more recent draft. Thanks, as well, to Yusuke Kubota, for his assistance with the LaTeX preparation of the manuscript for publication.

A LaTeX Package for CSLI Collections.
Edie Tor and Ed Itor (eds.).

Library, below street level. Lingens, standing among the stacks, just doesn't know which location he is in. Hence, though he wants to leave, he doesn't know whether to go down five floors or up three. It seems clear in this case that he doesn't know how to get out of the library. That is, there is a sense in which (2) is true in this scenario:

(2) Lingens doesn't know how to get out of the library.

Actually, just one additional piece of information would enable Lingens to get out, the self-ascription of the property of being Rudolph Lingens, which would permit him, on the basis of his propositional information, to locate himself in the Stanford Library. Hence, (3) is true, as well:

(3) If Lingens knew that he was Rudolph Lingens, he would know how to get out of the library.

But, as David Lewis (1979) has argued convincingly, the additional information Lingens needs is not propositional. On the view of a proposition as a set of possible worlds, the information Lingens needs does not distinguish between possible worlds, but between locations within one and the same world.

This, in a nutshell, is the central problem with a paper by Jason Stanley & Timothy Williamson (2001) on knowing-how. It argues cleverly for the thesis that knowledge-how, like knowledge-that, is propositional. But I will argue that knowledge-how is richer: It involves self-ascription, and hence is not reducible to propositional knowledge. This is clear in virtue of our intuitions about the meanings of examples like (1)–(3), intuitions that Barbara Abbott (2006) rightly defends in her response to Stanley & Williamson. But it also follows from systematic compositional semantic analysis of the constructions and lexical items involved, an analysis whose parts can all be independently motivated.

As Abbott demonstrates, in order to maintain their central thesis Stanley & Williamson have relied on some controversial assumptions about the infinitival *how to* construction, and, crucially, on the assumption of a "practical mode of presentation" which is not at all innocent from the perspective of the truth conditional distinction between knowing-how and knowing-that. I propose a linguistic analysis of the construction that is crucially different from that appealed to by Stanley & Williamson. Given the *de se* character of knowledge-how statements observed above, I will argue that it isn't that we have a choice between two equally plausible linguistic analyses. Rather, the analysis sketched here is empirically superior in that it correctly predicts the attested interpretations more accurately than does Stanley &

Williamson's analysis, which requires various *ad hoc* stipulations and leaves a number of loose ends, all of which have been pointed out by Abbott.

1.2 A compositional analysis of the *know how-to* construction

Here's what a fully adequate compositional semantic analysis of the *know how to* construction in English requires:

- a general account of the meaning of *to* infinitival phrases: Portner (1997)
- a general account of the meaning of interrogatives, and of interrogative complements in particular: Groenendijk & Stokhof (1984,1997)
- an account of *wh*-infinitival complements that builds on the first two accounts: slight modification of Dowty & Jacobson (1991)
- an analysis of the meaning of *how*, as opposed to the other *wh*-words that occur in *wh*-infinitivals
- a general account of the meaning of *know* and of how that combines with the meaning of its *wh*-infinitival complement to yield the attested interpretation
- an account of the phenomenon of control, whereby the understood subject of the complement infinitival VP is conveyed

In the optimal theory, all these elements would be independently motivated, on the basis of the behavior of the components in other constructions. I think we can provide such an account, though convincing you of the independent motivation for each of the pieces would take a good deal more space than I have here. But I hope that in the following sketch of an analysis I can make the claim plausible, and suggest how the pieces of the puzzle fit together to yield the sorts of meanings we observe in the relevant examples. Moreover, I think the resulting account helps to explain why certain combinations are unattested, and why the combinations we do see fail to have certain readings. This is just what we want from a generative linguistic account supplemented by a semantic theory of the sort originally proposed by Richard Montague (e.g. 1973): a prediction of all and only the grammatically sanctioned strings and their interpretations.

Let's begin with infinitivals. Paul Portner (1997:185) is concerned, among other things, with infinitival clauses like *for Joan to arrive in Richmond soon*. His account of these complements is summarized in the following truth conditions:[2]

[2]An anonymous reviewer claims that use of the operator $\mathcal{F}$ to introduce the characteristic semantics of the infinitival construction "sounds strangely uncompo-

(4) Given a set of situations S, a situation of evaluation $r \in S$, an infinitival formula ϕ, and an operator $\mathcal{F}$ that introduces the characteristic semantics of the infinitival construction:
$||\mathcal{F}(\phi)||^r = \{s \in S : s$ has as its initial segment a dispositional counterpart of r and for some $s' \leq s, s' \in ||\phi||^r\}$

For his (5), this means (p.185):

(5) James wants for Joan to arrive in Richmond soon.
gloss: 'In all of James' buletic alternatives[3], Joan arrives in Richmond soon.'
embedded infinitive denotes: a set of situations which (speaking loosely) begin with James's wanting and extend into the future, eventually including a situation of Joan arriving in Richmond soon after the wanting.

Like imperatives (Portner 2004, 2006), *to*-infinitivals are tenseless (Wurmbrand 2001), but in both cases there is a futurity conventionally associated with the construction, as we see in (5), and this is crucial to their sense, distribution, and function. I'll assume that this is the correct general view of infinitivals.

Extending this analysis, we derive the following semantics for infinitival VPs:

(6) Given:
- an infinitival VP of the form *to* δ,
- a model with domain *Dom*, a set of situations S, and a situation of evaluation r, and
- Portner's operator $\mathcal{F}$ that introduces the characteristic semantics of the infinitival construction (as in (4) above),

$||\text{to } \delta||^r$ is that function $f \in (Dom \times Pow(S))$ such that for all $d \in Dom, f(d) = ||\mathcal{F}(\delta(d))||^r = \{s \in S : s$ has as its initial segment a d-dispositional counterpart of r and for some $s' \in s, s' \in ||\delta(d)||^r\}$.

For any given agent d and situation r, a d-dispositional counterpart of r is a situation in which d has the same doxastic and buletic dispositions—the same beliefs and desires—as in r. The notion derives from the dispositional theory of action of Lewis(1986) and Stalnaker (1987); see Portner (1997), pp.173 and 177, for discussion and implementation within his theory. If we add a temporal dimension to the

sitional". This is Portner's terminology; one could simply take it as the meaning introduced by overt *to* in examples like (5) below.

[3]These are situations accessible to the situation of evaluation r under a buletic (conative) accessibility relation, one reflecting James' wishes or desires in r.

model, *d*'s dispositions must be the same in the two situations at the time of evaluation.

What about interrogative infinitival complements, of the sort we find in *know how to* constructions? These differ from the clausal infinitivals studied by Portner in two respects: They are interrogative, with an initial interrogative pronoun, and they cannot have an overt subject. To capture the interrogative component, Stanley & Williamson adopt the prominent theory of embedded questions of Karttunen (1977), on which (7) entails that Stuart knows all the true answers to the question of what Mark had for breakfast:

(7) Stuart knows what Mark had for breakfast.

If Mark had scrambled eggs, Stuart knows that Mark had scrambled eggs. If he had a bagel, Stuart knows this, etc. Groenendijk & Stokhof (1997) call Karttunen's theory *weakly exhaustive*, contrasting this with strongly exhaustive theories like their own. Strong exhaustivity adds a closure condition, so that on this account Stuart not only knows all the positive answers, he also knows all the negative answers to the question. The intuitive difference is that if the denotation of a question is the conjunction of all the true answers, this is just a proposition, which is what Stanley & Williamson assume; but if it is strongly exhaustive, then we know not only the exhaustive true answer, but *that it is the exhaustive true answer to that question*. More concretely, if Mark did not have pancakes for breakfast, Karttunen's theory cannot predict that (7) entails (8), whereas the strongly exhaustive theories can:

(8) Stuart knows whether Mark had pancakes for breakfast.

For this and a number of other reasons not directly relevant here, I'll adopt Groenendijk & Stokhof's theory. Formally the denotation of a question is a partition over the set of possible worlds, a set of (non-intersecting) propositions the union of which is identical to the set of all possible worlds. Any two worlds *w* and *w'* are in the same cell of the partition corresponding to *what did Mark have for breakfast?* in case Mark had exactly the same things for breakfast in *w* as in *w'* . The partition corresponding to the *whether*-clause in (8) divides the set of all possible worlds into two cells: those in which Mark had pancakes and those in which he did not. Because the question of whether Mark had pancakes is a subquestion of *what did Mark have for breakfast?*, the partition corresponding to the former is a sub-structure of that for the latter, so that knowing which cell corresponds to the correct answer for the super-question entails knowing it for the sub-question as well.

Stanley & Williamson assume that *wh*-infinitivals like *how to* are clausal, with a subject position in the syntax filled by a phonologically unrealized element, PRO. They appeal to the long literature in syntactic theory which attempts to explain how PRO gets its reference as a syntactic reflex of the control properties of the main-clause verb. In this literature, PRO may be obligatorily controlled by either one of the arguments of that main verb, as specified in the verb's lexical entry, or it can receive the so-called PRO_{arb} interpretation, where it denotes the arbitrary individual. I'll call the arbitrary interpretation *generic*.

I will argue for a different analysis of *wh*-infinitivals, one developed by David Dowty and Pauline Jacobson (1991). Their work builds both on the view of questions of Groenendijk & Stokhof and on a different kind of approach to infinitivals without overt subjects, one in which the infinitivals in question are VPs rather than sentential constituents. The agentive argument of the infinitival VP is not given as a syntactic subject—the implicit PRO of Stanley & Williamson's theory. Rather, other factors in the semantics and pragmatics of the utterance lead the hearer to understand who is entailed to have the property denoted by the VP.

In keeping with the VP status of these constituents, Dowty & Jacobson argue that infinitival questions denote not propositions, but properties of a certain sort: "Infinitival Questions denote hypothetical, unsaturated, appropriate actions". Note that the notion of action they have in mind is rather different from the colloquial sense, as we see in (9):

(9) Dowty & Jacobson's (1991) semantics of *wh*-infinitivals (informal):
"Infinitival Questions denote hypothetical, unsaturated, appropriate actions", i.e.

   a) **actions**: properties which it is under an agent's control to possess or not to possess

   b) **appropriate**: by some contextually implicit criterion, e.g. useful for attaining some goal, profitable, healthy, safe, legal, moral, pleasurable, etc.

   c) **unsaturated**: the value of one or more arguments (represented by the *wh*-word) in the actions are unspecified; these correspond to the range of choices the agent will have in selecting the particular action to perform (now or later).

   d) **hypothetical**: it is presupposed that they are not yet carried out by an agent at the time referred to.

> "That is, an Infinitival Question denotes a function from one or more arguments into a kind of property, what we call an action."

Dowty & Jacobson illustrate their proposal formally for the denotation of *what to eat* as in (10):

(10) *what to eat* denotes
$\lambda x_{agent} \lambda w \lambda w' [\lambda y_{theme} [\mathrm{ACT}(eat(w)(y))(x) =$
$\mathrm{ACT}(eat(w')(y))(x)]]$
where $\mathrm{ACT}(P)(x)$ means 'P is an action appropriately performed by x' [with the sense of action in (9a), CR]

This is a function from individuals (agents) to partitions over the set of worlds. In (10) the partitioning is captured via a curried function, correlating to a relation over the set of worlds.[4] But any two worlds are in the same cell of the partition for a given agent just in case for any given edible object, either the agent acts so as to eat that object in both worlds or does not do so in either. Hence, a cell in the partition contains worlds where the agent aims to eat exactly the same things. This is the interrogative counterpart of an infinitival VP; instead of denoting a function from an individual to a proposition, it denotes a function from an individual to a question.

As noted, the sense in which these properties are actions is not that they are precisely actions to be undertaken. Dowty (1972, 1979) had discussed in detail, the so-called "agentive statives" and their occurrence in imperatives such as *Don't worry!*, *Be polite!*, *Be a gentleman!*, and the like. These agentive statives also occur in *wh*-infinitival complements: *Marvin wondered how not to worry.* It is with a view to the occurrence of such statives in the construction of interest that Dowty & Jacobson use the notion of action in this constrained sense. Ginzburg & Sag (2000), noting the same issue, accordingly characterize the class of properties in the denotations of both infinitival questions and imperatives as *outcomes*. For reasons that will become clear, I prefer to choose a term that underlines the intentional character of the agent's relation to these outcomes: As in Dowty & Jacobson's *actions* and Portner's analysis of imperatives, the denotations of these constructions represent the kind of eventualities the agent is (or might be) *committed to bringing about*. So for any given agent, I will call the set of such prop-

[4] Currying, sometimes called a *Schönfinkelization* (e.g., in Heim & Kratzer 1998), transforms a function taking a tuple of arguments into one which takes those arguments one at a time. E.g., from $f : (X \times Y) \mapsto Z$ into $X \mapsto (Y \mapsto Z)$. A partition takes any two worlds into a truth value (true just in case they're in the same cell of the partition); but the function in (10) instead takes any two worlds one at a time.

erties that agent's *goals*, keeping in mind the sense of that term in the philosophy of action and in Planning Theory in AI, wherein having a goal entails having a persistent commitment to achieving the goal (e.g. see Bratman 1987, Pollack 1986). Thus, I propose (11), with the associated conditions on goals in (12):[5]

(11) *what to eat* denotes
$\lambda x_{agent} \lambda w \lambda w' [\lambda y_{theme} [\text{GOAL}_x(eat(w)(y))(x) = \text{GOAL}_x(eat(w')(y))(x)]]$
where GOAL_x means 'is a rational goal given x's circumstances and commitments'

(12) **Goal Rationality**: It is only rational to adopt a goal if:
a) **payoff**: there is a potential payoff if one achieves it. (This may be indirect; e.g., Mary hates codfish, but if she eats it, she stands a better chance of avoiding rickets.)
b) **feasibility**: one has reason to think it's achievable, given the information one has.
c) **compatibility**: one doesn't have pre-existing goals or commitments which preclude acting to achieve the goal in question.

If any of these conditions fail, adopting the goal is at best a waste of one's time.

Though the change from (10) to (11) is to a large extent terminological,[6] the association of the type of actions in question with goals in the Planning sense brings out other features of this account which

[5]There is another benefit to characterizing Dowty & Jacobson's ACT as GOAL, though there isn't space to discuss that here: As Stanley & Williamson note, an infinitival *how-to* question typically has a mention-some interpretation, rather than mention-all. That is, for an answer to satisfactorily resolve (Ginzburg 1995) a question about how to do y, it needn't entail all the ways that one might do y. One way would do. I would argue that this is due to the way that resolution of questions generally should be judged relative to the goals that the questions subserve. One way of doing x will typically serve the goal of getting x done as well as another, and so there is generally no need to specify more than one way, let alone all the possible ways one might accomplish it, unless there are questions about the feasibility of the various methods. Hence, the so-called "mention-some" interpretation (which I have argued elsewhere to be due to pragmatic domain restriction, instead of a distinct interpretation) arises out of the subsumption of the question-answering goal to the over-arching goal.

[6]I do not mean that Dowty or Jacobson would agree to the proposed modification, and in fact I know that Dowty (p.c.) prefers the original term. Rather, the modification aims to preserve what is correct about their account, while drawing out some of the crucial features of what it is to adopt an ACT of the sort they describe.

help to explain the properties of the *know how to* construction under discussion. When any of the conditions in (12) fail, adopting the goal in question would be irrational. So, one can only rationally adopt a goal so long as one believes it has not yet been accomplished; otherwise, there would be no pay-off and condition (a) would fail. In this respect, we can see how the futurity generally associated with infinitivals, as in Portner's analysis, makes them well-suited to the expression of goals; thus, the semantics of the *wh*-infinitivals is compatible with that for infinitivals more generally. We'll see some other virtues of this characterization shortly.

The futurity involved in both *wh*-infinitivals and infinitival VPs is not the only reason to assume that *wh*-infinitivals characterized as in (11) are derived from infinitival VPs with denotations like that in (6). To derive (11) compositionally, an interrogative pronoun would take an infinitival VP to make a function from individuals to a relation between worlds, i.e. a function from individuals to questions. According to Portner's analysis, infinitival VPs involve a disposition and what we might call an outcome; Portner doesn't make explicit the relationship between the disposition and the outcome, but I believe it would be in keeping with his conception, and with the Kratzer-style modal semantics on which it is based,[7] to characterize the latter as the ideal outcome given that disposition. The notion of a goal, as defined in Planning Theory and constrained by (12), is stronger than the usual colloquial notion of a disposition, since goals involve persistent commitments, while dispositions need not. But I believe we would say that anyone who has a given goal is disposed to attempt to achieve it, so that having a goal entails holding the corresponding disposition to act. Suppose we give the agent argument to the denotation of the *wh*-infinitival as characterized by Dowty & Jacobson and reframed in (11). The result is a question about what kind of goal it would be ideal for that agent to adopt, and hence a question about what kind of disposition that agent should cultivate. Suppose that in a situation s a given agent a has goal g. This entails that in s a has a disposition whose ideal outcome is g.

Working out the details of how we might derive (11) from (6) is nontrivial. Technically it involves the interrogative binding the situation-of-interpretation r in (6), so that the resulting question partitions the set of situations (or worlds—the maximal situations) into maximal sets in which the relevant agent shares the same dispositions. One challenge is to explain how, when an interrogative pronoun takes an infinitival VP as argument, this results in strengthening the disposition associ-

[7] e.g., see Kratzer 1980, 1989

ated with the VP into a goal. Another is that since Portner's account is couched in situation semantics, we would have to transpose Dowty & Jacobson's possible worlds-based account into situation semantics in order to perform the derivation in a rigorous fashion. But this in turn would depend on a general account of questions in situation semantics, something which, to my knowledge, has not yet been satisfactorily worked out. Such an account in turn would require exploring the ramifications of interrogativity for a number of difficult issues that tend to arise in situation semantics, e.g. issues of persistence, genericity, and negation,[8] and tackling such issues would take us way beyond the current discussion. Another way of technically coordinating the two accounts would be to attempt to re-frame Portner's in terms of classical possible worlds; e.g. one might introduce temporal intervals, and characterize the agent's dispositions in a world-at-an-interval instead of in a situation. However, Portner's motivations for using situations semantics are quite subtle, and it isn't clear whether the transposition to the coarser-grained possible worlds framework would retain all the essential features of his account. I will not attempt to address these issues in the present paper, except to say that I suspect that all these challenges and more would face anyone attempting to give a compositional account of the denotation assumed by Stanley & Williamson. I only hope that I have made clear the intuitively plausible connection between Portner's infinitival VP denotations and Dowty & Jacobson's *wh*-infinitival denotations.

Now consider how (11) interacts with verbs that take *wh*-infinitival complements. For all such verbs, "some person knows, communicates, decides, etc. what values can be given to the unsaturated argument(s) to yield an action that is appropriate (for someone) in the implicitly relevant way" (Dowty & Jacobson). Different verbs entail different relations of the understood agent in question to the potential goal. Dowty & Jacobson point to the following classes of verbs that take infinitival question complements:[9]

[8] See Barwise & Perry 1983, Veltman 1984, Kratzer 1989, and Portner's work for the flavor of these problems.

[9] I've added a few verbs to their lists and moved a couple to different categories. Some of these are slippery; for example, it isn't clear that *ask* or *suggest* or *recommend* entail an intention to act on the choice in question. But there do seem to be these general classes, exemplified by at least some of the verbs in the lists. In a fully detailed account, the point would not be to put these verbs in the appropriate pre-existing category, but to determine for each its precise contributions to the truth conditions of the whole utterance in which it occurs. The categories would then exist only as generalizations over these verb-particular senses.

(13) Dowty & Jacobson's classes of verbs with infinitival question complements:
   I. Cognitive class: "pertain to a mental choice of one value for the unsaturated argument over another"
      A. intransitive: *know, understand, discover, remember, wonder, notice, discern, forget, be unsure, be (un)certain, consider, contemplate, discuss*
      B. subject infinitival complement: *elude, escape, be unclear, be obvious*
      C. transitive: *demonstrate to, explain to, inform, advise, remind, convey to, mention (to)*
   II. Active class: "entail a choice of value for the unsaturated argument and an intention to act, given that choice"
      A. intransitive: *ask, plan, decide, determine, resolve, practice*
      B. transitive: *tell, ask, indicate to, advise, suggest to, recommend to*

I believe that the verbs in (13) form a natural class. Briefly, I note two features which they share semantically and which bear on the semantics of *knowing how*: First, note that none of the verbs in question are factive. Factives, like *surprise*, and other predicates that tend to implicate factivity, like *predict*, do not occur with infinitival complements (or subjects), as we see in these examples from Dowty & Jacobson:[10]

(14) *Where to go surprised me. (cf.: Where he went surprised me.)

(15) *John has predicted who to invite to the party. (cf.: John has predicted who he will invite to the party.) (Huntley 1982)

But this follows if we assume that Portner's semantics for infinitivals is generally correct, since the unrealized, future entailment of the infinitival is incompatible with a presupposition or implication of factivity. I take this to capture the hypotheticality of Dowty & Jacobson's actions, as stipulated in their (9d).

Notice also that all but one of the verbs Dowty & Jacobson list are what I will call *epistemically reflective*, which is to say that they make the following schema true:

(16) A verb V is **epistemically reflective** if it truthfully instantiates the following schema: If for some relation R, you R something, then you know that you R it:

If you know something, you know that you know it.

[10] See footnote 20 below for one possible exception.

If you wonder about something, you know that you wonder about it.
If you decide something, you know that you decide it.
If someone demonstrates to/explains to/informs/advises, etc. something to you, you know that they have done so (and they know they have done so, too).

Forget is not directly epistemically reflective, but it does involve a presupposition of epistemic reflectivity:

If you forget something, this presupposes that you once knew it, hence knew that you knew it.

Note that the epistemic reflectivity of the verbs in (13) doesn't necessarily entail knowledge of the correct answer to the question corresponding to its *wh*-infinitival complement; e.g., for *decide*, one must often decide what to do without knowing whether the course one has chosen is actually the best under the circumstances.

Not all predicates denoting mental attitudes are epistemically reflective in this sense. It is often argued that we can have merely implicit (or emergent) beliefs, and hence that if you believe something, you don't necessarily know that you believe it. It's interesting, then, that *believe* doesn't take infinitival questions:

(17) *Mary believed whether to eat/what to do/how to dance.

So far as I can determine, the predicates that take infinitival questions are all self-reflective, in this sense. They all either entail or presuppose self-reflective knowledge.

Of course, there is a long debate in epistemology over whether knowledge itself is self-reflective in this sense.[11] I do not mean to weigh in on that debate. Rather, I would only point out that the behavior of the verb *know* suggests that speakers of English treat it as self-reflective, since it classes with these other verbs in its behavior in the construction in question, which otherwise all seem to display self-reflectivity.

But of course the verbs in (13) differ semantically in some respects, among them whether the understood agent of the infinitival is entailed to have adopted the goal associated with the infinitival. For example, when *wonder* takes a *wh*-infinitival complement, the main subject is

[11] Polly Jacobson (p.c.) reports a high school saying: *He who knows not, and knows that he knows, he is a freshman; he who knows not and knows not that he knows not, he is a sophomore; he who knows and knows not that he knows, he is a junior; he who knows and knows that he knows, he is a senior.* The problem is the junior, and Sophocles might argue that we're all juniors. This just underlines the reasons for the philosophical controversy. But to me, it seems to equivocate about what it means to know.

only entailed to entertain the infinitival question with a view to resolving the correct value for the understood agent. There is no entailment that the correct value has been determined, let alone the goal adopted. And one can understand what to do but decide not to do it. Knowing what to do seems to entail knowing what would be a rational goal under ideal circumstances of some relevant sort, but alas neither rationality nor ideal circumstances always obtain. But with *decide*, there is that commitment: The subject believes that she probably grasps the correct value for the *wh*-word, with herself as understood agent, and moreover she has adopted the goal entailed by the infinitival with that value for the gap. This pertains to another desirable feature of the proposed semantics for *wh*-infinitivals in (11): Combined with the feasibility condition on goal adoption, (12b), we know that any rational agent who has adopted the goal corresponding to an answer to the infinitival question must believe that she is capable of achieving the goal. So if, as with *decide*, there is entailed commitment to the corresponding goal, then this in turn by (12b) entails that that individual believes that she is probably capable of achieving the goal.

A verb like *demonstrate* directly entails that the subject *is* capable of achieving the goal in the manner demonstrated, so it entails ability. But since *know*, one of the verbs of "mental choice", does not entail that the goal has been adopted, the disputed implication of ability sometimes associated with the *know how to* construction only arises when there is a pragmatic implication that the goal has, in fact, been adopted. If we know that Georgia is looking for an ivory-billed woodpecker, and one of us says that she knows how to find one, this suggests that (assuming she is rational) she has adopted the goal of finding one in that fashion and therefore believes she is capable of pursuing it successfully. But capability is not entailed by the meaning of the *know-how* statement by itself. Hence, it is compatible to claim that *John knows what to eat but can't afford it*;[12] neither ability nor feasibility directly apply in this case. So in this way, the compositional semantic account of *know how to* can accommodate those whose intuitions correctly seize the implication of ability in many cases, while admitting the counterexamples to entailed ability offered by Ginet (1975) and others. Ginet argues that "ascriptions of knowledge-how do not even entail ascriptions of the corresponding abilities", and Stanley & Williamson illustrative this with the case of a ski instructor who knows how to perform a complex stunt without being able to perform it herself (due to Jeff King, p.c. to Stanley & Williamson), and that of a master pianist who has lost her arms

[12]This example was suggested by an anonymous reviewer.

in an accident and hence knows how to play a Beethoven sonata but no longer can.

In this way we can also explain why *know how to* statements often have the flavor of *could* statements, as Stanley & Williamson note: This is just the feasibility clause (12b) made hypothetical, in keeping with the infinitival's futurity. More generally, treating these properties in terms of goals also captures what Dowty & Jacobson seem to mean in calling them *hypothetical* in their informal characterization (9): One only rationally adopts goals conditional on the satisfaction of all the preconditions. The goal-orientation in the analysis also explains Stanley & Williamson's observation that there is sometimes a rather deontic flavor to *know how to* statements: Goals involve commitments, and commitments are things one should try to fulfill. But these different modal implications don't result from ambiguity: All the conditions on rational goals must obtain simultaneously, so that the feasibility and the deontic character co-exist. It's just that one of the modal flavors may seem to predominate in a given example, as a function of a variety of lexical and pragmatic factors.

The other feature Dowty & Jacobson claim for the properties denoted by infinitival questions is appropriateness. To see how this follows from the goal-based semantics, consider the following examples and paraphrases:

(18) Mary wondered whether to go to Shanghai.
'Mary wondered about the value for $y \in$ {does/does not} such that y(*go to Shanghai*) would be a rational goal to adopt, given what she knew and her other goals, commitments and intentions.'

To wonder about something suggests a puzzle, and in (18), given the rationality conditions on goal adoption in (12), the puzzle could be (a) whether there really is a potential payoff in going, or (b) whether circumstances might make it impossible or improbable to achieve the goal of going, or (c) whether one might have conflicting prior commitments. Here, going to Shanghai seems to allude to a particular potential trip, and so the question seems to be about Mary's going or not going on a particular occasion. The appropriateness condition follows from making her adoption of the infinitival goal conditional on whether it would be rational, in the sense outlined, including compatibility with her other goals, commitments and intentions.

Let's look at some more examples. (19) is more likely to have a generic reading, because of the bare present tense of *knows* and the non-specific indefinite *spicy food*:

(19) James knows what to drink with spicy food.
'James knows the value for y that would make *drink y with spicy food* a rational goal, given normal circumstances and lack of conflict with other, pre-established goals, commitments and intentions of the agent.'

In (20), we can get either the particular or the general readings:

(20) Jessica showed Mary how to fix her sink.
'Jessica demonstrated for Mary's benefit the procedure y such that *fix her sink via procedure y* would be a rational goal to adopt, given what is known and other pre-established goals, commitments and intentions.'

If there's any implication that the sink is actually broken, the example is likely to have the object-control reading; otherwise we get a generic reading. We can see the latter possibility more readily if we replace *her* with *a*: Maybe Jessica is teaching Mary how to be a plumber. The pay-off requirement on goals predicts one will only adopt the goal if the sink needs to be fixed and it would be useful to have it working. But just because Mary now knows how to fix the sink, even if it's broken (so that there would be a payoff), this doesn't mean that she adopts that goal: This might depend on whether she gets her APA paper finished in time! So, again, the hypothetical flavor captured in the paraphrase by *would* is really the presumption that the rational preconditions are satisfied, a sort of pragmatic presupposition arising from the requirement of rationality and what it is to fix a sink.

The proposed semantics for infinitival questions has another virtue: It works when they serve as subjects, as in (21), which has both a generic interpretation and one where the subject is taken to be some particular individual under discussion—perhaps poor Lingens:

(21) How to escape is obvious—it's what to do afterwards that's tough.
'The value for y such that *escape via procedure y* is a rational goal, given what's known and other pre-established goals, commitments and intentions of the agent, is obvious.'

The possibility of both kinds of readings here raises challenging questions for the type of linguistic theory that Stanley & Williamson appeal to in explaining the interpretation of PRO in their account, the linguistic theory of Control, which studies how such abstract, phonologically unrealized constituents get their interpretations. Control is generally assumed to involve governance of PRO in an infinitival complement by the main verb. But in (21) the infinitival is the subject, and verbs do not govern their subjects, at least in English. Still, here we see attested

the same two types of readings we get for the earlier examples where the infinitival was a complement.

Control is a theory about verbs taking subjectless non-finite complements like the *wh*-infinitivals at issue here. The theory is intended to explain why with with some verbs, including *wonder* (18) and *know* (19), the implicit agent of the infinitival is taken to be the subject of the main verb, while with others, including *show* (20), *suggest* and *tell*, the subject of the infinitival is taken to be the object of the main verb. In syntactic theories of control, this is assumed to be a function of syntactic features of the governing verb, which assigns the proper referential index to the implicit PRO subject in its complement. But as with the purported sentential character of the infinitival, this type of theory of control is not universally accepted, and I think that a variety of problems argue for a non-syntactic account of Control, one in which the semantics of the matrix verb and various pragmatic factors combine to determine who is understood to be the agent of the infinitival. There is a significant body of literature which takes this general approach.[13]

Jackendoff & Culicover (2003) give a detailed, compelling critique of the syntactic approach to control involving PRO, and argue instead for three classes of control based on the lexical semantics of the matrix verb:[14]

(22) Jackendoff & Culicover's (2003) classes of control:

Unique control: e.g. in object complements of *persuade, promise, shout to, ask, request, be rude to*, etc.

Free control: e.g. in object complements of *beats, outranks, entails, is as good as*; and in subject complements of *help, important, ruin, intrigues*; etc.

Nearly free control: e.g. in object complements of verbs of communication and thought, including *talk about, mention, discuss*

[13] Jackendoff (1972), (1974), Ruzicka (1983), Nishigauchi (1984), Williams (1985), Dowty (1985), Farkas (1988), Chierchia (1988), Sag & Pollard (1991), Pollard & Sag (1994), van Valin & LaPolla (1997), Culicover & Jackendoff (2001), and Jackendoff & Culicover (2003), the last of which provides a useful overview of the literature and issues.

[14] For those unfamiliar with the theory of Control, note that the classification of verbs into these three categories is orthogonal to the issue of which of the verb's arguments, if any, is the controller. That is, in an example where the subject of the main verb is understood to be the subject of the infinitival as well—so-called subject control—the verb may be in any of Culicover & Jackendoff's three classes. *Promise* typically exhibits unique subject-control, as in *Jane promised to come to the party.* In nearly-free *discuss*, we also often see subject-control, as in *Jane discussed coming to the party.*

In matrix verbs exhibiting unique control, Jackendoff & Culicover argue that the verb always selects for what they call an *Actional complement*, one felicitous in the context *what X did was...*, which may be an object or (less often) a subject. The matrix verb's lexical semantics entails that exactly one of its other arguments (that fulfilling a specified thematic role) should be understood as the controller; the thematic role of the controller differs from verb to verb (e.g. *promise* vs. *persuade*). However, they do note (p.524) that even with verbs that normally exercise unique control, infinitival indirect question complements (in object or subject positions) may also have a generic control interpretation (the PRO_{arb} interpretation noted above). In their non-unique control, the verb does not select for an Actional infinitival. With free control, the controller is not semantically determined by the verb. The possibilities for controller in such cases include:

- the denotation of one of the explicit NP arguments of the verb,
- a split antecedent (the join of the denotations of two or more explicit arguments)
- a generic agent
- a long-distance controller—the denotation of an NP in a higher clause
- some entity under discussion in prior discourse
- the speaker or hearer, or the join of the speaker and another salient entity

In nearly free control, which involves verbs of communication or thought, the options are somewhat more restricted, but include the denotations of an argument of the matrix verb, a split antecedent, a discourse antecedent, or the generic interpretation.

I agree with the general approach proposed by Jackendoff & Culicover. As argued in Dowty (1985), it is the lexical semantics of the verb, and not its syntactic properties *per se*, that are at the crux of obligatory control. But things are a bit more complex in certain cases than their account would suggest: Even with verbs that usually display unique control, pragmatics may also enter into the determination of the controller, as we can see when they take infinitival question complements. Consider:

(23) John promised Mary to mow the lawn.

(24) John asked Mary to mow the lawn.

(25) John asked Mary how to mow the lawn.

The verb *promise* takes three semantic arguments: an agent, a patient and a goal. Since a promise is a commitment on the part of the agent,

and a commitment involves the intention to achieve a goal, the semantics of the verb here entails that the subject *John* is the controller of the goal-denoting infinitival; this is quite similar to the analysis of *promise* in Jackendoff & Culicover. It's a different matter to ask someone to do something, since that involves presenting them with a potential goal, which we propose that they adopt. Hence, in (24) the denotation of the *object* is the one to whom the goal is proposed: Mary is the one who would be making the commitment, it is she who would be the mower; hence, the object controls the infinitival, and again we needn't appeal to syntax. This is in keeping with the analysis of *ask* in Jackendoff & Culicover (2003), who argue that its semantics yields unique control.[15] In neither (23) nor (24) is there the possibility of a generic interpretation: The semantics of the verb plus the goal-denotation of the infinitival combine to entail that the argument who is entailed to make a commitment is the agent of the infinitival. Otherwise, the utterance would be incoherent.

But (25) demonstrates clearly that the control features of *ask* aren't due to its lexical semantics alone, let alone some arbitrary syntactic feature.[16] The same verb now permits either of two readings—generic or subject control—but not the object-control reading attested in (24). This is because what John proposes to Mary is not a goal in the world, as in (24), but the goal of answering the question corresponding to the *wh*-infinitival. Asking is posing a kind of request, proposing to the addressee that they adopt a given goal; but that goal may either be a particular type of action in the world (an Actional infinitival, as in (24)) or it may be informational—helping to resolve a question, as in (25). Without trying to pin down a full definition of *ask*, we can characterize this feature of its meaning via the following necessary conditions:

(26) Constraints on the meaning of *ask*:
ask subcategorizes for a subject (agent of the request), an object (addressee or patient), and a goal—an infinitival VP or question
Take InfP to be either an infinitival VP or an infinitival question. Then *ask*

[15] See their section 4.2, discussion of their class 2, pp.533–535. They acknowledge that such predicates have free control when they take *about* plus a gerund, but argue that they display unique control when they occur with infinitives. But the discussion of (25) just below argues that the semantics of the complement plays a role in the determination of control, so that it is not just an arbitrary fact about the *about* case that differentiates its control behavior from that of the canonical case with an infinitival VP complement.

[16] See Sag & Pollard (1991) for detailed discussion of these kinds of examples.

presupposes: InfP has the right sort of denotation to serve as a goal (e.g., if an infinitival VP, it is Actional in Jackendoff & Culicover's sense

has as a lexical entailment:

$$\lambda NP_{obj}\lambda InfP\lambda NP_{subj}[request(NP_{subj}, NP_{obj}, \text{Adopt-Goal}(NP_{obj}, InfP)]$$

If the goal is an action, then by virtue of what it is to adopt an action as one's goal, *ask* entails that what the agent requests is that the addressee be the agent of the proposed action, as argued by Jackendoff & Culicover. But if the goal is that the addressee resolve a question, the entailment by itself fails to say anything about the understood subject of the question. Hence, the nature of the denotation of the complement itself, and not the semantics of the verb alone, also plays a role in determining the understood controller. Moreover, in interpreting an utterance of (25), we must consider what possible motivation the agent (subject) might have for her request.

One frequent reason for asking how something is done is so that we can do it ourselves. If we take that to be John's motivation, which I think is the default case when we encounter (25) out of the blue, we will most likely take him to be the controller. But that isn't necessarily the case: John might be the instructor in a lawn maintenance course, quizzing Mary about what she has learned. In that case, he already knows the answer to the question, and the only reasonable interpretation seems to be the generic.[17] Hence, pragmatics plays a role in determining control, as well as the semantics of the verb and that of the complement.

Pragmatics also plays a role in control in examples with split antecedents, as in (27) and (28), due to Dowty & Jacobson, where in each case the antecedent of the underlined NP is taken to be the controller of the infinitival, which is in turn understood to be Mary and John:[18]

[17] E.g., if we change *the* to *her*, in the quiz-case we might take the question to be how Mary should mow her lawn—e.g., it might be seeded with a particular kind of grass seed that needs to be mowed at a certain height, etc.

[18] Moreover, control occurs not only with subjectless infinitivals, but with nominals as well, as discussed by Culicover & Jackendoff. Dowty & Jacobson note:

> "[T]he same range of generic versus individual interpretations ... is found in sentences with the verb 'know' and all sorts of NPs denoting methods, not just infinitival questions:
>
> (46) John knows a shortcut to Mary's house.
> the formula for solving a quadratic equation
> Prolog
> a good recipe for carrots
> the right dress for the opera

(27) John suggested to Mary how to amuse themselves during the afternoon.

(28) John reminded Mary what not to say to each other's parents.

Not all transitive predicates so readily permit split antecedent control, as we see in (29):

(29) #?John told Mary how to amuse themselves during the afternoon.

While *suggest* and *remind* are cooperative predicates, readily implicating that the suggested goal is to be cooperatively adopted, *tell* is directive, hence doesn't readily lend itself to the implication of cooperative goal-adoption that I believe is the necessary condition for split-antecedent control in general, including in cases like (27) and (28). The potential non-generic controller is the individual or set of individuals who are entailed or implicated to (potentially) adopt the goal associated with the infinitival. Jackendoff & Culicover (2003) characterize *remind* as a verb of unique control, and that seems correct when it takes a non-interrogative complement. But again, pragmatics plays a crucial role in determining control of an infinitival question.

But what about the generic reading of the infinitival questions? how does it arise? It is most likely when there are other indications in the infinitival that it describes not a particular situation or circumstance, but the general case. Another way of saying this is that generic control of the infinitival agent is a function of the genericity of the circumstance of evaluation. For example, in (19), the object of the infinitival is the mass indefinite *spicy food*, suggesting that the speaker is alluding to spicy food in general, not to the fare on some particular dining occasion; hence, the generic interpretation for the agent naturally arises. In (18) since travel to exotic places is not an ordinary issue and *wonder* entails an issue of concern to the subject, we take the infinitival question to have a particular interpretation; but cf. (30):

(30) Whether to travel to exotic places is not a decision many of us have to make.

where the subject does have the generic interpretation.

---

the best wine for this entrée

"Some of these also have [a] more strongly generic than ... individual flavor, but not all need really be generic. If the shortcut John knows to Mary's house involves cutting through a back yard where there is a vicious dog that will attack anyone but him, (50a) is still appropriate, though it's not a "generic" shortcut. Notice that if [we] substitute "decided on" for "know" in the last sentence, then usually the individual "reading" is what comes to mind, e.g. "We decided on the best wine for this entrée, decided on a shortcut to Mary's house", etc.

Note that in Portner's semantics for the infinitival, interpretation is relativized to some situation r. That is, interpretation of infinitival questions is always deictically anchored to some understood situation, which is conveyed pragmatically. Let us call this the situation of interpretation for the infinitival. This may be either a particular situation relevant to the discussion—as in (18), one reading of (20) and (21), and the default interpretations of (23)–(25)—or the arbitrary, generic situation, as in (19) and the other readings of (20) and (21). Thus in (18), *to go to Shanghai* will be understood relative to a pragmatically implicated particular occasion, which may be either specific or non-specific, e.g. 'as part of the forthcoming business deal' or 'for a vacation'. We see a contextually-suggested specific definite situation of interpretation in (31):

(31) We were in a terrible mess during our vacation when we lost our passports in Turkey last summer. But we called John, and fortunately he knew what to do.

Besides a subject-control interpretation where John knows what he should do to save the day, on another prominent interpretation (31) means that John knew what the speaker and her companion(s) should do in their particular circumstance in Turkey. Again, the control here is largely pragmatically determined.

When the pragmatically conveyed situation of interpretation for the infinitival is particular, the resulting reading always involves non-generic control. There is another important property of these non-generic readings, given in (32):

(32) When an attitude verb takes an infinitival complement, the interpretation involving control of the infinitival by the experiencer of the attitude verb is always *de se*.

In such a control situation, no true *de dicto* readings arise, although the generic may in some cases entail a *de dicto* truth.

Stanley & Williamson come close to the generalization in (32) when they claim that "uses of 'PRO' where they are controlled by the subject in the main clause invariably give rise to "de se" readings, that is, readings involving a first-person mode of presentation." [19] The sole example they offer in support of this claim is (33) (from their footnote 26), which indeed can only be true if Hannah wants her*self to win the lottery:

(33) Hannah wants to win the lottery.

[19] Stanley & Williamson give no references for this observation, so I assume it is theirs. I'd be interested to hear of any other claims in this vein from the literature.

Parallel to this, *Lingens wants to win the lottery* can't mean only that Lingens wants that poor fellow Rudolph Lingens that he's been reading about to win the lottery, unaware that he* is that poor fellow. Although Stanley & Williamson's generalization seems correct for many control verbs, it over-generalizes in a way that is avoided by (32). For one thing, they ignore the possibility that the experiencer of an attitude predicate may not be the subject, a possibility illustrated by *excite* (or *dismay*, or *frighten*, etc.):

(34) It excited Lingens to find the map of the Stanford Library.

(34) can't merely mean that it excited Lingens that the fellow he'd been reading about, Rudolph Lingens, found the map of the Stanford Library. Instead, it entails that what excited Lingens was that he* had found the map. So here object-control is *de se*, since the object is the experiencer. But a non-experiencer object fails to yield a *de se* interpretation, as in (35):

(35) John believes Louis to be a vampire.

A *de se* interpretation, with its "first-person mode of presentation", presupposes a presentation of the relevant denotatum to the holder of an attitude. Since Louis is not entailed here to hold any attitude, nor is John entailed to hold any attitude pertaining to John, there can be no question of *de se* interpretation.

Stanley & Williamson's generalization is close to right because it seems to be the case that the majority of the verbs that take infinitival complements with interpretations involving subject control are in fact attitude verbs with subject experiencers, or at least entail attitudes on the part of the subject. Consider*connive*:

(36) Lingens connived to leave the library.

This entails a desire or wish on Lingens' part, hence a kind of attitude, and so we are not surprised to find that it conveys that Lingens was conniving for him*self to leave, and not necessarily for that fellow Rudolph Lingens to do so. Similarly with *contrive*, *desire*, *endeavor*, *expect* (with subject control), *fail* (which presupposes an attempt), *hope*, *long*, *manage* (again presupposing an attempt, hence a desire), *plan*, *plot*, *start*, *strain*, *strive*, *struggle*, *try*, *want*, *wish* and *yearn*.[20]

[20]This list of control verbs is drawn from the non-exhaustive list on Wiktionary: `http://en.wiktionary.org/wiki/Category:English_control_verbs`. The only verb on that list that is a subject-control verb and doesn't seem to entail an attitude on the subject's part (at least in my dialect) is *proceed*: *Lingens proceeded to leave the library* doesn't entail an attitude or goal on Lingens' part, just reports a fact: Lingens then left the library (perhaps presupposing some preceding event just

Now note another generalization that I believe holds of all the predicates which fall under the generalization in (32):

(37) *de se* controllers are epistemically reflective with respect to the controller. That is, for any of the predicates denoted by these verbs, if the experiencer *Vs to* δ, then the experiencer knows that the experiencer *Vs to* δ, instantiating the schema in (16).

As (37) would lead us to expect, preliminary evidence suggests that non-epistemically reflective predicates do not license subject-control of infinitival complements:

(38) *John believes to be hungry.

An exhaustive consideration of English control verbs would be required to test these generalizations. But I think the preliminary evidence is strong. Then since all the predicates which take *wh*-interrogatives are (I have argued) epistemically reflective, this would lead us to expect that with experiencer control they would yield only the *de se* interpretation, as we observed earlier with *know how*. Note further that, as (32) and (37) predict, in the split antecedent examples in (27) and (28), both antecedents are epistemically reflective arguments of the verbs, and the only reading is *de se* with respect to that split antecedent.

But why should (32) hold in the more general case, and in particular for the predicates which take *wh*-infinitival complements? And why should there be this correlation between (32) and (37)? I strongly suspect that the answer lies beyond the present range of issues, and probably beyond my expertise. But I think we can say this much: The epistemic reflectivity of verbs like *know* suggests that in holding such an attitude the experiencer has a certain kind of privileged access to the relata, the intended denotations of the verb's arguments. By this, I don't mean to say that the experiencer knows who or what these relata are in some absolute sense, but that if the intended denotation entails certain relations (e.g., involving identity) among these relata, then the experiencer should have access to that information under the entailed epistemic reflectivity. Consider (39), the positive counterpart of (2):

(39) Lingens knows how to get out of the Stanford library.

One of the relata in (39), the infinitival question, is about what would be the ideal goal for some individual. Suppose the intended interpretation involves non-generic control by the subject of *know*; this entails

mentioned). I note that this factivity would appear at least *prima facia* to challenge Portner's analysis of infinitival VPs. Possibly the utterance doesn't literally mean that Lingens left, but only conversationally implicates it. But this warrants further consideration.

that the individual whose ideal goal is in question is the experiencer. Under epistemic reflectivity, the experiencer should have access to that information. Then the interpretation could be paraphrased 'Lingens knows that he* has the property of being an x such that x knows the value for y that would make *get out of the Stanford library via procedure y* a rational goal for x, given x's own circumstances and other, pre-established goals, commitments and intentions'. The *he** in this paraphrase is justified by the epistemic reflectivity of the matrix verb, which I am treating thus as a kind of self-ascription. If something like this is the case, then the generalization in (32) follows from the semantics of the attitude verbs that take infinitival complements, including *wh*-infinitivals.

Whatever the reason for the correlation, the standard, syntactic theory of control adopted by Stanley & Williamson cannot account for these generalizations, because, as Castañeda pointed out, mere coreference, as guaranteed by coindexation of the controller with PRO, cannot guarantee the *de se* (or in his terms, the *he**) reading. The explanation must lie in the lexical semantics of the infinitival complement-taking verbs.

I have argued that the reading paraphrased is the one predicted for (39) on the basis of the independently motivated semantics for *wh*-infinitivals and an independently motivated theory of control.[21] I think this semantics does a far better job of explaining our intuitions about these examples than does Stanley & Williamson's, while shedding light on the difficulty of pinning those intuitions down. And it supports the contention of those from Ryle to Abbott, who have argued that knowing-how cannot be reduced to knowing-that.

1.3 Conjunction of unlike categories

Here is one objection that might be raised against the proposal just sketched: On this view, a *how-to* complement and a *that* complement are distinct both in syntactic character and in type of denotation (denoting a question vs. denoting a proposition). It is generally assumed that we can only conjoin like-categories, so on this account one might expect that *how-to* and *that* complements could not be conjoined. Yet Stanley & Williamson (2003) offer acceptable examples involving coordination of *wh*-infinitivals with *that*-complements:

[21] I haven't attempted here a full semantics for *know*. However, deriving this interpretation for (39) relies mainly on the fact that it is a member of the epistemically-reflective class of verbs of interest.

(40) John knows that bicycle accidents can happen and also how to avoid them in most cases.

They assume that this is an argument for treating these two types of complements as identical in both syntactic category and semantic type.

But conjunction is not so simple as the like-category generalization might lead us to believe. Focusing on the case at hand, Groenendijk & Stokhof (1984) had pointed out that we can conjoin finite embedded questions with *that*-complements. The following are variants of non-finite examples in Stanley & Williamson (2003):

(41) a. John knows that Peter has left for Paris and how we can track him down.
b. Alex told Susan that someone was waiting for her, but not who it was.

But as discussed above, tensed *wh*-complements are generally argued to denote questions, not propositions. So in this respect, *how to* infinitivals are just acting like interrogative complements in general.

And the conjunction problem is even more complex than this. It has long been acknowledged in the linguistic literature, and discussed in detail in Sag, Gazdar, Wasow & Weisler (1985), that both *that*-complements and infinitival questions can be conjoined with NPs. Here are (variants on) examples due to Dowty & Jacobson (1991):

(42) a. Mary explained to James both the question and how to find the answer.
b. Mary knows where to find the safe and the combination to the lock on it.
c. We asked her how to get home and several similar questions.
d. His answer and how he pronounced it both surprised me.

And the following examples, conjoining finite interrogative complements with infinitival questions or NPs, seem fine to me:

(43) a. Mary asked what articles she should read and where to get them.
b. Mary asked what articles she should read and the address of the nearest library.
c. Mary determined/learned the cost of the car and that she could buy it on credit.
d. Mary forgot both the address and how she was to get there.

There are other examples which don't seem as good, but these suffice to show, I think, that all the combinations are possible in principle, with no zeugma effect.

Dowty & Jacobson point out that this is not the only respect in which infinitival questions behave like nominal arguments:

- All verbs that subcategorize for infinitival question complements also subcategorize for (plain) NPs as well (with a few exceptions).
- All infinitival questions after transitive verbs (except for *wonder*, *resolve* and *decide*) passivize, as in:

(44) a. How to solve the problem is now understood by everyone.
b. Where he found the mushrooms was discovered by his neighbor.

And we find that *that*-clauses behave as nominals in some respects as well. As Sag, Gazdar, Wasow & Weisler (1985) discuss in detail (note that the title of the paper is a play on the issue), it seems that what constrains coordination isn't a matching requirement on the fully specified syntactic categories of the conjuncts, but whether they are of the same class of categories. Here, roughly speaking, the fact that the categories in question are all nominal in several respects is what seems to license coordination. Coordination is not an argument that they are all sentential (and hence proposition-denoting), or all property-denoting, or all NPs.[22]

In any case, any theory of coordination must wrestle with how to reconcile a fairly broad range of types of syntactico-semantic mismatch with the otherwise vigorous generalization that coordination involves like-constituents. Hence, the problem is far more general than the present issue and examples like (41)–(43) would suggest.

Moreover, from a purely semantic point of view we should keep in mind Lewis' point about the relationship between attitudes *de se* and *de dicto*:

> . . . if a map is made suitable for portable use by leaving off the "location of this map" . . . , its incompleteness is not at all misleading.

[22]It is true, as Polly Jacobson (p.c.) points out, that in general NPs coordinated with interrogatives as in (42) and (43) can be construed as concealed questions, and this is probably a clue to why the coordination is acceptable. It seems that when one of these complements is a question, as in *how she was to get there* in (43d) and *how to pronounce it* in (42d), we understand that what the subject forgot or what surprised her was the answer to this question, an answer the speaker may or may not know. That is, in its interaction with the verb *forget* or *surprise*, the interrogative might be taken to be a non-specific stand-in for its answer. Then part of what would be at issue is whether any complement to such a verb—*that* clause, finite or non-finite interrogative, or NP—always denotes a question (with the verb entailing a relation to the answer to that question) or denotes something that could be understood to be an answer. Exploring this would take us beyond the current essay.

> . . . Knowledge *de dicto* is not the whole of knowledge *de se*. But there is no contradiction, or conflict, or unbridgeable gap, or even tension, between knowledge *de dicto* and the rest. They fit together as nicely as you please. (Lewis 1979:528)

Hence, the fact that *that*-complements denote propositions while *wh*-infinitivals do not does not preclude characterizing the information conveyed in comparable terms. So the argument from conjunction is not a strong one.

1.4 Comparatives and knowledge-how

Here is another argument for the proposed distinction in type between *that*-complements and *how to*-complements: We can felicitously compare knowledge of the *how-to* type, but not of the *that*-type:

(45) Marcus knows how to swim better than how to do pirouettes.

(46) #Marcus knows that he's learning to swim better than that he's learning to do pirouettes.

Now, it's not that we can never take a comparatively different stance with respect to one proposition than another:

(47) Mary admits to herself more readily that John loves her than that he's bad for her.

(48) Marcus confesses that he's learning to swim more comfortably than that he's learning to do pirouettes.

The difference between (46) and (47)/(48) is due to the difference in relation to their complement of the denotation of *know* vs. those of *admit*/*confess*. The point is that *know how* is not odd in comparatives.

I think we can explain this difference on the account due to Dowty & Jacobson. Knowing a proposition or a fact is an all or none matter: Either whatever conditions are necessary for knowledge obtain—the proposition is true and we believe it's true, etc.—or they do not. There's nothing in between. But knowing the answer to a question is not in general an all or none matter. For example, to the question *What does Moira take in her tea?*, there are several partial answers: *she takes sugar*, *she takes honey*, *she takes lemon*, *she takes milk*, etc. Knowing who someone is surely admits of degree in this respect; we can take a lifetime to get to know our own properties, let alone another's. Knowing how to do something is also a gradual matter—we might say that when Marcus is first learning to swim he has only a very partial answer to the question of how to swim, but that as he progresses, he knows more and more about how to swim, refining his methodology as he learns. Comparing where he stands on the scale from complete novice to

master, we can see where he stands in this gradual process. The process involved in learning to do pirouettes is quite different, of course, but we can still talk about it in the abstract as involving a scale of mastery. And so we can compare where Marcus stands in the two processes of resolving the question of how to do something or other.

Interestingly, when we compare knowledge of the denotations of NP objects, they seem to be interpreted as concealed questions:

(49) Marcus knows chess better than poker.
'Marcus knows how to play chess better than how to play poker.'

Comparison isn't so felicitous with *knowing whether*:

(50) John knows whether to swim better than whether to do pirouettes.

But this is to be expected on the account just sketched. This is because a *whether-to* question has the same semantics as a yes-or-no question, with only two cells in the corresponding partition. Groenendijk & Stokhof define a partial answer as one that entails that one of the cells in the corresponding partition is not the correct answer. Hence, with only two cells, a partial answer is a complete answer. So there are no properly partial answers to *whether-to* questions, hence no proper scale of resolution for such questions: you either know the answer or you don't.

Again, the linguistic evidence converges on the conclusion that *how-to* infinitivals are of a different semantic type than *that*-complements: they are property-denoting VPs built on interrogative semantics. We cannot get this result if we regard the infinitival question as merely denoting (some or all) true answer(s) to a question, understood as mere propositions. It is true that we must understand the entailments deriving from these clauses in terms of the propositional content of the answer, but an *answer* is more than that—it also stands in relation to an underlying question and can be compared with other answers to the same question with respect to how well they resolve the question. This gradedness of answers in respect to resolution permits us to understand how we can compare degree of resolution of different questions. The semantics of *that*-complements does not provide us with such a notion.

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November 5, 2007