Technical Appendix to "Know-How and Gradability"[1]

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A. Against the Free Relative Analysis

In the main text I have been conforming to orthodoxy in taking the complement of a know-how ascription to be an interrogative (pp. 354-5). *Contra* this standard linguistic assumption, some philosophers have recently suggested that the embedded phrase 'how to φ' might not be an interrogative but rather a 'free relative'. Free relatives are constructions of the form 'wh-ψ' that can occur in nominal position. For example, in (1), 'believe' cannot take interrogatives as complements, so there 'what you said' cannot occur as an interrogative. Hence, in (1), 'what you said' must work as a quantifier phrase in objectual position:

(1) Mary believed what you said.

Accordingly, the idea of the free relative analysis would be that the phrase 'how to φ' plays in ascriptions of know-how the same semantic function that is played by 'what you said' in (1).

This analysis is not really plausible.[2] It is a well-known linguistic generalization that infinitival-'*wh*' constructions, such as 'how to φ', simply cannot work as free relatives, as indicated, among other things, by the fact that a verb such as 'believe' cannot take them as complement:[3]

(2) a. # Mary believes what to believe.

b. Mary believes what she should believe.

c. # Mary believes who to believe.

d. Mary believes who she should believe.

Moreover, as observed in the main text (p. 353), the phrase 'the way to swim' can be taken as complement by certain verbs, such as 'learn' and 'tell,' that do not allow other kinds of nominal complements:

(3) a. I learned the way to swim.

b. I learned the capital of Italy.

c. # I learned Rome.

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[1]See *Philosophical Review*, volume 126, number 3 (2017), pp. 345–83. DOI 10.1215/00318108-3878493.

[2]See also Habgood-Coote 2017, for a critique of the free-relative analysis.

[3]See Schaffer (2009) for an accessible review of the main reasons why infinitival 'wh'-clauses cannot be free-relatives.

(4) a. I told Mary the way to reach Donegal.

b. I told Mary the capital of Italy.

c. # I told Mary Rome.

This observation suggests that the position occupied by that phrase is not referential:

The free-relative analysis of know-how ascriptions is often motivated on the basis of the seeming equivalence between ascriptions such as (5-a) and (5-b):

(5) a. Mary knows how to swim.

b. Mark knows the way to swim.

But in light of the considerations mentioned above and in the main text (§4.1, p. 353) about the inadmissibility of free relatives within 'learn' reports, we should aim at explaining the seeming equivalence between (5-a) and (5-b) in a way that does not commit us to the free relative analysis. The simplest explanation (also rather standard among linguists) is that in a construction such as 'S knows a way to φ' and 'Mary found out a way to φ', the nominal 'a way to φ' is a concealed interrogative. On this analysis, (5-b) is equivalent to:

(6) Mark knows what way is a way to φ.

which is in turn taken to be equivalent to (5-a).[4]

Bengson and Moffett (2011) speculate that know-how ascriptions ascribe an acquaintance relation towards *ways of doing things* rather than towards answers to questions. The main motivation offered is linguistic—i.e., the equivalence between (5-a) and (5-b). But a further reason to think that this analysis is implausible is that in languages employing verbs other than the propositional verb (e.g., '*connaitre*' in French and '*conoscere*' in Italian) to express the acquaintance relation, the acquaintance verbs cannot be used to ascribe know-how:

(7) a. # Mary connait comment nager.

b. Mary knows-by-acquaintance how to swim.

(8) a. # Mary conosce come nuotare

b. Mary knows-by-acquaintance how to swim.

Note, however, if know-how were knowledge by acquaintance of a way to do something, as Bengson and Moffett (2011) maintain, we would expect sentences such as (7a) and (8a) to be felicitous in those languages.

Finally, the acquaintance view cannot explain the fact that ascriptions of know-how in other languages, such as French and Italian, take bare infinitivals 'to φ' as complements, which cannot be taken plausibly to refer to ways:

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[4] See Baker 1969, Grimshaw 1979, and more recently Aloni 2008, Aloni and Roelofsen 2011 for defenses of such analysis.

(9) a. Mary sa comportarsi in pubblico.

b. Mary sait se conduire en public.

c. Mary knows to behave in public.

d. 'Mary knows how to behave in public.'

Hence, all in all, the free relative analysis of the complement 'How to φ' in know-how ascriptions is a non-starter.

Next, I argue against the hypothesis that in English, know-how ascriptions are ambiguous between a logical form embedding an interrogative complement and another logical form—one not embedding an interrogative complement.

B. Against the Ambiguity Hypothesis

A variety of philosophers (such as Rumfitt (2003), Ginzburg (1995), Michaelis (2011), Wiggins (2012), Abbott (2013), and Ditter (2016)) have used cross-linguistic considerations to motivate the hypothesis according to which English know-how ascriptions are ambiguous between two different logical forms—one embedding the interrogative complement 'How to φ' (= 'S knows + (interrogative) how to φ') and one not embedding an interrogative at all.

Call the hypothesis according to which English know-how ascriptions are ambiguous between these two logical forms the 'Ambiguity Hypothesis'. The purpose of this section is to show that the arguments usually leveled on behalf of the Ambiguity Hypothesis fail and there are, moreover, several reasons to think that the Ambiguity Hypothesis is false. Therefore, I conclude that we should accept what in the text I label (p. 352) *The English Univocal Logical Form Assumption*—the assumption that English ascriptions of know-how univocally have the logical form they superficially appear to have—i.e., 'S knows + (interrogative) how to φ'. Rumfitt (2003)'s main argument for the Ambiguity Hypothesis goes as follows. It is often observed that in Romance languages such as French and Italian, know-how can be ascribed by means of ascriptions that appear to take bare infinitivals 'to φ' as complements rather than interrogatives, such as, for example, (10-a) and (11-a):

(10) a. Marco sait nager.

b. Marco sait comment nager.

(11) a. Marco sa nuotare.

b. Marco sa come nuotare.

Rumfitt (2003) (p. 162) goes on to observe that the bare infinitival construction embedding 'to φ' can differ in meaning from the corresponding ascription embedding the interrogative: (10-b) and (11-b)—but not (10-a) nor (11-a)—can be used to mean that Marco has solved the problem of how to swim. As Wiggins (2012) also observes, moreover, the bare infinitival construction is somewhat more tied to ability:

(12) a. ??Marco sa nuotare ma non ne ha la capacita'.

'Mark knows how to swim but cannot swim'.

c. Marco sa come nuotare ma non ne ha la capacita'.

'Marco knows how to swim but cannot swim'.

While one can affirm the interrogative construction while at the same time denying that its subject possesses the relevant ability (as in (12c)), one cannot affirm the infinitival construction and at the same time denying that the subject possesses the relevant ability, witness the infelicity of (12a).

On similar bases, Rumfitt and Wiggins suggest that English ascriptions of know-how may be ambiguous between the '*savoir faire*' reading—the genuinely practical reading, the one especially tied to ability—and the '*savoir comment faire*' reading—which may well be reducible to propositional knowledge and does not quite have quite the same connection to ability. Both Rumfitt and Wiggins speculate when used to ascribe *savoir faire*, English ascriptions of know-how might have a different logical form—one not embedding an interrogative—than when used to ascribe *savoir comment faire*.

Now, both Wiggins and Rumfitt seems to assume that the interrogative form in Italian or French cannot express genuinely practical know-how, or *savoir faire*. This assumption is not correct. In particular, it is not true that, for example, in Italian, the interrogative construction cannot express the sort of genuinely practical know-how (or *savoir faire*) standardly ascribed by (10-a) and (10-b)—i.e., standardly ascribed in Italian by the ascriptions embedding bare infinitivals. In fact, in Italian and in French with some embedded verbs, the bare infinitival construction is infelicitous and only the interrogative construction is allowed. Consider:

(13) a. #Mary sa prendere suo padre.

b. Mary knows to-deal-with his dad.

c. Mary sa come prendere suo padre.

d. 'Mary knows how to treat her father'

(14) a. ??Mary sa trattare i suoi colleghi.

b. Mary knows to-treat his colleagues.

c. Mary sa come prendere i suoi colleghi.

d. 'Mary knows how to treat her colleagues.'

(15) a. ??Mary sait traiter son clients.

b. Mary knows to treat her clients.

c. Mary said comment traiter son clients.

d. 'Mary knows how to treat her clients.'

In examples (13)–(15) above, the infinitival forms (13a), (14a), (15a) are out: in order to ascribe to Mary *savoir faire* vis a vis her relationship with one's father, for example,

one would have to use the interrogative construction. (If used, the infinitival construction would ascribe a different sort of know-how from that ascribed by the corresponding interrogative form. For example, (13a) would ascribe to Mary knowledge how *to grab* her father, not knowledge how to deal with him.)

Moreover, if Rumfitt were correct in thinking that Romance languages could not express *savoir faire* through the interrogative form, then it would follow that no genuinely practical know-how (no genuine *savoir faire*) is, or can be, ascribed in all of these cases. But this conclusion is implausible: in these cases, the interrogative form seems to replace the infinitival form for all intents and purposes. Hence, this evidence suggests that, in Romance languages too, the interrogative form can sometime express genuinely practical know-how—or *savoir faire*. Hence, this suggests that in Romance languages, the interrogative form can be used with a reading that is truth conditionally equivalent to that expressed in those languages through the infinitival form.[5]

Crucially, this interpretation of the data is compatible with the univocity of English know how ascriptions—i.e., with the claim that in English, ascriptions of the form 's knows how to φ' univocally exhibit the interrogative form. After all, the fact that the bare infinitival form and the interrogative form can sometimes come apart in their truth values in other languages is not sufficient to motivate the claim that English know-how ascriptions are ambiguous between those two logical forms. One would also have to show that there is no interpretation of the interrogative form on which it has the same truth conditions as the bare infinitival form. But it is, as we will see, rather plausible that the interrogative form alone is susceptible of two different interpretations, one corresponding to *savoir faire* and another corresponding to *savoir comment faire*. This sort of ambiguity is not an ambiguity between an interrogative form and some other non-interrogative form. Rather it is an ambiguity in the interpretation of the interrogative form itself.

In English, know-how ascriptions can receive different interpretations in different contexts—i.e., they are context-sensitive. Moreover, they differ in their interpretation depending on the interpretation of the subject of the infinitival complement and the modal expressed by the bare infinitival complement. Neither phenomenon is an ambiguity between the logical form 'know + (interrogative) how to φ' and the logical form 'know-how + (infinitival) to φ'. First, consider the context-sensitivity of know-

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[5] A very plausible, and independently motivated, explanation for both the ungrammaticality of a sentence such as "Mary sa prendere duo padre" or "May sait traiter son clients" in French and Italian appeals to the argument/adjunct distinction. Typically, manner adverbials (such as 'how') are not arguments but adjuncts, so they do not need to appear at surface form and can be preferentially omitted on account of its brevity (Hence the grammaticality of "Mary sa comportarsi in publico" or "Mary sait se conduire en public"). With some verbs, however manner adverbials can work as arguments: for example, 'prendere' in Italian and 'traiter' in French are ambiguous between a meaning that thematically select for manner ('to treat somebody in some way') as opposed to a meaning that does not ('to take' or 'to negotiate'). So in know-how ascriptions that embed those verbs in linguistic environments that only permit the former meaning, the 'wh'-word 'how' has to appear at surface form, barring a syntactic violation. More precisely, a violation of the projection principle. Observe that this explanation treats ascriptions in those languages of the form "S knows + to φ" as the elliptical variants of their more explicit form "S knows + how to φ." It is an interesting question why in English, the question word 'how' cannot ever be omitted. I suspect the explanation has to do with the fact if it were omitted, the English construction "know+infinitive" would be susceptible of two different meanings: the deontic meaning that one knows that one should φ and the know-how reading. By contrast, in French and Italian, the infinitival construction does not allow for the deontic meaning, so no ambiguity has to be avoided.

how ascriptions. As observed by Schaffer (2007, 396), in some context, one may count as knowing how to play the flute in some sense, by coming to know Monty Python's explanation of how to play the flute is as follows: "Well, you blow in one end and move your fingers up and down the outside." But knowing such an explanation does not give one know-how, in the relevant practical sense. In "Know-How and Gradability," we have seen that a source of context-sensitivity has to do with the selection of a mode of presentation that is distinctively practical (§4.3, pp. 363–64). This dimension of context-sensitivity is associated with the question word 'how'.

In addition to this sort of context-sensitivity, know-how ascriptions are also ambiguous between a generic interpretation ('how to φ' = 'how one could φ') and a *de se* interpretation ('how to φ' = 'how oneself could φ').6 And it is quite plausible that in Italian, ascriptions embedding interrogatives can be used to express the English generic interpretation of the subject of the complement, whereas the ascriptions embedding a bare infinitival complement mandatorily require a de se interpretation. That would explain why the bare infinitival form and the interrogative form can sometimes come apart in their truth conditions: that happens when the interrogative form selects the generic reading. And such an explanation would be compatible with the claim that English ascriptions only allow for the interrogative form.

If so, the claim that there is a further ambiguity in English, between a logical form embedding interrogative and one non-embedding interrogative, is as of now quite unsupported. The Ambiguity Hypothesis is not motivated by the observation that *savoir faire* is ascribed in languages such as Italian and French through the non-interrogative form, for we have seen that in those languages, the interrogative form can have a genuinely practical reading. Furthermore, there are different and independently motivated possible explanations for the contrast in usage between the interrogative form and the infinitival form in those languages. I suggested that this contrast might have to do with the fact that only one of the two forms mandatorily selects the *de se* interpretation of the subject of the infinitival 'to φ'.

Let me expand a little more on why acknowledging the context-sensitivity of know-how ascriptions as well as the ambiguity in the interpretation of the subject of the embedded infinitival help undermine the main arguments in favor of the Ambiguity Hypothesis. It is quite plausible that in Italian, ascriptions embedding interrogatives could be used to express both the English generic interpretation and the de se interpretation, whereas the ascriptions embedding a bare infinitival mandatorily express the English de se interpretation. Similarly, it is quite plausible that in Italian, just like in English, ascriptions embedding interrogatives may contextually select a non-practical reading, whereas ascriptions embedding bare infinitival mandatorily select the practical reading. That would explain why in Italian the infinitival form and the interrogative form can come apart in their truth values at least in some of their uses (for the interrogative form an also be used with a generic interpretation), and this explanation would be still compatible with the claim that English ascriptions of know-how only allow for the interrogative form. After all, ascriptions of the form 's knows + (infinitival) to φ' in French or Italian are only translatable in English by *de se* ascriptions 's knows + (interrogative) how (de se) to

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[6]A further ambiguity has to do with whether the infinitival expresses an ability modal ("how to φ" = "how one could φ") or a deontic modal ("how to φ" = "how one should φ").

φ.'

To make this point more clearly, consider the widely discussed case in the literature of the ski instructor, who intuitively can count as knowing how to perform a ski stunt despite not having the ability to do so. In Italian, one could not use the infinitival form to describe the ski instructor knowledge. That suggests that the ski instructor lacks the genuinely practical know-how ascribed by those infinitival forms. But note also that, in English, we would say that the ski instructor only knows how one can perform a ski stunt, but *do not know how to perform it themselves*. That suggests that the English predicate 'knowing how to perform the ski stunt' is true of the ski instructor only on generic reading of the subject of the embedded infinitival verb (= knowing how one can φ) but is not true on its *de se* and practical reading (= knowing how to perform the ski stunt *themselves*). This observation provides strong support for thinking that only the *de se* reading is relevant for the genuinely practical reading of know-how ascriptions and that only in their *de se* readings do ascriptions of the form "s knows how to φ" entail the relevant sort of ability.[7]

To sum up, the fact that the bare infinitival form and the interrogative form can sometimes come apart — differ in their truth conditions — is not sufficient to motivate the claim English know-how ascriptions are ambiguous between those two logical forms. One would have to also show that there is no interpretation of the interrogative form on which it has the same truth conditions as the bare infinitival form. But as I have argued above, in Romance languages the interrogative form can sometimes receive the genuinely practical interpretation. Hence, there is no reason to expect that that does not also happen in English. In fact, I suggest that that is exactly what we observe when know-how ascriptions are interpreted *de se* and when a practical mode of presentation is contextually selected.

So here is a general picture. In Romance languages, the infinitival form is truth conditionally equivalent to the *de se* and practical reading of the English know-how ascriptions; by contrast the interrogative form (in both Romance language and English) can sometimes be given the generic and non-practical interpretation. Hence, the discrepancy in truth conditions observed by Rumfitt and Wiggins between some uses of the infinitival form and some uses of the interrogative form.

The current analysis explains the observable data, without positing an implausible ambiguity in the logical form of the English ascription, over and beyond the ambiguity having to do with the interpretation of the subject of the infinitival complement. Given these observations, the claim that there is a further ambiguity in English, one between a logical form involving an interrogative and one not involving an interrogative, is left quite unsupported.

Ditter (2016) uses evidence from Russian, German, and Turkish to provide a new argument for the Ambiguity Hypothesis. In my response, I will focus, as Ditter (2016) does, on Russian, since German and Turkish do not seem to raise special

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[7]Another possible strategy, suggested by my view of practical modes of presentation (cf. Pavese 2015, Pavese forthcoming-b) is to say that the ski instructor knows an answer to the question "how to φ" but not under a practical mode of presentation. For a practical mode of presentation represents a task in terms of operations that a subject can primitively perform. And the ski instructor cannot perform some parts of the ski stunt. And so she cannot represent the task under a practical mode of presentation. On this strategy, the *de se* aspect of know-how is contributed by the practical mode of presentation rather than by the interpretation of the embedded infinitival.

or additional difficulties. As Ditter observes, in Russian, we have two kinds of constructions: one with the embedding verb '*umetj*'—which cannot take a that-clause nor an interrogative as complement—and the standard 'know + how to φ' construction. Ditter claims that the 'know + how to φ' construction must ascribe a different state from the '*umetj*' ascription because, in Russian, one can coherently use sentences of the following form:

(16) a. John znaet kak igrat'na pianino, no on ne umeyet igrat.

b. John knows how play to the piano, but he does not know-how to play the piano.

c. 'John knows how to play the piano, but he doesn't know how to do it'

As Ditter acknowledges, the literal translation of (16a) (stated in (16c)) would be a straight contradiction in English. According to Ditter, this observation motivates the claim that the English construction 'knowing how to φ' is ambiguous between an interrogative construction and some other constructions—not involving an interrogative and corresponding to Russian's *umetj*'s ascriptions—of which Ditter omits to give the details. My discussion above shows that Ditter's argument for the ambiguity hypothesis is too quick. First, the availability in Russian of constructions such as (16) does not show that the Russian construction 'know + (interrogative) how to φ' cannot ever receive an interpretation truth conditionally equivalent to an '*umetj*'-ascription. Nor does it show that in English 'knowing how to φ' is ambiguous between an interrogative and a non-interrogative logical form. For, as Ditter goes on to acknowledge, a way to make (16) intelligible in English is to translate it as:

(17) One knows how one could play the piano but does not know how to play the piano himself.

In English, (17) makes perfect sense. As Ditter (2016) notices, it also translates (16) perfectly well. So, the phenomenon that Ditter observes fails to establish that there is an ambiguity in the English ascriptions of know-how that cannot be traced back to the already noted ambiguity between *de se* and generic reading. For the same reason, Ditter (2016) fails to establish that in Russian, genuinely practical know-how cannot ever be ascribed by means of the construction 'know + interrogative (how to φ).' Plausibly, the reason why (16a) is acceptable in Russian that, while the '*umetj*' ascription mandatorily requires a *de se* interpretation, in Russian the construction 'know + how to φ' can also license the generic reading, which is made explicit in (17). Because the *de se* reading of the Russian 'know + (interrogative) how to φ' would make (16a) contradictory, and because the generic reading of that sort of ascription is also possible, that is the reading that is selected instead, so to rescue the sentence.

Hence, Ditter fails to establish that in Russian, genuinely practical know-how cannot be ascribed by means of the construction 'know + (interrogative) how to φ'; he also fails to establish that there is an ambiguity in the English ascriptions of know-how that cannot be traced back to the already noted ambiguity between *de se* and generic reading and in the context sensitivity in the selection of modes of presentation. For this reason, Ditter fails to give new motivations for the ambiguity

claim. Lacking reasons to think that there is a special ambiguity in English ascriptions of know-how that is not reducible to the independently motivated ambiguity between *de se* and generic reading, it is good practice to proceed as if the logical form of English know-how ascriptions is univocal and, moreover, exactly what it looks to be—i.e., s know + (interrogative) how to φ.

In fact, there are several independent reasons to reject the Ambiguity Hypothesis. Consider the question: What logical forms would English know-how ascriptions be ambiguous between? I have already argued against the objectualist analysis of 'how to φ'—i.e., against taking 'how to φ' to be equivalent to the phrase 'a way to φ'. What are the other options? The proponents of the Ambiguity Hypothesis never provide a detailed analysis. But presumably, the two logical forms are something like, respectively, (18) and (19):

(18) *s* knows + (interrogative) how to φ.

(19) s knows + how + (infinitival) to φ.

Now, consider (19). What is the logical role played by 'how' in it? Since it is not supposed to be a question word, presumably in this occurrence, 'how' works as an adjunct modifying the infinitival 'to φ'. (Note that in (19), 'how' cannot plausibly modify 'know', for it cannot precede 'know':

(20) #S how knows to φ.

It follows that, in (19), 'how' must modify 'to φ'.) But this would be a quite unprecedented construction for an adverb modifying the embedded infinitival verb. To see this, consider:

(21) a. Mary knows how to swim.

b. Mary knows to swim.

c. Mary knows quickly to swim;

d. Mary has come to know effortlessly to swim.

(22) a. Mary learned how to swim.

b. Mary learned to swim.

c. Mary learned quickly to swim.

d. Mary learned effortlessly to swim.

(20-c)–(20-d) and (22-c)–(22-d) only license a reading on which the adverbial phrases modify the embedding verb 'know' or 'learn', a reading stated in:

(23) a. Mary has quickly learned to swim.

b. Mary has effortlessly learned to swim.

But note that in (20-c)-(20-d) and (22-c)-(22-d) , 'quickly', 'effortlessly' and 'willingly' cannot modify the infinitival phrase 'swim'—they cannot have a reading equivalent to:

(24) a. Mary has learned to swim quickly.

b. Mary has learned to swim effortlessly.

This suggests that in English, adverbials such as 'quickly', 'effortlessly' in (23-a)-(23-b), which modifies an infinitival verb such as 'to swim', cannot in general move up and land between the embedding verb and the infinitival. Hence, the current proposal, on which 'how' in (19) is not a question word but an adverbial phrase modifying the embedded infinitival, would have to posit a quite unprecedented syntactic construction.

If so, the main cross-linguistic argument for thinking that English ascriptions of know how must be ambiguous between two different logical forms—one corresponding to the infinitival form of Italian, French, Russian ascriptions and the other corresponding to the interrogative form of the ascriptions in those languages—is undermined. Note that the same considerations hold if one tries to argue for the Ambiguity Hypothesis starting from the observation that in English, 'learn' ascriptions license a bare infinitival complement (cf. Glick 2012, Wiggins 2012). Now, it is true, as Glick (2012) observes, that the following ascriptions are grammatical in English and that they mandatorily require a genuinely practical reading:

(25) a. Mary learned to swim

b. Mary learned to cook.

But again, this observation is not sufficient to show that in English know-how ascriptions are ambiguous between a reading corresponding to the 'learn' ascription embedding a bare infinitival and a reading corresponding to the 'learn' ascription embedding the interrogative construction. For just as before, the genuinely practical reading mandatorily expressed by 'learn'-ascriptions such as (25a) and (25b) are expressible by both learn-how ascriptions and know-how ascriptions in their interrogative form. The analysis developed in the main text (pp. 362-3) makes clear how the genuinely practical reading can be expressed by a know-how ascription in its interrogative form: according to it, the interrogative form can express the same reading expressed by 'learn'+ infinitival ascriptions provided that the *de se* reading of the embedded subject is selected, and provided that the context provides a *practical* mode of presentation.

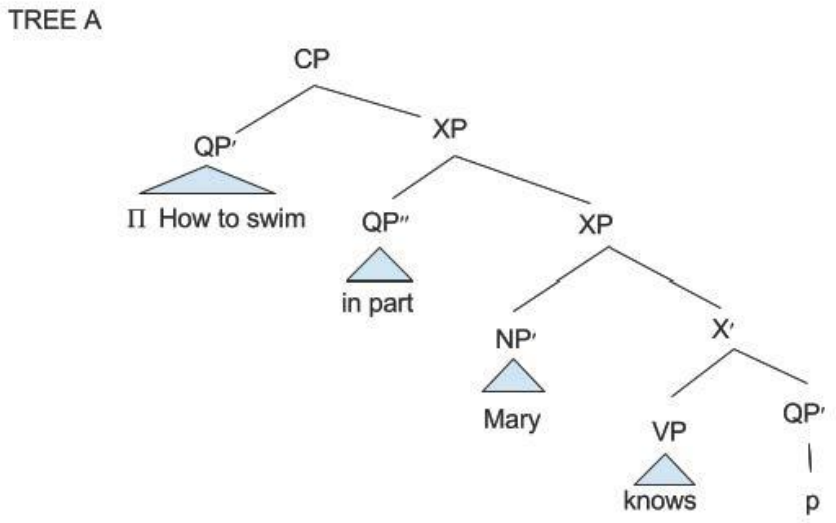
Given this analysis, there is no need to posit an implausible ambiguity in the construction of English know-how/learn-how ascriptions in order to predict their genuinely practical reading. If there is no need to posit, we should not do it.

C. Quantitative Gradability

I am following the standard practice of taking relative clauses and embedded interrogatives to arise from a common abstract 'Wh- ψ' (cf. George (2011)). The interrogative complement arises from the application of an interrogative feature 'Π'

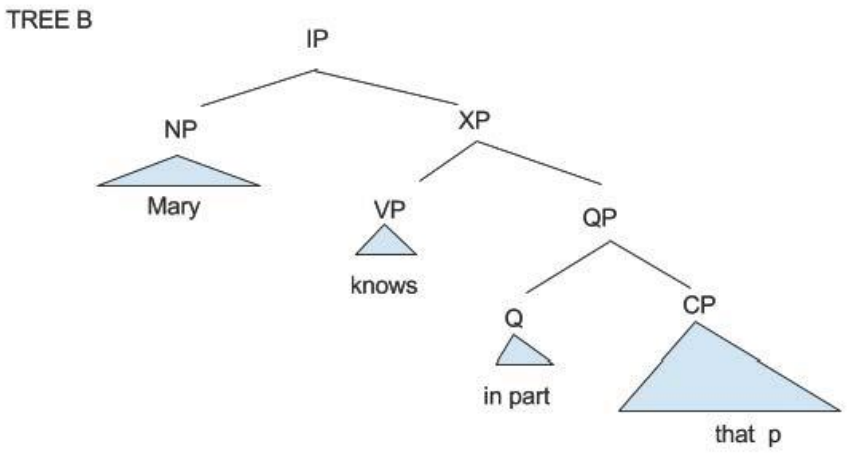
to that abstract. The interrogative feature 'Π' serves two purposes. First, it takes the abstract (in our case the predicate 'PRO to swim w-ly') into a set of true answers (in our case, into a set of true answers to the question *How one could swim*); then it existentially generalizes over that set. The logical form to be interpreted for knowledge-'*wh*' reports is reached through two standard quantifier movements. Consider the sentence 'Mary knows in part Π how to swim'.

We have two quantifier phrases, one embedded into the other: 1) QP′= 'Π how to swim'; 2) QP″ = 'in part Π how to swim'. The embedding quantifier phrase QP″ moves up, this time because of a type mismatch with the verb 'know' which takes propositions as arguments.[8] Because 'in part' quantifies over propositions that are parts of an answer, by moving up, we expect the quantifier to leave behind a trace of the type of propositions (<*p*> = <*s*, *t*>). The embedded quantifier phrase QP′ also moves up because of a type-mismatch with 'in part': 'in part' takes an answer as its argument whereas QP′ existentially quantifies over answers. As a result of the movement, QP′ leaves behind a trace of the type of answers. In particular, the type of an answer α = <*p*, ℚ>, where <*p*, ℚ> = <<*s*, *t*>, <<*s*, *t*>, *t*>>. The resulting logical form to be interpreted is:



For know-that ascriptions, I will assume the following rather standard logical form:

[8] I am following Heim and Kratzer (1998)'s analysis of lifted quantifiers.



How can practical modes of presentation be implemented into a compositional semantics? My analysis closely follows Kaplan (1968)'s analysis of *de re* belief reports and its semantic implementation in Yalcin (2015). The only differences have to do with the peculiarities of know-how reports as compared to belief reports—i.e., that they embed interrogatives rather than *that*-clauses. Following Kaplan (1968), we can start by assuming that the Fregean truth conditions of a belief ascription such as (26) in its *de re* reading are given by (26-b):

(26) a. Mark believes somebody to be a spy.

b. $\exists x: \exists m \in C$: M($m$, x) & Mark B $\langle m \oplus$ is a spy$\rangle$.

(where C is a set of modes of presentations selected by the context c). M(m, x) iff m is a mode of presentation of x; B is the (Fregean) belief relation; '$\oplus$' (as Yalcin (2015) calls it, 'the sense glue') combines m and the sense of '*is a spy*' into a Fregean proposition. Fregean propositions will be indicated by wide corner quotes—i.e., '$\langle$, $\rangle$'—whereas ordered pairs are indicated with smaller corner quotes—i.e., '$<$, $>$'.

According to (26-b), for Mark to believe *de re* that somebody is a spy, there must be a mode m of presentation of some person x such that Mark believes the Fregean proposition $\langle m \oplus$ is a spy$\rangle$. By extending the same analysis to know-how ascriptions, we can analyze the Fregean truth conditions of (27-a) as (27-b):

(27) a. Mark knows how to swim.

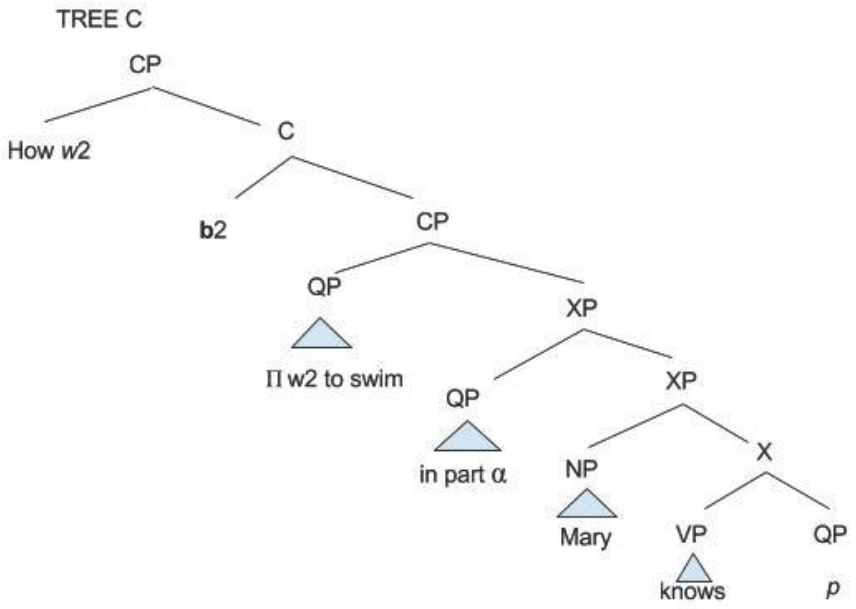
b. $\exists x: \exists \mathcal{P} \in C$: M($\mathcal{P}$, x) & $\exists \alpha$: $\alpha = <p^F$, *How one could swim*$>$ & $p = \langle \mathcal{P} \oplus$ HOW ONE COULD SWIM$\rangle$ and Mark knows every part of α.

(where C is a set of modes of presentations selected by the context c).

According to (27-b), 'Mark knows how to swim' is true at a context c just in case there is a way to swim and a practical mode of presentation for that way to swim selected by the context c, such that for some practical answer to the question How one could swim, Mark knows every part of that practical answer. Recall that a practical answer is an ordered pair. The first element of the ordered pair is a Fregean

proposition pF of the form ⟨$\mathcal{P}$ ⊕ IS HOW ONE COULD SWIM⟩ , where '$\mathcal{P}$' is a variable over practical senses that have as their referents ways w to sim. The second element of the ordered pair is the practical question How one could swim. So according to (27), for Mark to know how to swim, there must be a contextually selected mode of presentation $\mathcal{P}$ of a way w to swim such that, for some complete answer to the question How one could swim, the first element of which is the Fregean proposition <$\mathcal{P}$ ⊕ IS HOW ONE COULD SWIM>, and for a set of contextually selected parts of that answer, Mark knows every part of that answer in that set.

In order to trigger the kind of quantification over modes of presentation that Kaplan(1968) and Yalcin (2015) introduce for *de re* belief reports, we need the movement from Tree A to Tree C:



Following closely Yalcin (2015), we can describe this structure as generated by movement of the quantifier word 'how', leaving behind a trace w_2; and before the quantifier lands at its new home at the top of the syntactic tree, it first adjoins to the tree a branching node dominating a numeral (call it a binder—$\boldsymbol{b}_2$) which matches the numerical index on the trace. Semantically, the trace w_2 will be interpreted as a variable, and the binder $\boldsymbol{b}_2$ will serve to trigger lambda abstraction over that variable. Once such a logical form is in place, its interpretation exploits the same kind of semantic rules postulated by Yalcin (2015) for Fregean *de re* belief ascriptions. We posit two kinds of semantic interpretations: one mapping expressions to their customary sense ($[\![...]\!]^{g,s}$) and one mapping expressions to the referent determined by their senses ($[\![...]\!]^{g,s}$).

The existential quantifier 'How$_{w2}$' introduces an existential quantification over *modes of presentation of ways to* φ, through what Yalcin (2015, p. 230) calls Fregean Predicate Abstraction:

Fregean Predicate Abstraction (FPA). Let β be a branching node with daughters γ and δ, where γ dominates only a numerical index i. Then, for any variable assignment g,

1. $[\![\beta]\!]^{g,rs} = \lambda x [\![\delta]\!]^{g[x/i],rs}$ if defined; else:

2. $[\![\beta]\!]^{g,rs} = \lambda x \exists m \in$ C: M(m, x) & $[\![\delta]\!]^{g[m/i],rs}$.

(where C is some restriction on the set of modes of presentations selected by the context).

Finally, we will need the two further semantic rules of Sense Composition and Functional Application, which is appropriately revised to be sensitive to either the sense of an expression ($[\![...]\!]^{g,s}$) or to its referent ($[\![...]\!]^{g,rs}$) (cf. Yalcin 2015, p. 245):

Functional Application (FA). If β is a branching node with γ and δ as daughters, then for any g: (a) If $[\![\delta]\!]^{g,rs}$ is in the domain of $[\![\gamma]\!]^{g,rs}$, then $[\![\beta]\!]^{g,rs}$ = $[\![\gamma]\!]^{g,rs}$ ($[\![\delta]\!]^{g,rs}$); (b) If $[\![\delta]\!]^{g,rs}$ is in the domain of $[\![\gamma]\!]^{g,rs}$, then $[\![\beta]\!]^{g,rs}$ = $[\![\gamma]\!]^{g,rs}$ ($[\![\delta]\!]^{g,s}$).

Sense Composition (SC). If β is a branching node with γ and δ as daughters, and $[\![\gamma]\!]^{g,rs}$ or $[\![\gamma]\!]^{g,s}$ is in the domain of $[\![\delta]\!]^{g,rs}$, then for any g, $[\![\beta]\!]^{g,s}$ = $[\![\gamma]\!]^{g,s} \oplus [\![\delta]\!]^{g,s}$.

In the lexicon, 'know' expresses a property of propositions, so that the semantics is fully Intellectualist:

$$[\![know]\!]^{g,rs} = \lambda p \lambda x\, (know\,(p)(x)).$$

'in part' takes an answer α and a property P into the true just in case part of that answer has that property—in this particular case, the property of being known by Mary:

$$[\![in\ part]\!]^{g,rs}([\![\alpha]\!]^{g,rs},\ [\![\gamma]\!]^{g,rs}) = 1 \text{ iff some part of } g(\alpha) \in P\text{: } g(\alpha) \in [\![\gamma]\!]^{g,rs}.$$

(where P is some restriction on the set of parts of α selected by the context).

The sense of the predicate in the interrogative abstract '*PRO to swim*' will be indicated by 'IS HOW ONE COULD SWIM'. The interrogative feature 'Π' takes the abstract $[\![\beta]\!]^{g,rs}$ into a set of true practical answers of the form $\langle p, \mathbb{Q}\rangle$ and then existentially quantifies over them. The answer $\langle p^F, \mathbb{Q}\rangle$ has two components—i.e., a Fregean proposition p^F and a question $\mathbb{Q}$. A little more formally, here is the contribution of the interrogative feature 'Π':

$$[\![\Pi]\!]^{g,rs}([\![\beta]\!]^{g,rs}, [\![\gamma]\!]^{g,rs}) = 1 \text{ iff } \exists \alpha : \alpha = \langle p^F, \mathbb{Q}\rangle \text{ (where } \mathbb{Q} = \{p\text{: } \exists x\text{: } p = \lambda i\, (x \in [\![\beta]\!]^{g,rs} \text{at } i)\}) \ \&\ p^F = \langle g(x) \oplus [\![\beta]\!]^{g,s}\rangle \ \&\ [\![\gamma]\!]^{g,s}(\alpha) = 1.$$

Truth is defined as follows:

Definition of truth

φ is true iff $[\![\varphi]\!]^{g,rs} = 1$ for all g.

To simplify a bit my presentation, I will set context-sensitivity aside. To model truth at a context, truth would have to be defined in terms of a value for g selected by the context, rather than by universally quantify over assignments (cf. Yalcin (2015, p. 244)).

Finally, the composition proceeds as follows to reach the desired Fregean truth conditions for ungraded and graded know-how ascriptions:

1. 'Mark knows in part/entirely how to swim' is true iff

2. (**By definition of truth**) $\forall g$ [[*How* b_2 Π w_2 *PRO to swim in part/entirely* α *Mark knows* p]]^{g,rs} iff

3. (**By FA**) $\forall g$ [[*How*]]^{g,rs} ([[b_2, Π w_2 *PRO to swim in part/entirely* α *Mark knows* p]]^{g,rs}) iff

4. (**By FPA**) $\forall g$ [[*How*]]^{g,rs} ($\lambda w \exists \boldsymbol{\mathcal{P}}$: $M(\boldsymbol{\mathcal{P}}, w)$ & [[Π w_2 *PRO to swim in part/entirely* α *Mark knows* p]]$^{g[\boldsymbol{\mathcal{P}}/w2],rs}$ = 1) iff

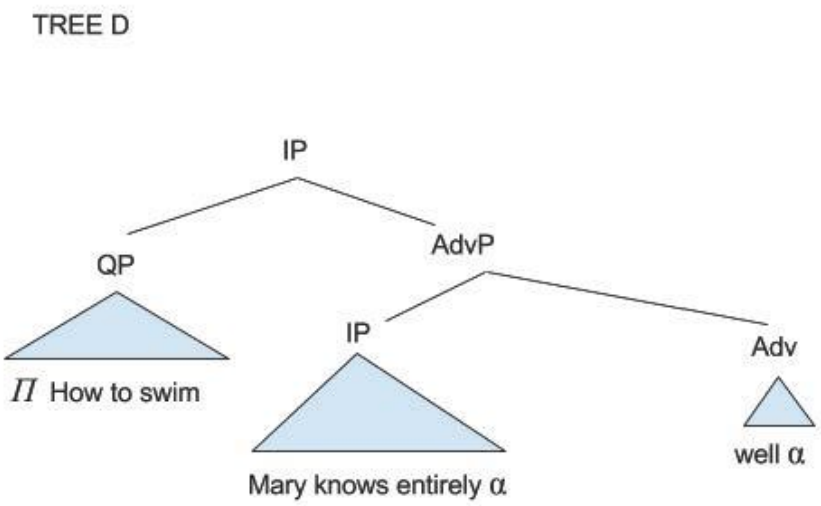
5. (**By meaning of Π, SC and simplification**) $\forall g$ [[*How*]]^{g,rs}(λw $\exists \boldsymbol{\mathcal{P}}$: M($\boldsymbol{\mathcal{P}}$, w) & $\exists \boldsymbol{\alpha}$ (α = <p^F, $\mathbb{Q}$>: $\mathbb{Q}$ = {p: $\exists x$: $p = \lambda i\,(x \in [\![\boldsymbol{\beta}]\!]^{g,rs}$ at i)} & p^F = $\langle g^{[\boldsymbol{\mathcal{P}}/w2]}(w_2 \oplus$ [[*PRO to swim*]]$^{g,rs}\rangle$ & for some part p^*/every part p^* of α, [[*Mark knows* p]]$^{g[p^*/p],rs}$ = 1)) iff

6. (**By lexicon and simplification**) $\forall g$ [[*How*]]^{g,rs}($\exists \boldsymbol{\mathcal{P}}$: M($\boldsymbol{\mathcal{P}}$, w) & $\exists \boldsymbol{\alpha}$ (α = <p^F, *How one could swim*>: p^F = $\langle \boldsymbol{\mathcal{P}} \oplus$ IS HOW ONE COULD SWIM$\rangle$ & for some part p^*/for every part p^* of α, Mark knows p^*)) iff

7. (**by FA, lexicon and simplification**) There is a practical answer α to the question *How one could swim* such that Mark knows some part/every part of α. □

D. Qualitative Gradability

The logical form is to be represented thus:



The meaning of the adverb '*well*' is as follows:

> $[\![\textit{Well}\ (\alpha)]\!]^{g,ts,C} = 1$ iff $[\![\alpha]\!]^{g,ts}$ is good (relative to the standards selected by the context C),

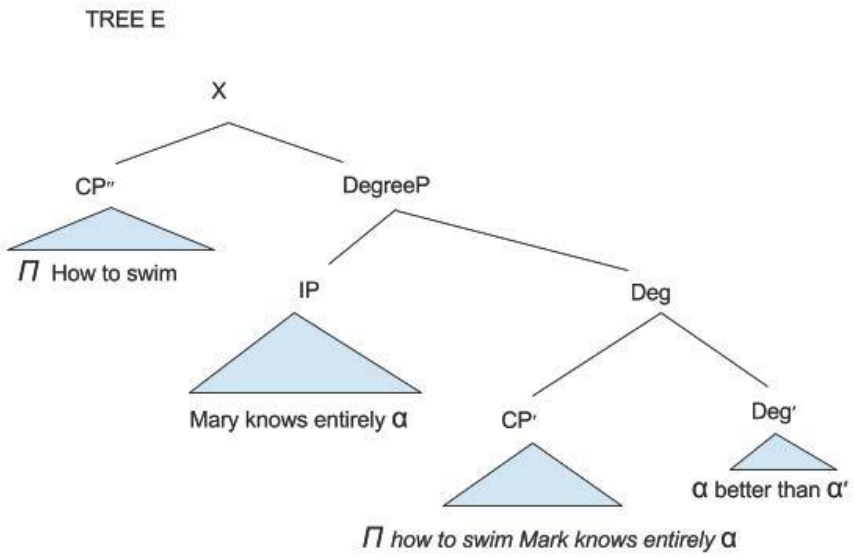
The composition proceeds thus (again setting context-sensitivity aside):

> 1. 'Mark knows how to swim well' is true iff
>
> 2. **(By definition of truth)** $\forall g [\![\textit{How}_{w_2}\ b_x\ \Pi\ w_2\ \textit{PRO to swim entirely}\ \alpha\ \textit{Mark knows p well}\ \alpha]\!]^{g,ts}$ iff
>
> 3. **(By FA, FPA, lexicon, SC and simplification)** $\forall g [\![\textit{How}_{w_2}]\!]^{g,ts}$ $(\exists \boldsymbol{\mathcal{P}}: \mathrm{M}(\boldsymbol{\mathcal{P}}, w) \ \&\ \exists \alpha\ (\alpha = \langle p^F, \textit{How one could swim} \rangle: p^F = \langle \boldsymbol{\mathcal{P}} \oplus [\![\textit{PRO to swim}]\!]^{g,ts} \rangle$ & for every part p of α, $[\![\textit{Mark knows p}]\!]^{g[\boldsymbol{\mathcal{P}}/w_2],ts} = 1$ & $[\![\textit{Well}\ (\alpha)]\!]^{g,ts} = 1$)) iff
>
> 4. **(By lexicon and simplification)** There is a way w to swim and a practical mode of presentation $\boldsymbol{\mathcal{P}}$ of w such that for some practical answer $\alpha = \langle p^F, \textit{How one could swim} \rangle$ where $p^F = \langle \boldsymbol{\mathcal{P}} \oplus$ IS HOW ONE COULD SWIM$\rangle$, Mark knows every part of α and α is good iff
>
> 5. **(By simplification)** For some practical answer α to the question *How one could swim,* Mark knows every part of α and α is good.
>
> □

What happens in a comparison, such as "Mariano Rivera knew how to close better than Trevor Hoffman knows how to close"? Recall that their logical form can be paragraphed as:

(28) There is a practical answer known by S to the question *How one could φ* that is better than any practical answer known by S to the question *How one could φ*.

And it can be represented by the following tree:



The meaning of 'better than' arises from applying the comparative construction '-er than' to the meaning of 'well'. I will spare the reader the details and will assume the following derived semantic value for 'better than':[9]

> $[\![$*better than* (α), (α′)$]\!]^{g,rs,C}$ = 1 iff $[\![\alpha]\!]^{g,rs}$ is better than $[\![\alpha']\!]^{g,rs}$ (relative to the standards set by context C).

The composition proceeds as follows (again setting context-sensitivity aside):

> 1. 'Mary knows how to swim better than Mark knows how to swim' is true iff
>
> 2. (**By definition of truth**) ∀*g* $[\![$*How*$_{w_2}$ b_2 Π w_2 *PRO to swim entirely* α *Mary knows p* Π *How* PRO to swim entirely α' Mark knows p better (α, α′)$]\!]^{g,rs}$ iff
>
> 3. (**By FA**) ∀g $[\![\text{How}_{w2}]\!]^{g,rs}$ ($[\![\text{b}_2$ Π w_2 How PRO to swim entirely α Mary knows p$]\!]^{g,rs}$ = 1 & $[\![\text{How}_{w3}]\!]^{g,rs}$ ($[\![\text{b}_3$ Π w_3 How PRO to swim entirely α' Mark knows p better (α, α′)$]\!]^{g,rs}$ = 1 iff
>
> 4. (**By FPA**) For some way to swim *w* and a practical mode of presentation $\mathcal{P}$ of *w*, there is a practical answer $\alpha^* = \langle p^F$, *How one could swim*$\rangle$ where $p^F = \langle \mathcal{P} \oplus$ IS HOW ONE COULD

[9] For more details on the compositional semantics, see Schwarzschild and Wilkinson (1990).

SWIM⟩ such that Mary knows every part of α^* and for every way w_i to swim and practical mode of presentation $\mathcal{P}$ of w_i such that there is a practical answer $\alpha^{**} = \langle q^{\mathcal{P}}$, *How one could swim*⟩ & Mark knows every part of α^{**}: $[\![better\ than\ (\alpha), (\alpha')]\!]^{g[\alpha'/\alpha^1, g[\alpha''/\alpha'']^{w,t,cs}} = 1$ iff

5. (By meaning of Π, lexicon, SC and simplification) For some practical answer α^* to the question *How one could swim* known entirely by Mary, α^* is better than any practical answer to the question *How one could swim* entirely known by Mark. □

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