1 Introduction

How do you say ‘hello’ in Arabic? asks Adam, ‘marhaba,’ responds his friend Bilal. After several visits to his local phonetician and no little practice Adam masters more or less the pharyngeal sound ħ and can utter ‘marḥaba’ on cue. He now knows that ‘marḥaba’ is how one says ‘hello’ in Arabic, he has learnt to say ‘hello’ in Arabic, so he can start a conversation in Arabic—he knows a little bit of Arabic. One way of framing the debate on intellectualism is to ask whether these changes to Adam’s cognitive state are to be described in terms of simply one pathway, the propositional epistemic pathway (needed in any case to account for the emergence of his knowledge that ‘marḥaba’ is how one says ‘hello’ in Arabic), or whether others should also be posited (which one might postulate to account for his having learnt to say ‘hello’ in Arabic and his ability to start a conversation in Arabic. And we could of course consider the pathways responsible for the corresponding acquisition for Bilal’s infant daughter).

As Abbott, 2006 points out, if the answer one is looking for is to be grounded empirically, then given e.g. the solid evidence for various distinct subsystems of memory (see e.g. Baddeley, 1997; Fletcher, 1994), one has to be quite brave to fight for intellectualism. Even limiting one’s gaze essentially to semantics, as I will here, defending intellectualism doesn’t seem too easy.

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In section 2 I argue for a certain ontology needed to explain the semantics of the attitude predicates involved in epistemic pathways. In particular, I motivate the need for skills/abilities as a distinctive kind of abstract entity. We will see that although there certainly do seem to be attitude predicates that require exclusively one type of entity as their complements (e.g. ‘ask’ requires questions and ‘believe’ propositions), there are certainly a variety of predicates that can genuinely combine with more than one (e.g. ‘be intriguing’ with questions and facts or ‘learn’ with facts and abilities). I will suggest that ‘know’ happens to be one of the latter—the evidence being stronger in some languages than others. From a semantic point of view there is nothing very intriguing about that.

And yet, much of the linguistic evidence against intellectualism comes from ‘how to’ clauses embedded by ‘know’, which are commonly analyzed in a way that diverges significantly from the analysis of other types of embedded interrogatives. One motivation for this divergence is that ‘how to’ clauses do not exhibit the exhaustiveness assumed to characterize interrogatives in a number of influential analyses. In sections 3 and 4 I take up the analysis of interrogative constructions and epistemic pathway complementation, respectively, sketching an approach to questions, based on the approach of Ginzburg, 1995a, 1995b; Ginzburg & Sag, 2000, which rejects the analysis of questions in terms of exhaustive answerhood conditions. In its stead this approach offers a view of questions as propositional abstracts and proposes resolvedness, an agent-relative generalization of exhaustiveness that has a strongly teleological nature, as the key notion needed for the semantics of resolutive complements (interrogatives embedded by e.g. ‘know’, ‘discover’, ‘learn’ and ‘forget’). I will also sketch a formal analysis of the various types of complements at issue—factive, resolutive, and ability–denoting. Although it would be technically straightforward to develop their analysis as ability–denoting complements, in section 5 I argue that ‘how to’ clauses embedded by resolutive predicates can and should be analyzed just like any other interrogative embedded by resolutives. In other words, they are propositional. Or, somewhat more precisely, they denote (indefinite descriptions of) facts that resolve the question denoted by the embedded interrogative. My argument will rely on data that demonstrates the compatibility of ‘how to’ with predicates that are incompatible with ability–denoting expressions and on a demonstration that ability attributions in ‘how to’ are often though not invariably defeasible (Bengson & Moffett, 2007). The account exploits the teleological nature of resolvedness combined with the fact that the demon-
stration of an ability is a potentially resolving answer to a ‘how to’ question.

2 Basic Ontological Picture

An account of the lexical semantics of the epistemic pathway(s) is faced with the problem that the predicates in question combine with a wide range of complements, both clausal (declarative, interrogative, and infinitival) and nominal. What makes this task even more difficult is that there are good grounds for assuming that each of the clausal types is at least two ways ambiguous, ditto for some classes of nominal complements. The methodology I adopt in trying to figure out what entities genuinely function as arguments of a given predicate involves using a number of tests, inspired by Quine and Vendler, relating nominal and clausal complements, particularly substitutivity and existential generalization.

2.1 The propositional pathway

I start by considering the pathway that starts with an issue being raised and leads, possibly via communicative interaction, to the emergence of knowledge that resolves that issue. Ginzburg, 1995b argued for a class of predicates that combines in a purely referential with questions, based on data such as (1):

(1) a. **Substitutivity:**
   Jean asked/investigated/was discussing an interesting question.
The question was who left yesterday.
Hence: Jean asked/investigated/was discussing who left yesterday.

b. **Existential Generalization:**
   Jean asked/investigated/was discussing who left yesterday.
Hence, there is a question/issue that Jean asked/investigated/was discussing yesterday.
Which question?
The question was who left yesterday.

In contrast to the influential analysis of Karttunen, 1977, I argued that none of the typically epistemic predicates such as know, discover, forget, learn, teach predicate directly of questions because even when they actually seem
to combine felicitously with question nominals, they fail pure referentiality tests, as exemplified in (2):

(2) a. **Substitutivity**: Jean discovered/revealed an interesting question. The question was who left yesterday. *It does not follow* that: Jean discovered/revealed who left yesterday.

b. **Existential Generalization**: Jean discovered/knows who left yesterday. *It does not follow* that: there is a question/issue that Jean discovered/knows.

A common alternative assumption to Karttunen’s conception, adopted *inter alia* by Hintikka, 1976; Groenendijk & Stokhof, 1984 is to assume that when predicates such as ‘know’, ‘forget’, ‘learn’ combine with interrogatives they predicate of a proposition. Ginzburg, 1995b argued against this strategy because: (a) resolutives fail pure referentiality tests with proposition denoting nominals, as in (3a); (b) there are predicates that pass pure referentiality tests with proposition denoting nominals, dubbed Truth Falsity (TF) predicates, e.g. ‘believe’, ‘deny’. Indeed such predicates only combine with nominals of which truth/falsity is predicable, see (3b,c); (c) TF predicates do not combine felicitously with interrogative complements, a pattern that holds with a high degree of cross-linguistic regularity. This apparent universal can be explained straightforwardly if one assumes that *interrogatives do not have a proposition–denoting manifestation*:

(3) a. The Fed’s forecast was that gold reserves will be depleted by the year 2000. Brendan discovered/was aware of the Fed’s forecast. *It does not follow* that: Brendan discovered/was aware that gold reserves will be depleted by the year 2000.

b. Brendan believes/denies the Fed’s forecast. Hence, Brendan believes/denies that gold reserves will be depleted by the year 2000.

c. Jackie believed/doubted Billie’s story/the claim/the forecast #Bo’s weight/#my phone number.

d. #Bo believes/doubts/supposes/assumes which pitcher will play tomorrow.
Since there is evidence that resolutives do combine in a purely referential fashion with facts, then adopting the Vendlerian assumption (Vendler, 1972; Asher, 1993; Peterson, 1997) that facts and true propositions are distinct, it is natural to assume that resolutive complements denote facts. Which facts? Facts that resolve the question, in a sense whose precise sense is the topic of section 3.

(4) a. Philippe knows/discovered whether Emanuelle was in town. Hence, Philippe knows/discovered a fact that indicates/proves whether Emanuelle was in town.

b. Philippe knows/discovered who attended the WTO meeting. Hence, Philippe knows/discovered a fact, one that resolves the issue of who attended the WTO meeting.

c. Dominique revealed to me when the train is leaving. Hence, Dominique revealed a fact to me, one that resolves the issue of when the train is leaving.

As I mentioned in the introductory section, there is also evidence that some predicates actually combine with more than one type of entity. Ginzburg & Sag, 2000 note the existence of a class of predicates, including intrigue, mystify, and puzzle, that are compatible with both questions and facts. These predicates satisfy pure referentiality arguments with interrogatives, though not with declaratives:

(5) a. The question is who entered the building last night. That question intrigues me. Hence, it intrigues me who entered the building last night.

b. The claim is that Jerry entered the building last night. That claim intrigues me. # Hence, it intrigues me that Jerry entered the building last night.

c. That Jerry entered the building last night intrigues me. Hence, there is a fact that intrigues me, namely the fact that Jerry entered the building last night.

Such data are of some theoretical interest. They argue against strategies such as the intensional/extensional strategy of Groenendijk & Stokhof, 1984.
in which any predicate that selects for facts (or propositions) and combines with an interrogative complements necessarily coerces it to denote a fact (or proposition). It is also telling against the intellectualist mindset because it indicates that attitude predicates can be perfectly tolerant of distinctive types of entities.

2.2 The ability pathway

There is lexical semantic evidence for a more complex pattern among the resolutive predicates with ability/skill nominals and with infinitivals: ‘learn’ and ‘teach’ combine with these in a purely referential way, as in (6) and (7), ‘understand’ and ‘explain’ resist such complements, whereas with ‘know’ and ‘forget’ the evidence is mixed.

(6) a. Bo taught me to swim.
   
   b. I learnt to ride a bike when I was eight.
   
   c. I acquired the ability to sing a high C at a relatively late age.
   
   d. Certain abilities cannot be taught.

(7) a. The Vezo people taught me an unusual skill.

   That skill was to swim without moving my legs.

   Hence, the Vezo people taught me to swim without moving my legs.

   b. I learnt that particular skill from an old Mapuche guide.

   That skill was to ride a bike without making a sound.

   Hence, I learnt to ride a bike without making a sound from an old Mapuche guide.

In English ‘know’ cannot combine with infinitivals like ‘learn’ and ‘teach’ can. There are, nonetheless, various languages where the same lexical item is used to describe ‘propositional’ knowledge and skills or abilities. These
include Hebrew, Greek, and Italian.\(^1\) (8) illustrates this with data from Hebrew:\(^2\)

**(8)**

a. \(\text{maya yod'at šebaxoref yored šeleg.}\)
   
   Maya knows that-in-winter falls snow
   
   Maya knows that in winter snow falls.

b. \(\text{maya yod'at lirkav al ofnayim.}\)
   
   Maya knows to-ride on bike.

c. \(\text{dina yod'at laruc al regel axat.}\)
   
   Dina knows to-run on foot one

d. \(\text{hadar yod'at lesaxek squoš.}\)
   
   Hadar knows to-play squash

Even in English ‘know’ seems to have some skill-oriented arguments. In (9a) ‘German’ clearly denotes neither a proposition nor a fact. Its content arises via some sort of metonomy, akin to (9c) widely discussed since Pustejovský, 1995: in (9d) ‘a novel’ gets coerced to denote an event. By the same token ‘German’ in (9a) would seem to denote a skill/ability, roughly paraphrasable as in (9b):

**(9)**

a. Max knows German.

b. Max can speak/write/understand (read) German.

c. Max began a novel. \(\rightarrow\) Max began reading/writing a novel.

This same coercion would seem to apply in (10):

**(10)**

a. Sabine taught me German. \(\rightarrow\) Sabine taught me to speak/understand (read) German.

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\(^1\)I became aware of data such as these—about my natively spoken Hebrew—during the discussion period of Zardini’s paper (Zardini, 2009) in which similar data are provided concerning the Romance verbs ‘savoir’/‘saber’/‘sapere’, citing (Rumfitt, 2003).

\(^2\)It is of course a loaded question whether to gloss these in English as ‘know how’ or ‘can’. I won’t make that decision here.
b. Max learnt German. \(\iff\) Max learnt to speak/understand (read) German.

Note now that there are resolutive predicates that seem incompatible with skills. (11a,e) illustrate this for ‘explain’ in English, whereas (11b) is the corresponding example in Hebrew; (11c) illustrates the incompatibility of an ability infinitive with ‘understand’, with (11d) the corresponding example in Hebrew. Finally, although (11f) is felicitous, it does not seem to involve the skill-oriented coercion we observed above:

(11) a. #Dina explained to me to swim.
    b. #dina hisbira li lisxot.
       Dina explained to-me to-swim
    c. #I understood to ride a bike when I was eight.
    d. #maya mevina lirkav al ofnayim.
       Maya understands to-ride on bike
    e. #Bo explained German to me.
    f. Bo understands German. \(\not\iff\) Bo can speak German.

A possible, if misguided reaction to (11) is that ‘something syntactic’ is responsible for the incompatibility. ‘forget’, however, illustrates that this cannot be the explanation. ‘forget’ is perfectly compatible with infinitival clauses. However, the only reading (12a) and the corresponding Hebrew datum (12b) obtain is eventive—Bo or Dina forgot to swim on some particular occasion. Similar comments apply to (12c,d).

(12) a. Bo forgot to swim.
    b. dina shaxaxa lisxot.
       Dina forgot to-swim
    c. Bo forgot to show up.
d. Bo forgot to speak German. \( \neg \) Bo cannot speak German.

In the literature various types of denotation have been proposed for infinitivals. Given our earlier discussion of ‘believe’ (13a) needs to be propositional; (Ginzburg & Sag, 2000), inspired by (Portner, 1997), posit an abstract entity they dub an outcome, which serves as the denotation of imperatives and subjunctives and is discussed briefly in section 4, as in (13b,c); the close synonymy of (13d) with (13b,c) suggests infinitivals have uses as outcomes. A characteristic of outcomes is futurate temporality: at the time of ordering in (13b,c,d) no money has been transferred, though the intended time can be specified (e.g. ‘now’). It is clear that skill infinitivals like (13e) have a very different temporal profile, which if anything is telic and certainly not futurate. Moreover, as (13f) shows, temporal adverbials can only modify the embedding predicate (i.e. the time of learning), not the time in which the skill occurs—the ability clause has no event time of its own. Indeed neither ‘learn’, nor ‘teach’ is compatible with subjunctive clauses, as in (13g). Since subjunctives are syntactically declarative, which ‘learn’ and ‘teach’ subcategorize for, this indicates that the problem is semantic—they are semantically incompatible with outcomes. In light of this it seems clear that skill infinitivals are not outcomes, nor given the incompatibility of ‘learn’ with truth/falsity nominals (e.g. ‘claim’, ‘forecast’) can they be propositions.\(^3\) One possible conceptualization will be sketched in section 4.

(13) a. Bo believes Mary to have stolen the money.

b. Jo: give me the money (now)!

c. Jo ordered that the money be given to him.

d. Jo ordered Mary to give him the money.

e. Bo learnt to swim.

f. Bo learnt to swim afterwards/immediately

g. #Bo taught Jo/learnt that he swim.

\(^3\)Of course ‘learn the forecast/claim’ is syntactically well formed, but the nominal is used as a ‘concealed question’ (=‘what the forecast/claim is’).
3 Resolving Issues in Interaction

3.1 From exhaustive answerhood conditions to propositional abstracts

Some recent analyses of knowing how (e.g. Roberts, 2007; Zardini, 2009) assume that resolutive ‘how to’ clauses are somehow exceptional in not exhibiting the exhaustiveness that many formal semantic treatments (e.g. Karttunen, 1977; Groenendijk & Stokhof, 1997) assume characterizes interrogative clauses. Accounts such as Karttunen’s and Groenendijk and Stokhof’s specify questions in terms of exhaustiveness answerhood conditions (EACs).

Ginzburg, 1995a; Ginzburg & Sag, 2000 argue against an EAC-based approach to questions. One important component of the argument is the claim that the requisite notion of exhaustiveness—that needed for the semantics of resolutive clauses—is an agent-specific notion and, consequently, cannot serve as the semantic underpinning of questions.

This claim originates in Ginzburg, 1995a, who made it primarily on the basis of examples with ‘where’, ‘when’, ‘why’, and ‘who’ interrogatives, exemplified in (14); Asher & Lascarides, 1998 make analogous claims with respect to (finite) ‘how’-clauses in the course of their detailed and insightful account.  

(14) a. Bo knows where he is (in Helsinki/near the stadium/opposite Nurmi’s statue ).

b. Bo knows when the train is leaving (At 2:58, 17.333398 seconds, according to our caesium clock/At 2:58./In about an hour./In a short while.)

Here I briefly mention one motivating example involving ‘who’ interrogatives. A scientist and a European Union politician are visiting an institute located in a distant country isolated from current academic activity. Both people are taken to visit a local research institute where the scientist gives a number of lectures. After the last lecture each asks (15a). It is clear that neither of them will satisfied with (15b) to which they would be entitled to react with (15c). What the visitors would really have welcomed would be responses of the type provided in (15e,f), which could then be reported as (15d):

---

4Asher and Lascarides do not discuss ‘how to’ clauses.
(15) a. Q: Who has been attending these talks?
   b. The director: (Provides list of names)
   c. I asked the director who had been attending the talks. She didn’t really tell me. All she did was recite a list of names, none of which meant much to me.
   d. The director was asked who had been attending the talks and she told us.
   e. [Querier is the high ranking EU politician.] The director: A number of linguists and psychologists.
   f. [Querier is the researcher in the field covered by the institute.] The director: A number of cognitive phoneticians and Willshaw-net experts.

This seems to be the case even despite the fact that neither response conveys information that enables either one of them to determine the extension of the predicate ‘has been attending the talks’. Furthermore, unless the scientist is compiling an inventory or the politician an indictment of the skills existing in far flung territories but not in his own backyard, it is reasonable to assume that they do not presume that all attendees necessarily conform to the descriptions provided. Moreover, permuting the responses results in inappropriateness: providing a specialised domain description to a politician completely unaware of basic information concerning a whole domain of research is pointless, as is the converse, providing a general response to a scientist aware of the intricacies of that field.

These data point to the fact that the semantically absolute notion of exhaustiveness is not appropriate as the notion underpinning the meaning of resolutive clauses—non-exhaustive answers can be resolving and which answers are resolving can vary across agents even in a single discourse context. Moreover, the putative mention-all/mention-some ambiguity—appealed to by Stanley & Williamson, 2001; Roberts, 2007 in their accounts of ‘knowing how’—is an artefact of ECA-based theories.

It is important to note, nonetheless, that when regarded purely in terms of query/response coherence all of (15b,e,f) are equally felicitous. The factors that discriminate in favour of one over the other depend on the belief/knowledge state and purpose of the querier. Hence it seems that on a
the question expressed by uttering (15a) should characterise all of (15b,e,f), if true, as potentially resolving the question asked. Indeed there are propositions that under no conditions resolve a question, yet are about the question, emphasizing that potential resolvedness and aboutness are distinct. Theories of interrogatives such as Karttunen, 1977; Groenendijk & Stokhof, 1984, 1997 do not, in fact, accommodate such propositions as answers.5

    b. A: Who is coming to the party? B: Few people you know.

Given all this, Ginzburg, 1995a; Ginzburg & Sag, 2000 conclude that the motivation for identifying a question—the semantic object associated with the attitude of wondering and the speech act of asking—with an entity that encodes exhaustive answerhood conditions is flawed. Ginzburg, 1995a; Ginzburg & Sag, 2000 propose that questions are entities by means of which the various disparate notions of answerhood should be characterized (and not vice versa). They show in detail how this can be done if questions are taken to be propositional abstracts. One of the traditional attractions of identifying questions with abstracts has been that they provide the requisite semantic apparatus for short answer resolution (Who left? Bo; Did Bo leave? Yes etc). However, therein also lies danger because this suggests that e.g. unary wh–questions have the same semantic type as properties, which seems counterintuitive given data such as (17):

(17) a. Some man is happy. So we know that happiness and manfulness are not incompatible. # So we know that the question of who is happy and who is a man are not incompatible.
    b. A: What was Bill yesterday? B: Happy. B: #The question of who is happy.

Ginzburg and Sag develop their account within the situation theoretic–motivated approach to ontology developed in (Seligman & Moss, 1997). The structure they axiomatize, a Situational Universe with Abstract Enti-
ties (SU+AE) involves propositions and other abstract semantic entities (e.g.

\footnote{The problem with accommodating (16a), for instance, is that the partitions corresponding to a polar question p? has only 2 cells, p and ¬p. For a more refined theory of answerhood see Groenendijk, 2006.}
outcomes—the denotata of imperatives, facts—the denotata of exclamatives)—being constructed in terms of ‘concrete’ entities of the ontology such as situations and situation types. An additional assumption made is that the semantic universe is closed under *simultaneous abstraction*, a semantic operation akin to $\lambda$-abstraction with one significant extension: abstraction is over sets of elements, including the empty set. Moreover, abstraction (including over the empty set) is *potent*—the body out of which abstraction occurs is distinct from the abstract. Within such a setting propositions and situation types are naturally distinguished and hence propositional abstracts—questions—are not conflated with situation type abstracts—properties and can be assigned a uniform type. Polar questions are 0-ary abstracts, whereas wh-questions are n-ary abstracts for $n \geq 1$. The fact that questions involve abstraction over *propositions*, which will turn out to be of some importance for how to interrogatives—receives empirical support from evidence concerning the distribution of *in situ* wh-phrases in English. In declarative clause-types, that in the absence of a *wh-phrase* denote propositions, the occurrence of such phrases leads to an ambiguity between two readings: a ‘canonical’ use which expresses a direct query and a use as a *reprise* query to request clarification of a preceding utterance. In all other clause types, ones which denote outcomes (18d), questions (18e), or facts (18f) the ambiguity does not arise, only a reprise reading is available:⁶

(18) a. The bagels, you gave to *who*? (can be used to make a non-reprise query.)

   b. You gave the bagels to *who*? (can be used to make a non-reprise query.)

   c. Who talked to *who*? (can be used to make a non-reprise query.)

   d. Give *who* the book? (can be used ONLY to make a reprise query.)

   e. Do I like *who*? (can be used ONLY to make a reprise query.)

   f. What a winner *who* is? (can be used ONLY to make a reprise query.)

   (Ginzburg & Sag, 2000, example (72), p. 282)

⁶*Apriori* one might expect (18d), for instance, to have a reading as a direct question paraphrasable as *who should I give the book to?* if one could simply abstract over the *wh*-parameter within an ‘open outcome’.

13
In subsequent work, the reliance on the situation theoretic notion of abstraction has been eliminated. (Ginzburg, 2005) shows how to formulate a theory of questions as propositional abstracts in Type Theory with Records (TTR) (Cooper, 2005), a model–theoretic descendant of Martin-Löf Type Theory, Ranta, 1994), while using the standard TTR notion of abstraction. An alternative modeling of the key entities of the situation theoretic ontology in TTR is provided in section 4.

3.2 Resolutive complements: from exhaustiveness to resolvedness

The implication from the data discussed above (examples (15)) would appear to be the following: the notion of resolvedness required for capturing certain basic inferences involving interrogatives embedded by propositional attitude predicates is a relative one: information resolves a given question relative to an agent’s information state. That is, a given question defines a class of true propositions each of which is potentially resolving. Whether a given member of this class, $p$, is actually a resolving answer in a given context depends on two additional factors fixed by an information state: the goal or desired outcome $o$, which determines a lower bound for $p$, and the inferential capabilities relative to which $p$ has $o$ as a consequence:

\[ p \text{ resolves } q \text{ relative to B’s information state } I \text{ iff } p \text{ is a potentially resolving answer to } q, \text{ and relative to B’s information state } I p \text{ leads to B’s desired outcome } o. \]

Under reasonable assumptions discussed in Ginzburg, 1995a, it is easy to show that if one fixes the contextual parameters to certain ‘default settings’, then resolvedness reduces to exhaustiveness. In other words, resolvedness is an agent–relativized generalization of exhaustiveness.

Since there are good reasons to assume that interrogatives never denote propositions or facts in contexts outside embedding by resolutives, resolvedness is.

\footnote{Ginzburg, 1995a suggests that $p$ potentially resolves $q$ if either $p$ strongly positively resolves $q$ (provides a description of a witness for the instantiation of $q$) or $p$ negatively resolves $q$ (entails the extension of $q$ is empty).}

\footnote{The phrase ‘$p$ leads to B’s desired outcome’ is to be understood in terms familiar from planning theory in AI, see Ginzburg, 1995a; Asher & Lascarides, 2003.}

\footnote{Ginzburg & Sag, 2000 offer a number of arguments for this conclusion, including the fact that interrogatives cannot be used equatively with fact-denoting nominals, see (i), nor}
tive embedding needs to arise by coercion. Given an interrogative clause S[+Interrog], the coercion needs to yield (a description for) a fact that in that context resolves the question denoted by S[+Interrog]. The coercion process will be well-defined if and only if the question is resolved. In other words, it is a presupposition of the coercion that there is a resolving fact for the question. Informally, we can specify this as follows, a formulation I refine in section 4:

\[
\lceil \text{Bo V S[+Interrog]} \rceil \text{ denotes } \exists f \forall (bo,f,I) \uparrow \text{Resolve}(f,q,I) \text{ for } I \text{ an information state, } q \text{ the question } S[+\text{Interrog}] \text{ denotes.}
\]

4 Complementation: ontology and context

(20) presupposes that resolvedness presuppositions emerge in context. These can be explicated very naturally within a Questions Under Discussion (QUD)–oriented view of context. I turn to a bare bones sketch of this and prior to that of an ontological setting for the concrete and abstract entities that constitute attitudinal objects (events, propositions, questions etc).

4.1 An ontology for Questions, Propositions, Outcomes, and Skills

As the underlying logical framework, I use Type Theory with Records. This provides a formalism with which to build a semantic ontology, and to write conversational interaction and grammar rules.

The most fundamental notion of TTR is the typing judgement \( a : T \) classifying an object \( a \) as being of type \( T \). A record is an ordered tuple of the form (21)—each assignment to a field constituting a component of the tuple. Crucially, each successive field can depend on the values of the

can they participate in anaphora with such nominals, see (ii):

(i) #The fact is who vanquished the anti-Leninist faction.

(ii) A: I’d like to point out a crucial fact to you. B: Go on. A: #Who is waiting for you in my office.

\[^{10}\]I assume that this is an indefinite description given the existence of many resolving facts and, moreover, the possibility of ascribing such knowledge without oneself knowing a resolving fact.
preceding fields. A record type is simply an ordered tuple of the form (21), where again each successive type can depend on its predecessor types within the record. Record types allow us to place constraints on records: the basic typing mechanism assumed is that a record r is of type RT if all the typing constraints imposed by RT are satisfied by r. This is defined more precisely in (21c):

\[
\begin{align*}
(l_i &= k_i) \\
(l_{i+1} &= k_{i+1} \ldots) \\
(l_{i+j} &= k_{i+j})
\end{align*}
\]

b. \[
\begin{align*}
l_i &: T_i \\
l_{i+1} &: T_{i+1} \ldots \\
l_{i+j} &: T_{i+j}
\end{align*}
\]

c. The record:
\[
\begin{align*}
l_1 &= a_1 \\
l_2 &= a_2 \\
\ldots \\
l_n &= a_n
\end{align*}
\]
is of type:
\[
\begin{align*}
l_1 &: T_1 \\
l_2 &: T_2(l_1) \\
\ldots \\
l_n &: T_n(l_1, l_2, \ldots, l_{n-1})
\end{align*}
\]

iff \(a_1 : T_1, a_2 : T_2(a_1), \ldots, a_n : T_n(a_1, a_2, \ldots, a_{n-1})\)

Cooper, 2005 proposes that situations and events be modelled as records. Situation and event types are then directly accommodated as record types. The type of a situation with a woman riding a bicycle would then be the one in (22a). A record of this type (a witness for this type) would be as in (22b), where the required corresponding typing judgements are given in (22c):

\[
\begin{align*}
x &: \text{IND} \\
c1 &: \text{woman}(x) \\
y &: \text{IND} \\
c2 &: \text{bicycle}(y) \\
time &: \text{TIME} \\
loc &: \text{LOC} \\
c3 &: \text{ride}(x,y,time,loc)
\end{align*}
\]

b. \[
\begin{align*}
x &= a \\
c1 &= p1 \\
y &= b \\
c2 &= p2 \\
time &= t0 \\
loc &= l0 \\
c3 &= p3 \\
\ldots
\end{align*}
\]

c. \(a : \text{IND}; p1 : \text{woman}(a); b : \text{IND}; p2 : \text{bicycle}(b); t0 : \text{TIME}; l0 : \text{LOC}; p3 : \text{ride}(a,b,t0,l0)\)
TTR offers a straightforward way for us to model propositions (in either their Russellian or Austinian (Barwise & Etchemendy, 1987) variants) and questions using records, record types, and functions. An Austinian proposition—employed here for reasons discussed in Ginzburg, 2010b—is a record of the form in (23a). The type of propositions is the record type (23b) and truth can be defined as in (23c):

(23) a. \[
\begin{bmatrix}
\text{sit} = r_0 \\
\text{sit-type} = T_0
\end{bmatrix}
\]  

b. \[
\begin{bmatrix}
\text{sit : Record} \\
\text{sit-type : RecType}
\end{bmatrix}
\]

c. A proposition \[
\begin{bmatrix}
\text{sit} = r_0 \\
\text{sit-type} = T_0
\end{bmatrix}
\] is true iff \[
\begin{bmatrix}
r_0 : T_0
\end{bmatrix}
\]

A question can be identified as a propositional abstract, which in TTR amounts to being a function from records into propositions. In what follows, I will often simplify the notation and use familiar λ notation to denote abstracts, as in (24c).

(24) a. who ran

b. TTR representation—\((r : \begin{bmatrix}
\text{x : Ind} \\
\text{rest : person(x)}
\end{bmatrix})\) \[
\begin{bmatrix}
\text{sit} = r_1 \\
\text{sit-type} = \begin{bmatrix}
c : \text{run}(r.x)
\end{bmatrix}
\end{bmatrix}
\]

That is, a function that maps records \(r : T_{\text{who}} = \begin{bmatrix}
\text{x : Ind} \\
\text{rest : person(x)}
\end{bmatrix}\) into propositions of the form \[
\begin{bmatrix}
\text{sit} = r_1 \\
\text{sit-type} = \begin{bmatrix}
c : \text{run}(r.x)
\end{bmatrix}
\end{bmatrix}
\]

c. \(\lambda x.\text{run}(x)\)

Outcomes are closely related to propositions, with the main difference being temporal—outcomes are intrinsically futurate, but with a temporal dimension which is typically unanchored (at speech time), which makes them useful theoretical entities for reasoning about future action. Truth is not applicable to such entities, what is applicable is the notion of being fulfilled. We can explicate this in an Austinian fashion—as records whose fields are a
situation and a situation type–abstract, of which a temporal argument has been abstracted away. We define the type Irrealis—temporal abstracts over the class of record types in (25a). An outcome will be a record of the form in (25b), the type Outcome given in (25c). The fulfilledness conditions of an outcome \[ \text{sit} = s_0 \]
\[ \text{irr-sit-type} = p_0 \]
involve the existence of a situation \( s_1 \) which is situated temporally after \( s_0 \) such that \( s_1 \) witnesses an instantiation of \( p_0 \). This is the sense in which outcomes are ‘futurate’. (25c,d) provide a simple illustration:

(25) \quad \text{Irrealis} = \text{def} \left( \left[ \begin{array}{c} \text{sit} = r_0 \\ \text{irr-sit-type} = p_0 \end{array} \right] \right) \text{RType}

a. \quad \left[ \begin{array}{c} \text{sit} = r_0 \\ \text{irr-sit-type} = p_0 \end{array} \right]

b. \quad \text{Outcome} = \text{def} \left[ \begin{array}{c} \text{sit} : \text{Record} \\ \text{irr-sit-type} : \text{Irrealis} \end{array} \right]

c. \quad \text{Jo wants Bo to swim.}

d. \quad \text{Want(j,} \left( \left[ \begin{array}{c} \text{sit} = s_0 \\ \text{irr-sit-type} = \left[ \begin{array}{c} \text{t : Time} \\ a = \text{Bo : Ind} \\ \text{effect} : \text{swim}(a, t) \end{array} \right] \right) \right)\text{)}

We can explicate skills/abilities in TTR in a somewhat analogous fashion, though as we noted above, in contrast to outcomes and propositions, skills and abilities do not intrinsically involve situational reference. (26a) can be conceived in terms akin to (26b):

(26) a. \quad \text{Bo learnt to swim.}

b. \quad \text{Bo learnt (what event/situation he needs to be in) to swim.}

This suggests conceptualizing abilities as functions relating situations where a certain effect obtains to their preconditions. (27a) gives one toy example relating to (Bo’s) swimming, which I will abbreviate as (27b)—it maps situations in which Bo is swimming to situations in which his hands and legs are moving at that time. (27c) offers a minimal characterization of
the general type as mapping a situation involving an individual and a time into another situation involving that agent and time:11,12

(27) a. \[ r : \begin{bmatrix} t : \text{Time} \\
a = \text{Bo} : \text{Ind} \\
\text{effect} : \text{swim}(a,t) \end{bmatrix} \mapsto \begin{bmatrix} t_1 = r.t : \text{Time} \\
h : \text{Ind} \\
c_1 : \text{hands}(h,\text{Bo}) \\
l : \text{Ind} \\
c_1 : \text{legs}(h,\text{Bo}) \\
c : \text{Moving}(l,h,\text{Bo}) \end{bmatrix} \]

b. \text{Ab(swim(Bo))}

c. \text{Ability} = r : (\begin{bmatrix} t : \text{Time} \end{bmatrix} r' : \begin{bmatrix} t_1 = r.t : \text{Time} \\
a : \text{Ind} \\
a_1 = r.a : \text{Ind} \end{bmatrix})

4.2 Information states in interaction

As I suggested above an analysis of resolutive complements needs to make reference to the cognitive or the \textit{information} states of the participants. This given that resolvedness is a notion relativized by the desired outcomes and the inferential abilities of agents. Moreover, we also need a means of explicating how presuppositions concerning the resolvedness of questions enter into context.

The general setting for such a theory needs to be a theory of interaction in which agents interact with each other and, in Hintikka’s phrase, with \textit{nature}. I assume here the perspective developed within the KoS framework (Ginzburg, 1994; Ginzburg & Cooper, 2004; Larsson, 2002; Purver, 2006; 11See Cooper’s reformalization of Barwise and Perry’s notion of constraints, (Cooper, 2005, p. 6. (27) employs \textit{manifest fields}—e.g. \( t_1 = r.t : \text{Time} \)—to enforce that the time of the effect and its agent can be used in the characterization of the preconditions. See also Fernando, 2007 for a detailed treatment of the fine structure of events in a type theoretic framework. The postulated type in (27b) is simplified in a variety of respects.

12This reverses a common conceptualization of rules in AI as mapping preconditions to effects. And follows another influential approach in AI—abduction (Hobbs, 2004), as pointed out to me by Shalom Lappin. The reason for adopting this tack here is, in part, the fact that linguistically what we are given is the effect (e.g. Bo swimming), whereas the preconditions are implicit. Moreover, in terms of learning this is not unintuitive: learning can be conceived of as grasping an increasingly refined description of the preconditions for achieving a desired outcome.

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an important characteristic of which is the assumption that a dynamic and partially ordered repository of questions—Questions Under Discussion (QUD)—is a key component of public context...

The type of such information states is given in (28a). The dialogue gameboard, here slightly simplified, represents information that arises from publicized interactions and, for now, we can identify it as the public context. Each DGB is a record of the type given in (28)—the $spkr, addr$ fields allow one to track turn ownership, Facts represents conversationally shared assumptions, Pending and Moves represent respectively moves that are in the process of/have been grounded, QUD tracks the questions currently under discussion:

$$
(28)\ a. \ TIS = \begin{bmatrix}
\text{dialoguegameboard} : \text{DGB} \\
\text{private} : \text{Private}
\end{bmatrix}
$$

$$
(28)\ b. \ DGB = \begin{bmatrix}
\text{spkr} : \text{Ind} \\
\text{addr} : \text{Ind} \\
\text{c-utt} : \text{addressing}(\text{spkr}, \text{addr}) \\
\text{Facts} : \text{Set(Prop)} \\
\text{Moves} : \text{list(Prop)} \\
\text{QUD} : \text{poset(Question)}
\end{bmatrix}
$$

As for the private part, drawing primarily on (Larsson, 2002), clearly private beliefs is a necessary private counterpart to the public FACTS, whereas AGENDA is a private counterpart to Moves representing those actions the agent desires to perform. GENRE, on the other hand, is a type of information which does not have a public counterpart, but plays an important role. It represents the conversational genre characterizing a particular conversation (bakery shopping, courtroom, etc.).

$$
(29) \ \text{Private} = \\
\begin{bmatrix}
\text{Genre} : \text{GenreType} \\
\text{Beliefs} : \text{Prop} \\
\text{Agenda} : \text{list(Prop)}
\end{bmatrix}
$$

In this set up the dynamics of resolvedness presuppositions can be explained roughly as follows: a question $q$ get introduced into QUD as a consequence of a query or an assertion. $q$ get downdated from QUD if and when
proposition \( p \) about \( q \) is accepted, in so far as \( p \) resolves it sufficiently to fulfill the goal \( g \) maximal in the agent’s agenda using the assumptions in either Facts or Beliefs. One of the side effects of downdating \( q \) is updating FACTS with the corresponding resolvedness presupposition \( \text{Resolves}(p, q, I_0) \), where \( I_0 \) is the information state at downdate time.

4.3 Factive, resolutive, and skill oriented complements

In section 2 we saw evidence that attitude predicates have types such as those given in (30), relating an attitudinal type (e.g. a question or proposition), an information state, and an agent (of type Ind). The additional, typically implicit, information state argument assumed here has been motivated in section 3 for resolutive complements. Its presence for other attitudes is in light of accounts of the attitudes such as those of (Crimmins, 1993).

(30) a. Ask : Question, TIS, Ind
    b. Believe : Prop, TIS, Ind
    c. Explain, Understand : Fact, TIS, Ind
    d. Intrigue, Mystify: Fact \( \lor \) Question, TIS, Ind
    e. learn : Fact \( \lor \) Ability, TIS, Ind
    f. know : Fact \( \lor \) (?) Ability, TIS, Ind

We can characterize three types of predicates: factives, resolutive, and ability-oriented. Note that in the current set up a single verb, say ‘learn’ or Hebrew ‘yodea’ or Greek ‘\( \xi\epsilon\rho\omega \)’ [both corresponding to ‘know’] can belong to all three types, **without any assumption of lexical ambiguity**. In (31) I provide lexical types that describe factive verbs, resolutive verbs, and ability-infinitival verbs. In these descriptions, the \( \text{spr-dtr} \) represents the subject argument of the verb, whereas \( \text{comp-dtr} \) its sentential complement.\(^{13}\) In the case of factives and ability-infinitive predicates the combinatorial rule is straightforward: predicating that the verb’s relation (e.g. ‘know’) composes

\(^{13}\)The types associated with the sentential complements are from Ginzburg & Sag, 2000.
with the denotation of the sentential complement and the implicit information state argument. In the case of resolutives complements, as explained previously, a coercion occurs so that for some fact \( f \) that resolves the question denoted by the interrogative complement the verb’s relation composes with \( f \) and the the implicit information state argument.

\[
\begin{align*}
(31) \quad \text{a. Factive} &= \left[ \begin{array}{l}
\text{Cat} : V[+\text{fin}] \\
\text{spr-dtr} = \left[ \text{content} = x : \text{Ind} \right] : \text{np} \\
\text{comp-dtr} = \left[ \text{content} = f : \text{Fact} \right] : \text{factive-cl} \\
I : \text{TIS} \\
\text{content} = \text{FactiveRel}(x,f,I) : \text{Prop}
\end{array} \right] \\
\text{b. abilityInfPred} &= \left[ \begin{array}{l}
\text{Cat} : V[+\text{fin}] \\
\text{spr-dtr} = \left[ \text{content} = x : \text{Ind} \right] : \text{np} \\
\text{comp-dtr} = \left[ \text{content} = \text{Ab}(x) : \text{Ability} \right] : \text{decl-non-subj-cl} \\
I : \text{TIS} \\
\text{content} = \text{AbilityRel}(x,\text{Ab}(x),I) : \text{Prop}
\end{array} \right]
\end{align*}
\]

\footnote{For simplicity, I have omitted including reference to a factivity presupposition, which would lead to a greater uniformity with the entry for resolutives. Indeed Ginzburg, 1995b suggested that factives have a presupposition of the form \( \text{Prove}(f,p,I) \), by analogy with the resolutive case.}

\footnote{Although I have offered various empirical motivations for the proposition/fact distinction, it is of little import to the main issues of this paper. (31a) presupposes a clausal type which is fact–denoting. For the fact–skeptics, merely assume that facts are true propositions.}

22
5 Resolving how to clauses

The technical apparatus set up in the previous section provides us with the resources to analyze ‘how to’ clauses, in the life they lead as complements of resolutive predicates, in one of two ways: as canonical (resolutive) wh-interrogative complements or as ability–denoting complements. The question is—which is the desirable analysis? I believe the data clearly point to the former as the right answer. However, in contrast to a number of previous works that have assumed a similar strategy (e.g. Stanley & Williamson, 2001; Roberts, 2007), when I say that ‘how to’ complements are canonical (resolutive) wh-interrogative complements I mean just that: I will not exploit distinctive apparatus from that employed to analyze other resolutive clauses.\(^{16}\) As I emphasized earlier, whether information resolves a question can only be evaluated relative to a desired outcome and background knowledge—we saw

\(^{16}\)Although I have argued that from a semantic point of view the intellectualist project is empirically unsustainable, Stanley and Williamson’s goal of deriving the semantics of resolutive ‘how to’ clauses from the semantics for resolutive wh clauses in general is laudable. However, in order to achieve this aim, using Karttunen’s approach (or by the same token Groenendijk and Stokhof’s.), they do seem to require to appeal to the additional device of ‘practical mode of presentation’—or lose the ability to account for knowledge of practical biking. Beyond this, a misconception that characterizes their project is the assumption of (semantic) parallelism between knowledge that and knowledge wh: as I showed in section 4, one can offer an account that differentiates between (declarative) factive clauses and (interrogative) resolutive clauses—e.g. only the former manifest resolvedness presuppositions that make explicit reference to an issue—without assuming any lexical ambiguity of ‘know’.

Roberts’ account appeals to a special interpretation of infinitival questions, an appeal which raises interesting empirical issues discussed below.
in section 3 how possession of what is for certain purposes resolving knowledge (that) can fail to provide a resolution of issues like ‘who attended the lecture’ in the absence of certain background knowledge. The agent–relative, teleological notion of resolvedness enables us to defuse similar recalcitrant cases concerning ‘how to’.

For current purposes, I do not need to make strong assumptions about the grammar of ‘how’ clauses. For simplicity, I assume a Montogovian approach to adverbials (for a recent exposition see e.g. Carpenter, 1997) in which ‘how’ introduces a functor ‘By’ (Goldman, 1970; Asher & Lascarides, 1998)\(^{17}\) which relates two properties of an agent \(a\), who may be implicit in the sentence out of which ‘how’ is extracted, as in (32d), with the first argument the \textit{means} argument being abstracted away:

\[(32)\]

\begin{enumerate}
  \item \text{How } \phi(a)
  \item \lambda mBy(m(a), \phi'(a))
  \item \text{How did Bo win the race? } \mapsto \lambda mBy(m(b), \text{won}(b, r))
  \begin{align*}
    \text{By running fast } & \mapsto \text{By(fast(run(b)),won(b,r))} \\
    \text{d. How was Bo persuaded to lie? } & \mapsto \lambda mBy(m(\text{arb}), \text{persuade}(\text{arb}, b, \text{lie}(b)))
  \end{align*}
  \item \text{By subjecting Mary Smith to torture. } \mapsto \text{By(torture(\text{arb}, m), persuade(\text{arb}, b, \text{lie}(b)))}
\end{enumerate}

This means, given our earlier discussion of resolutive complements that the content of a resolutive ‘how’ clause will be as in (33b):

\[(33)\]

\begin{enumerate}
  \item Bilal knows how \(\phi(a)\)
  \item \exists f \text{know}(B, f, I), where Resolves(f, \lambda mBy(m(a), \phi(a)), I)
\end{enumerate}

I assume, adapting Asher & Lascarides, 1998 slightly, that the relation ‘By’ satisfies (34). This will be of crucial importance in accounting for—or defusing—the ‘ability implication’ characteristic of ‘how to’ clauses.

\[(34)\] \(\text{By}(m(a), \phi(a)) \models \text{If } m(a) \text{ and Intend}(a, \phi(a), \text{then normally } \phi(a) \text{ happens.}\)

\(^{17}\)I depart here notationally from Asher and Lascarides, 1998, who call what I call ‘By’ ‘Can’.\)
Note that an entirely analogous approach applies to other adjunct wh-clauses, e.g. ‘why’, where ‘why’ introduces a *Cause* relation, of which the *causer* argument gets abstracted away:

(35) a. Why φ  
   b. \( \lambda r Cause(r, φ') \)  
   c. Why did Bo win the race? \( \mapsto \lambda r Cause(r, won(b, r)) \)  

Because Mary helped him \( \mapsto Cause(help(m, b), won(b, r)) \).

This approach extends directly to ‘how to’ or ‘why to’ clauses—the controller of the agent argument of the interrogative clause being the subject of an embedding predicate if there is one. Just as with finite how clauses, here we can assume that knowing how to \( V \) involves knowledge of a fact that resolves the issue how to \( V \):

(36) a. How to \( V \)  
   b. \( \lambda m By(m(a), V'(a)) \)  
   c. Why to \( V \)  
   d. \( \lambda r Cause(r, V'(a)) \)  
   e. Anand knows how to \( V \) \( \mapsto \exists f know(A, f, I) \), where Resolves(\( f, \lambda m By(m(A), V'(A)), I \)  
   f. Anand knows how to please Joanna \( \mapsto \exists f know(A, f, I) \), where Resolves(\( f, \lambda m By(m(A), please(A, j)), I \))

Let me now offer empirical justification for this non-exceptionalist approach to ‘how to’ clauses. For a start, like other interrogatives ‘how to’ clauses can appear equatively in denotations as questions, not as facts or skills, and are selectable by all question and resolutive predicates:

(37) a. The question Bo faces is how to ride that bike.

\(^{18}\)The idea that ‘how to’ clauses are ambiguous between a canonical resolutive and an ability–denoting denotation has been floated around repeatedly. For against such an ambiguity see Bengson & Moffett, 2007.
b. The issue that intrigues Bo is how to ride a bike with no pedals.

c. The fact Bo is aware of is how to ride a bike with no pedals.

d. The skill Bo possesses is how to ride a bike with no pedals.

e. Bo asked/wondered/investigated/discovered/revealed/understands how to ride that bike.

As expected from this semantics, the resolution of a ‘how to’ question is often described in propositional terms in conversation. Let me exemplify this with some evidence from the British National Corpus (BNC). In (38), the interlocuters are discussing a test B is about to take at school. A offers a succinct summary of what it amounts to know how to cross the road. Of course the fact that the knowledge is easy to characterize does not mean it application in practice, with the desired outcome of not getting run over, is easy.

(38) A: I mean you know how to cross the road now, don’t ya?, look one way and that

Consider another example from the BNC. It emerges that Anon3 does not know how to get to a particular shop: she is provided with several items of information that apparently resolve the issue: (starting at Dawson) take the 106 bus to Clapton, cross the street, take an S2 bus (until) the market, and then walk through. This knowledge is efficacious in resolving the issue of how to get to the shop, but only relative to Anon3’s detailed local knowledge, her knowledge of how to use buses and cross roads etc, and with the aim of getting there using public transport:

(39) Grace: You don’t know where to, you don’t know how to get there? Anon 3: No. Grace: I (will) tell you. Well if she lives down Dawson, all she has to do is get a one O six to Clapton, right? Anon 3: Yeah. Grace: And just cross over, you know Anon 3: And, what, get a number eight bus? Grace: You get S two. Anon 3: S two? Grace: Yeah. (pause) Anon 3: And it takes you all the way there? Grace: It takes you straight there. It takes you outside the market and then you walk through.

19 These data were found using Matt Purver’s search engine SCoRE, (Purver, 2001).
We now need to tackle the elephant in the room for any non-exceptionalist approach—how do we explicate the existence of the ‘ability implication’ in resolutive ‘how to’ clauses—prototypically, if Bo knows how to ride a bike, then Bo can ride a bike (e.g. Ryle, 1949; Lewis, 1990). A first point to note is that this implication is by no means restricted to ‘how to’ clauses but applies to a variety of other types of wh-phrases, as exemplified in (40).

(40) a. Bo knows when to press the eject button.
   b. Jo knows where to ride her bike.
   c. Mo knows why to leave work early.

This means that whatever we do we cannot employ a strategy that involves supplying an ad hoc treatment of ‘know how to’ (for a recent example see e.g. Williams, 2007), but need a far more general strategy. One enticing strategy would be to extend the notion of question beyond propositional abstracts to include also abstracts over other entities. The most obvious such strategy, given our earlier discussion, would be to assume that wh-infinitivals are abstracts over abilities as exemplified in (41):

(41) a. ‘how to ride that bike’ \(\mapsto\) \(\lambda m Ab(By(m(a), ride(a, b)))\)
   b. ‘why to ride that bike’ \(\mapsto\) \(\lambda c Ab(Cause(c, ride(a, b)))\)
   c. ‘where to ride that bike’ \(\mapsto\) \(\lambda l Ab(Loc(l, ride(a, b)))\)

An answer to this type of question would be a(n instantiated) ability. Consequently ‘know wh to’ would involve knowledge of an ability, not propositional knowledge, capturing the ability implication directly. Nonetheless, even assuming that technical problems can be overcome, such an approach faces significant empirical challenges. It predicts that predicates incompatible with abilities should be incompatible with wh infinitivals, a prediction which is entirely incorrect.\(^{21}\)

\(^{20}\)In the approach of Ginzburg & Sag, 2000, this would entail reformulating a number of the fundamental constraints governing the construction of question meanings so that their input is not solely propositional, the latter assumption having clear empirical justification, e.g. (18).

\(^{21}\)Similar considerations apply to the proposal of Roberts, 2007 who, building on earlier work of Dowty & Jacobson, 1991 on wh-infinitivals, proposes that wh-infinitivals denote
a. Bo understands how to ride a bike.

b. Mo explained to me how to construct the platinum airplane.

c. Bo forgot when to press the ejector button.

Moreover, in languages like Hebrew, Greek, and Romance (Rumfitt, 2003; Abbott, 2006), where simple epistemic ability statements are possible, one typically avoids using ‘how to’ clauses for similar purposes, as exemplified here for Hebrew. This follows if (43b) has a canonical interrogative denotation from which ability is implied somehow, but is surprising if it directly denotes an ability.

(43) a. ani yodea lisxot/lirkav al ofnayim.
    I know to-swim/to-ride on bike

b. #ani yodea eyx lisxot/lirkav al ofnayim.
    I know how to-swim/to-ride on bike

Given these intrinsic problems for a reasonably general approach to building in the ability implication to wh infinitivals, and a fortiori the additional problems more ad hoc approaches face, it is worth checking carefully the extent to which we really want to grammatically build in the ability implication. Bengson & Moffett, 2007 argue that the ability implication occurs with what they term ability-based concepts (e.g. addition and certain simple logical reasoning.), for instance that:

abstracts over outcomes (in her terminology goals). This makes resolutive complements denote specifications of attaining the goal denoted by the infinitival. Such a proposal faces similar technical issues—allowing for abstraction over outcomes against which there is independent evidence. Given our earlier discussion about the difference between abilities and outcomes, it is questionable whether abstracting over outcomes gives wh-infinitivals the temporal profile needed to characterize abilities, which do not seem to be futurate. Beyond this, there is also the expectation that predicates like ‘demand’ and ‘insist’ which combine with subjunctive and infinitival outcomes should combine with wh–infinitivals were the latter to have outcome–denoting denotations. This expectation is not met:

(i) Bo demanded/insisted to leave immediately.

(ii) Bo demanded/insisted that he leave immediately.

(ii) #Bo demanded/insisted when to leave.
If Millie knows how to add small natural numbers, then she can add small natural numbers.

On the minimal semantics of ‘by’ provided above, if the means clause is fulfilled straightforwardly, the ability follows. It, therefore, seems feasible to accommodate cases like (44).

Consider pure task predicates—the source of most of the data driving the propositional/ability dichotomy. The first thing to note is that the ability implication does not arise for various resolutive predicates:

(45) a. Jo understands how to ride a bike, though she hasn’t ever dared get on one and for all we know would fall off as soon as mounting it.

b. Millie has very patiently explained to me how to play that violin, but I still can’t do much with it.

In general, for pure task predicates, the ability implication would appear to exhibit the characteristics of a conversational implicature, namely cancellability and calculability. Cancellability has been widely discussed in the literature since initially argued for by Ginet, 1975—see Bengson & Moffett, 2007 for extensive exemplification, though there is much controversy over judgements. It is worth considering a number of additional examples that bring out how purpose dependent the judgements are, in line with my claim that what is at issue are judgements about the resolvedness of an issue. Consider first a case where I enter a shop and point to a fancy large frame bike that has all sorts of gizmos. I get talking to a petite mechanic there who is, say, 1.55 meters tall and so cannot actually ride the bike. Nonetheless, in such circumstances the following dialogue seems to be perfectly acceptable presumably because the desired outcome is that I be able to ride the bike:

(46) Me: Do you know how to ride that bike? Mechanic: Yeah, the only thing you need to know is that the gears and the brakes are merged and that it’s got optional electronic gear changing.

Similarly, take Paula, who says (47a). This would seem to justify (47b), but not (47c). Here the desired outcome is theory, not practice—at least in the short term.

(47) a. I’ve discovered that by running 5 minute miles throughout and drinking lots and not starting too fast, I would run a 2:10 marathon.
b. I've figured out how to run a 2:10 marathon.

c. I can run a 2:10 marathon.

Finally consider me walking in a military command and control center where a switch located on a wall in such a way as to be inaccessible is the means for launching a rocket. I can say (48a), which licenses (48b) and—for those who cannot see the placing of the switch but only for them—suggests (48c). That’s all assuming discussion is at a theoretical level. Someone can of course dispute my assertion of (48b) in this context, by uttering (48d) if launching the rocket becomes a practical issue:

(48) a. I know that by hitting that switch over there I will get that rocket to launch.

b. I know how to get that rocket to launch.

c. I can get that rocket to launch.

d. In theory. Not if you can’t figure out how to scramble up that wall and hit the switch.

(47) and (48) illustrate the calculability of the ability implication—it arises also from propositional epistemic reports, whose content approximates the content we postulate for ‘how to’ clauses. If one indicates a causal chain leading from A to B and A is a feasible state to be in, then there is a clear implicature that B can also be attained.

A crucial issue I have not as yet addressed is this: if resolutive ‘how to’ clauses are fact-denoting, why is it that frequently, particularly when the embedded predicate is task oriented, it is knowledge of the ability that seems to be at issue? On the one hand in such cases the crucial propositional knowledge is, typically, of little import and difficult to verbalize. Consider the issue of how to ride a bike, from a child’s perspective. This issue is actually a highly complex one, which requires the resolution of a host of sub-questions. Consider an instructional session where the instructor Dina sets out the issues to Maya, as she sees them and offers her answers:

(49) Dina: what you need to know is this. Where to put your bum (Here), where to put your hands (Here, on the handlebars), what to do once you’re sitting on the bike (start waddling, after you’ve got
a bit of momentum, lift your legs and start pedaling), how to stop (pedal backwards and then lean the bike to one side) where to look (stare right ahead)

Note that we could report the exchange using (50a). So at least, relative to one information state, information resolving the issue has been provided. We could also describe Maya using (50b) and (50c). And relative to Maya’s information state, partially resolving information has been provided:

(50) a. Dina explained to Maya how to ride her bike.
   b. Maya has a good understanding of how to ride the bike.
   c. Maya knows to some extent how to ride her bike: she knows where to put her hands, how to get started, . . .

An yet an explanation like after you’ve got a bit of momentum, lift your legs and start pedaling is intrinsically vague, so attaining the ability—the desired outcome in such a case—in this way is difficult.22

On the other hand, note that for task predicates the demonstration of ability is actually an (ostensive) answer to the corresponding ‘how to’ question, by direct analogy with answers such as (51a,b):

(51) a. A: Who broke the vase? B: [points to C, who is standing nearby.]
   b. A: Where do I go now? B: [points to a street down which A should ride her bike.]
   c. A: Can you tell me how to hold the bow? B: Look! [grasps the violin bow appropriately]
   d. A: How do you crack open that nut? B: [Takes a walnut from a bag and cracks it open with a nutcracker.]

Hence, for many practical purposes, providing the answer in this way—or possessing the potential to do so—is the best means to resolve the question.

22And probably even if the explanation could be made precise and the teaching involved beeps at the precise moment, that is unlikely to eliminate this problem because attaining abilities typically involves practise.
6 Conclusions

The main conclusions can be summarized briefly:

- Intellectualism is *incompatible* with the facts about complementation in a variety of languages.

- One of the main empirical bases for anti-intellectualism—the alleged existence of ability-denoting ‘how to’ clauses does not survive close scrutiny.

In this paper I have:

1. demonstrated the need to have abilities in the ontology of abstract entities that serve as arguments of attitude predicates.

2. exemplified the existence of epistemically oriented attitude predicates that select for both facts and abilities.

3. sketched an ontology formalized in Type Theory with Records for events, propositions, questions, outcomes, and abilities.

4. indicated how a single verb can select for factive, resolutive, and ability-denoting infinitives without assuming lexical ambiguity.

5. shown how a semantic account of resolutive complementation—interrogatives embedded by predicates such as ‘know’, ‘learn’, and ‘understand’—extends to ‘how to’ clauses without introducing any additional mechanisms.

References


