Synthese (2009) 166:133–155
DOI 10.1007/s11229-007-9269-3

The logic of how-questions

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Received: 9 February 2007 / Accepted: 8 October 2007 / Published online: 27 October 2007
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Abstract Philosophers and scientists are concerned with the why and the how of things. Questions like the following are so much grist for the philosopher's and scientist's mill: *How can we be free and yet live in a deterministic universe?*, *How do neural processes give rise to conscious experience?*, *Why does conscious experience accompany certain physiological events at all?*, *How is a three-dimensional perception of depth generated by a pair of two-dimensional retinal images?*. Since Belnap and Steel's pioneering work on the logic of questions, Van Fraassen has managed to apply their approach in constructing an account of the logic of why-questions. Comparatively little, by contrast, has been written on the logic of how-questions despite the apparent centrality of questions such as *How is it possible for us to be both free and determined?* to philosophical enterprise.[1] In what follows I develop a logic for how-questions of various sorts including how-questions of cognitive resolution, how-questions of manner, how-questions of method, of means, and of mechanism.

Keywords Explanation · Questions · Determinable · Determinate · Goldman · Bennett · Kim · Van Fraassen · Belnap · Steel · Why · How · Erotetic logic · Manner · Means · Method · Mechanism · Possibility · Logic · Functional analysis · Event

[1] Cross (1991) has tried to apply Van Fraassen's analysis of why-questions to how-questions.

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1 Types of how-questions

How-questions are of at least three types. There are *analytic* how-questions which include what I will call how-questions of *means*, of *method*, and of *mechanism*. There are also how-questions *of manner*, and finally how-questions *of cognitive resolution*. Consider:

> Swat team captain: "Headquarters, there's a high yield explosive timed to detonate in four minutes!
> How do we disarm it?"
>
> Headquarters: "Very carefully!"

The answer strikes us as ridiculous because we assume the captain was requesting a *method* for disarming the bomb, a series of steps, not a directive of manner. Similarly:

> "How do I get a New Jersey driver's license?
> "With great patience."

What we expect is something like, "First, go to the local Motor Vehicle Services office. Next, fill out the pink form. Then. . ." (Contrast "How do I apply for the New Jersey tax rebate program?" to which we expect a response such as, "With great futility"). Likewise,

> "How did Judith kill Holofernes?"
> Answer A: "With a mixture of revulsion and determination."
> Answer B: "With a mixture of bile and snake venom."
> Answer C: "With a mixture of seduction and cunning."

The first answer supplies a manner; the second a method; the third a means.

Analytic how-questions ask for a description of steps which contribute in a certain way to the accomplishment of some activity or procedure. Given "How do you dance a swing?" the answer, "First, get a good teacher; then. . .," takes the question to ask for means. The answer, "Backstep, one-two-three, one-two-three," accompanied by a demonstration takes the question to ask for a method. A mechanistic interpretation is harder to imagine, but suppose a student in a neuroscience class complained as follows: "Look, all we're talking about is how individual neurons perform simple little tasks. What I want to know is how humans manage to perform big complicated tasks. For instance, how do you dance a swing?" The answers, "Poorly these days; I've a bum knee," and "First, get a good teacher," and "Backstep, one-two-three, one-two-three"—answers which take the question to ask for manner, means, and method, respectively—are clearly out of place. What the student has in mind is an answer such as, "The primary motor cortex has a group of cells which generate actions potentials; and these generate action potentials in the adjacent cells, and those in turn. . ." Such an answer aims at describing the mechanisms at work in dancing a swing.

The difference between means, on the one hand, and method and mechanism on the other is roughly that means need not be related synchronically to their correlative ends; the accomplishment of the end can follow in time the performance of the steps which are means to it. A method or mechanism, by contrast, *constitutes* an activity

(cf. Searle 2001, pp. 51–52). Filling in one's name on the application is part of the means whereby a driver's license is secured, but part of the method whereby the application is filled. The difference between method and mechanism is harder to characterize, but roughly the steps comprising a method are actions, paradigmatically ones we train ourselves to perform such as dance steps, fingering techniques, checkmating combinations, and the like—the stuff of how-to books. The steps comprising a mechanism tend not to be actions at all, but unconscious processes such as those described in biology or engineering.

Distinct from all of the foregoing are how-questions which request information to relieve some type of cognitive tension. Hempel (1965, 428ff.), Dray (1957, 156ff.), and Salmon (1989, p. 137) have discussed these questions under the heading of *how-possibly* questions. They arise when the context implies a set of claims which seem jointly improbable, perhaps inconsistent, and a request is made to remove the appearance of improbability:

"How did you manage to notice her (a toddler) in all the commotion?"

Here the question presupposes that I noticed her (a toddler), but the context implies the following claims, which render that improbable:

(i) It is improbable that someone would notice a toddler in such a commotion.
(ii) The current situation involves a commotion of that sort.

Some responses aim at undermining one of the claims. The response, "Someone in yellow pajamas, however small, stands out in a room of pinstripes," for instance, challenges (i), whereas the response, "What? It's not as though a bomb had just gone off in here," indirectly challenges (ii). On the other hand, the response, "I didn't notice her actually; Eleanor did, and brought her to me," challenges the question's presupposition, and the response, "I was lucky to be standing by the nursery when she came out" challenges nothing at all, but effectively asserts that noticing her was simply "one of those things" however improbable.

Requests for cognitive resolution include a familiar type of how-question we find in philosophy:

How can we be free and yet live in a deterministic universe?
How can God exist and yet evil exist as well?
How can we cause our actions if our mental states are externalistic?

Each of these examples arises against a background of mutually inconsistent claims and asks for a response that resolves the apparent inconsistency. The first question, for instance, trades on something like the following background assumptions:

(i) Something is free only if its behavior is not governed by deterministic principles.
(ii) Everything in the universe is governed by deterministic principles.
(iii) We live in the universe.

Given certain assumptions, the answer "Freedom requires only that we do what we want, and determinism doesn't rule that out," challenges (i); the answer "Everything is governed by quantum principles, but those are indeterministic," challenges (ii); and

the answer, "We are completely nonphysical beings," challenges (iii). Finally, as in the foregoing case, it is possible to challenge the question's presupposition as in, "We can't be both free and determined; in point of fact we're really not free."
The goal in what follows is to lay the groundwork for a logic of how-questions that enables us to distinguish among how-questions of the foregoing sorts, and that enables us to make sense of possible responses to them including corrective responses which challenge a question's presuppositions.

2 Erotetic logic

Belnap and Steel (1976) have done yeoman's service in clarifying the general logic of questions and answers. In what follows I will have recourse to some of their terminology and assumptions. Their central idea is that a question presents a range of alternatives and requests that the respondent make a selection from that range "as from a tray of hors d'oeuvres" (Belnap and Steel 1976, p. 17). In this way, every question contains implicitly the logical form of its answer, and so it is possible to use resources native to the more familiar logic of assertions (assertoric logic) to develop the less well understood logic of questions (erotetic logic):

> . . .we rely on Hamblin's dictum: "Knowing what counts as an answer is equivalent to knowing the question." On this insight rests the whole of our erotetic logic: the essence of a question is the way in which it determines its direct answers, so that from the question it is possible for the participants in an erotetic situation to tell what the direct answers are to be (35).

According to Belnap and Steel, questions can be understood as abstract entities like propositions. They are expressed or rather *put* by interrogative sentences or *interrogatives* in something analogous to the way propositions are supposed to be expressed by declarative sentences. As in the case of propositions and declarative sentences, the same question can be put by different interrogatives. The sentences 'Why does water freeze at 32°F at standard pressure?' and 'What explains the freezing of water at 32°F at standard pressure?' could be used to express the same question. I will generally follow the convention of using italics to refer to abstracta such as questions or propositions and using single quotes to refer to sentences. Hence, the sentence 'It is raining' expresses the proposition *It is raining*. In addition, I will also use double quotes to express bits of ordinary conversation, and occasionally I will forego the use of quotation marks altogether when the context makes it clear what I am referring to or when ambiguity is not problematic.

According to Belnap and Steel, interrogatives have the form $?\rho\sigma$, where ρ is a *request*, σ a *subject*, and ? a function which takes a request and subject as arguments and yields a question as its value. The *subject* of a question consists of a set of alternatives and the *request* is that a respondent make a selection among them. Hence, the sentence

(1) Is Alexander taller than Madeleine?

might put a question which requests that a selection be made between members of the pair {Alexander is taller than Madeleine, Alexander is not taller than Madeleine}. Belnap and Steel call questions of this sort *whether-questions*. If $A_1, \ldots, A_n$ are the alternatives constituting the subject, the form of a whether-interrogative is $?\rho(A_1, \ldots, A_n)$.

There are various ways of responding to a question only some of which count as answers to it. Consider the following:

(2) Are both the Chrysler and Flatiron buildings further uptown than the Empire State?

The responses, "There's a map right behind you," or "I'm just a tourist," do not provide an answer. *Direct answers*, such as

(a) The Chrysler and Flatiron buildings are both further uptown than the Empire State.
(b) The Chrysler and Flatiron buildings are not both further uptown than the Empire State.

answer a question completely without supplying any further information. *Complete answers* are answers which imply a direct answer as in:

(c) The Chrysler and Flatiron buildings are both further uptown, but the Empire State is taller.

Partial answers, on the other hand, are answers implied by direct ones:

(d) The Chrysler Building is further uptown than the Empire State.

Coded answers are abbreviations. The answers "Yes" and "No", for instance, are *code* for (a) and (b) respectively. Likewise, "Only the Chrysler Building," is code for a complete answer implying (b). Other responses are more difficult to classify. Taken by itself, for instance, the following seems to fall short of being an answer at all:

(e) The Chrysler is a few blocks north of the Empire State, whereas the Flatiron is several blocks south of it.

Taken with additional assumptions about how uptown and downtown correlate with the points of the compass, however, the answer seems complete. Following Van Fraassen we might call this a *relatively complete answer*. An answer to question Q is complete relative to some theory or set of assumptions T (in this case assumptions about the correlation of compass points with uptown and downtown) just in case its conjunction with T implies a direct answer to Q.

Corrective responses to a question such as (f)–(h) are responses that imply the falsity of one of the question's presuppositions. Examples for the foregoing question include

(f) The Empire State Building was torn down years ago.
(g) The Flatiron Building and the Empire State are in different cities.
(h) There is no uptown or downtown in New York.

A *presupposition* of question Q is any proposition implied by all the direct answers to Q. Both answer (a) and answer (b) imply, for instance, that the Chrysler Building,

the Flatiron Building, and the Empire State Building are still standing, something challenged by (f). Likewise, each implies that the ordering implied by the *is-further-uptown-than* relation applies to all three buildings, something challenged by (g) and (h).

Belnap and Steel's work suggests that a logic for questions of a certain type can be built around an account of its direct answers and presuppositions. In what follows I will construct an account of various how-questions that borrows from their insights and those of Van Fraassen (1980), who has successfully applied their work to the logic of why-questions. Since my goal is applicability, the account is largely informal. It will be fairly clear, however, how a formal account can be constructed on its basis.

3 How-questions of cognitive resolution

I will begin by considering how-questions of cognitive resolution. Consider the following utterances:

(3) How did you manage to notice her (a toddler) in all the commotion?
(4) How can we be free and yet live in a deterministic universe?

Consider contexts in which each of these utterances puts a request for cognitive resolution. We leave to one side, therefore, contexts in which the illocutionary force of (3) and (4) is different—contexts, for instance, in which (3) is used to express an exclamation or (4) to issue a challenge. The basic point of such questions, I would suggest, is to present a set of mutually inconsistent or at least mutually improbable claims, and to request that the incompatibility or improbability be resolved through a rejection of some member of the set.

Let X be a set of propositions which we will assume for simplicity to be finite. Let Y be a subset of X, Z a proper subset of Y, and let P stand for the propositions which are members of Z. In that case, the form of requests for cognitive resolution might be construed along the lines of

How P (given the rest of Y)?

where the subjective probability of P (the probability assigned by the questioner) given the other propositions which are members of Y is relatively low, perhaps zero. The form of (3), then, might be expressed as

How did you manage to notice her (given that there is so much commotion)?

where the tacit assumption is that noticing a toddler in such commotion is unlikely. Call P the question's *focus* (or *the propositions in focus*); call Y the question's *foreground*, and call Y's members *foreground assumptions*. Call X the *scene*, and call the scene minus the foreground the question's *background*. Call the background's members *background assumptions*. Finally, assume the scene includes the proposition *The probability of P given the rest of Y = N,* for some N which is relatively low. Call this proposition the question's *probability assumption*. In that case, the focus of (3) is the proposition *You managed to notice her*; its foreground includes that proposition and the proposition *There is so much commotion*; and its probability assumption is that the

probability of the former proposition being true given the latter proposition's truth is relatively low.

Consider likewise (4). Its focus is the proposition *We can be free and yet live in a deterministic universe*, the only element in its foreground. Its background also includes the assumptions that freedom and determinism are incompatible, and that we are part of a deterministic universe. Finally, its probability assumption is that the probability of the focus is zero; certain background assumptions *imply* its falsity.

The boundaries separating a scene's background, foreground, and focus are fluid and context-dependent. We can imagine different questions with the same scene:

(5) How can noticing a toddler under the circumstances be difficult? You just noticed Eleanor!

(6) How can there be a great deal of commotion given that you just managed to notice a toddler?

What distinguishes (3), (5), and (6) are their foci and foreground assumptions. The scene for each might be the set {Madeleine noticed Eleanor, Eleanor is a toddler, There is such-and-such commotion at Madeleine's house, The probability of noticing a toddler given such-and-such commotion is relatively low, . . .}.

On Belnap and Steel's model, direct answers to a question make a selection from its subject, which consists of a range of alternatives. The subject of a request for cognitive resolution seems to consist of the question's scene minus its focus, and the request seems to be that we reject some member of that set. Consider some responses to (3):

(a) I had been listening to the nursery monitor, and heard her climb out of the crib.

(b) Someone in yellow pajamas, however small, stands out in a room of grey pinstripes.

(c) I was lucky to be standing by the nursery when she came out.

(d) It's not as though a bomb had just gone off in here!

(e) I didn't notice her actually; Gabriel did, and brought her to me.

(f) I just noticed her, that's all.

Responses (a), (b), and (c) imply the falsity of the probability assumption in different ways. Noticing a toddler amidst a ruckus is not as improbable with special monitoring equipment of the sort mentioned in (a). The circumstance described by (b), on the other hand, implies a higher-than-expected probability given certain assumptions about color contrast and visual attention. And (c) implies a higher-than-expected probability given certain assumptions about proximity and attention. Response (d), on the other hand, challenges the assumption that there is (in the context) the sort of commotion that would render noticing a toddler improbable.

By contrast with responses (a)–(d), response (e) challenges the question's focus. This would seem to be a corrective response. There would seem to be a presumption that the focus of a how-question of cognitive resolution is true—or at least that there is *prima facie* reason to think it true. Two considerations support this understanding. First, there is a difference between the form of responses rejecting the question's focus and responses rejecting some other element of the scene. The latter cases often use 'because', as in

> I managed to notice her because I had been listening to the nursery monitor, and heard her climb out of the crib,

where the proposition expressed by the 'because' clause falsifies an element of the scene other than the focus. This form doesn't apply when that proposition falsifies the focus, as in

I managed to notice her because I didn't notice her. . .

This suggests that requests for cognitive resolution presuppose the truth of the propositions in focus, and that responses like (e) are therefore corrective.

Second, consider interrogatives of the following sort:
How did you manage to notice her, or didn't you?

The form of such interrogatives doesn't seem to be

How (p or ∼p)?

For in that case the answer would be trivial, and the question empty. The form seems rather to be

How p? Or is it not the case that p?

What an utterance of this sort seems to suggest is that the question doesn't arise if p is false, for in that case, there is no perplexity to be resolved. Consider likewise the following responses to (4):

We aren't free.
The universe isn't deterministic.

They do not succeed in showing how we can be free and yet determined, but rather suggest that the question is misguided. So the truth (or at least *prima facie* acceptability) of the focus seems to be a presupposition of the question, and so a response implying its falsity is a correction.

Responses like (f) are akin to responses like (e). They do nothing to resolve the tension in a scene. This is clearest when elements of the scene are inconsistent. Responding to (4) with "We just *can* be (both free and determined)!" doesn't answer the request. The effect is slightly different when the value assigned by the probability assumption is non-zero. It emphasizes the focus's non-impossibility in the face of its improbability; it claims that what the focus expresses is just "one of those things" however improbable. Notice, however, that it in no way *accounts* for the focus:

"I noticed her *because* I just noticed her; that's all."

Given the foregoing considerations, I would suggest identifying a request for cognitive resolution with an ordered quadruple $<Z, Y, X, R^f>$. Here Z comprises the question's focus, Y its foreground, and X its scene. R^f is a *falsification relation*. Proposition A bears R^f to X exactly if there is some member of X other than the proposition(s) in focus which is false if A is true. We can take the form of a direct answer to a request for cognitive resolution to be

P because A,

where A bears R^f to X.

All questions trade on certain presuppositions. What does a request for cognitive resolution presuppose? It clearly does *not* presuppose that all the propositions in the

scene are true. It requests precisely an answer to the effect that a certain element of the scene is false. Nor, however, does a questioner know in advance *which* element is false. Requests for cognitive resolution typically arise precisely when we have *prima facie* but defeasible reasons for endorsing the elements of a certain scene. Nothing in the scene, then, can imply that one member in particular is false or that all of its members are true. Naturally, if the members of the scene are jointly inconsistent, at least one of them must be false. The point is that nothing in the scene implies that it is *this* member that is false as opposed to some other.

We have already indicated that requests for cognitive resolution presuppose that the propositions in focus are true. Someone might object that, for instance, committed incompatibilists might utter (4) with an eye to exploring the merits or demerits of compatibilism without thereby committing themselves to the truth of the proposition in focus. The response, I think, is that such a case involves not a request for cognitive resolution, but something else. Consider likewise a committed incompatibilist who utters (4) as a challenge—an act, we might assume, which presupposes the propositions in focus to be false. Although many acts might *resemble* a request for cognitive resolution, a *sincere* request presupposes the truth of its focus.

Importantly the presumption of truth attaches to distinct propositions in focus, not their conjunction, which may be subjectively improbable. Consider a paradox with the form:

How can it be the case that p and yet ∼p?

The question is not how a logical falsehood can be true, but rather how it can be that p (which there is *prima facie* reason to endorse), and also ∼p (which there is also *prima facie* reason to endorse). The focus here consists of two propositions: the proposition p and the proposition ∼p. The focus does not consist of a single conjunctive proposition (p & ∼p). In other words, Z, the set comprising the focus, is {p, ∼p}, not {(p & ∼p)}.

In light of the foregoing, we might say that a request for cognitive resolution presupposes the following:

(i) The propositions in focus are true.
(ii) Nothing in the scene implies that this or that member of the scene is false or that all of its members are true.
(iii) At least one proposition bearing R^f to the scene is true.

Corrective responses could challenge any one of these presuppositions. Response (e), for instance, challenges (i). Responses like (f), on the other hand, seem implicitly to challenge (iii). Consider:

"How did Atom A manage to decay while Atom B did not (given that they are of the same kind, have existed under the same conditions. . .)?"

"It just did."

In this context at any rate, there is a clear sense in which the response challenges the appropriateness of the question; the latter asks for an account which cannot be given.

Finally, following Van Fraassen, we can say that how-questions of cognitive resolution *arise* only if the background theory and information accepted in the context

imply conditions (i) and (ii) of its presupposition, and do not imply that condition (iii) is false.

4 How-questions of manner

Another family of questions commonly put by how-interrogatives request a description of something's manner, as in:

(7) *How did Judith kill Holofernes?*

"With a mixture of revulsion and determination."

(8) *How does Madeleine play chess?*

"Very well"

What such questions involve, I want to suggest, is the application of a determinable n-adic predicate to an object or objects, and the presentation of a range of more determinate predicates from which a selection is to be made. As a first approximation, consider an event such as *Caesar swims at t*, for some time t. Let P^*, and $P_1, \ldots, P_n$ be predicates, and $a_1, \ldots, a_m$ terms such that $P^*(\ldots a_j \ldots)$ expresses an event, the way 'Caesar swam' or 'Caesar did swim' might express the event *Caesar swims at t*. Suppose, moreover, that the predicates $P_1, \ldots, P_n$ are related to P^* as follows, where X^m and Y^n stand for the variables $x_1, \ldots, x_m$, and $y_1, \ldots, y_n$, respectively:

D1. Necessarily, for any X^m, $P^*(X^m)$ only if $P_i(X^m)$ for some i.
D2. Necessarily, for any X^m, if $P_i(X^m)$, then $P^*(X^m)$, for any i.
D3. Necessarily, for any X^m, if $P^*(X^m)$, and $P_i(X^m)$, for any i, then possibly there is a Y^n such that $P^*(Y^n)$ and $P_j(X^m)$ for some $j \neq i$.
D4. Necessarily, for any X^m, if $P_i(X^m)$, for some i, then $\sim P_j(X^m)$ for any $j \neq i$.[2]

In that case, call P^* a *determinable predicate* or *determinable*, call $P_1, \ldots, P_n$ *determinates of P**, and call a predicate that is a determinate of some other a *determinate predicate* or *determinate*.

Take a paradigm case: 'is red' is a determinate of 'is colored'. Every colored object must have a determinate shade: blue, yellow, red, etc. Moreover, anything of a determinate shade, such as red, is colored. Colored things needn't be red; they could be some other determinate shade. But if something is red, then it is not blue or yellow, or any other determinate shade. (Saying an object is *red and blue* is typically to say that some *parts* of it are red while others are blue, not that it is both red and not red (but blue).)

I have couched this discussion in terms of predicates not properties. The point of D1–D4 is conceptual not metaphysical. How-questions that request more determinate descriptions of a particular postulate a set of concepts along the lines of D1–D4. An apparatus of this sort invites the suggestion that there are no determinable

[2] I glean these conditions from Johnson (1964) and Prior (1949). Yablo (1992) discusses the determinable-determinate relation as well, but only articulates principles corresponding to D1 and D2. Worley (1997) and Ehring (1997) add various conditions besides.

properties, but only more or less determinate *concepts*, or *predicates*, or *descriptions*. What eventually I hope to capture using the apparatus of how-questions and D1–D4 is the intuitive idea that, say, being red is a *way* of being colored. We cannot identify being red with being colored, and yet we don't say that something is colored, and that it is *also* red as if its redness were a property in addition to and distinct from its being colored.

Consider questions like (8) which ask for a qualitative redescription of a particular. Belnap and Steel (1976, pp. 79–82) suggest such questions can be understood as a species of description-question. The latter posit a particular, b, and ask that it be described through the application of a predicate or predicates, $H_1, \ldots, H_n$, of a certain type, H^*. Belnap and Steel suggest the form of these questions can be represented as

Des(H^*x // b).

Here the alternatives from which an answer is selected are $H_1b, \ldots, H_nb$. Belnap and Steel's example is

(9) *What color is Tom?*

which they take to have the form

Des(x is colored // Tom),

and which they take to present as alternatives 'Tom is red', 'Tom is yellow', etc. Similarly,

(10) *How does your garden grow?*

can be understood to have the form:

Des(x grows // your garden),

where the alternatives are 'My garden grows well,' My garden grows poorly', etc. The descriptors 'grows well', 'grows poorly', and the like, they say, are determinates of the determinable 'grows' in the thin sense (not the sense of D1–D4) that something satisfies the condition 'x grows' if and only if it satisfies at least one of the former, determinate conditions. I will try to develop an account of how-questions along these lines.

First, how-questions of this sort involve what I will call a *queried particular*. Particulars include not just individuals such as *Tom* and *your garden*, but events such as *Madeleine's playing chess this morning*, and what I will call 'tropes' such as *Madeleine's chess-playing*. We might suppose that events have the form $[a_1, \ldots, a_n; R; t]$, where $a_1, \ldots, a_n$ are individuals, R an n-adic relation in which they stand, and t a time (Goldman 1970; Kim 1973; Kim 1976; Bennett 1988). It might be possible to understand tropes on the model of events. *Madeleine's chess-playing*, for instance, might be understood as *Madeleine's playing chess* (*whenever she plays*). This is rough at best since in speaking of Madeleine's chess-playing we might not mean *all* the times she has played. We might wish to exclude, for instance, games early in her chess career, games played on "off" days, or the like. Let $\forall tCt$, then, designate all and only the occasions on which Madeleine has played chess which also satisfy condition C. If the condition is empty we might simply employ the notation $\forall t$. Hence, what I am calling

'tropes' might have roughly the form $[a_1, \ldots, a_n; R; \forall tCt]$, for some perhaps empty condition C.

How-questions of the sort that interest us seem to query events and tropes more than individuals. Consider:

"How is Xavier these days?"
"He is 5 feet 11 inches."
"No, I mean how is his *health*."

The queried particular is not Xavier *simpliciter*, but his health. As a rule, it seems, we ask about individuals not *simpliciter*, but in some respect (health, business, family issues, etc.), or in a more or less open-ended range of respects: health or family issues, say, but not business.

Queried particulars might be designated by diverse linguistic expressions. Just as the expressions 'Xavier' and 'my brother-in-law' might designate the same individual, 'Madeleine's playing chess this morning' and 'my biggest surprise today', or 'Madeleine's chess-playing' and 'Madeleine's most publicized activity' might designate the same event or trope. This has at least two important implications. First, a question such as

(11) *How did Madeleine play chess this morning?*

might be expressed in English in a variety of ways such as "How was Madeleine playing chess this morning?", "How was Madeleine's chess-playing this morning?", or just, "How was Madeleine's chess-playing?", or even "How was Madeleine?" where in the context the time and/or activity are a given. Likewise, consider:

"How was Madeleine playing chess this morning?"
"Very well: she won every game."
"No, I mean how was *she*: In a good mood? Preoccupied?. . ."

Here the queried particular is not Madeleine's chess-playing in the morning at all, but Madeleine's *mood* at the time she was playing chess. This question might have been put less ambiguously as "How was Madeleine while she was playing chess this morning?" Or better yet: "How was Madeleine's mood while she was playing chess this morning?" Second, recall that a direct answer makes a selection from among a range of alternatives presented by the question's subject. Following Belnap and Steel, we can distinguish a range of *real alternatives* and a range of *nominal alternatives*. Suppose, for instance, that two different sets of labels, 'excellent', 'very good', 'fair', on the one hand, and 'outstanding', 'above average', 'average' on the other, designate the same three categories of a single evaluation scheme. In that case, the range of real alternatives presented by a how-question would have three elements, while the range of nominal alternatives would have at least six.

Belnap and Steel define a question's real range of alternatives in terms of its nominal range. The nominal range of the question *Which primes lie between 10 and 20?*, for instance, is the set of results achieved by substituting non-zero Arabic numerals for 'x' in 'x is a prime lying between 10 and 20'. The nominal alternatives presented by the question are thus '1 is a prime lying between 10 and 20', '2 is a prime lying between 10 and 20,' etc. Intuitively, the question's real alternatives would correspond

to the numbers expressed by the numerals in the nominal range. Belnap and Steel define these real alternatives as ordered pairs $<f$, 'x is a prime lying between 10 and 20'$>$, where f is a function assigning to x a positive integer which satisfies the matrix 'x is a prime lying between 10 and 20'. Likewise, the subject of *What sports do Cecilia's children play?* determines a nominal range consisting of all and only those propositions in which the names of Cecilia's children have been substituted for 'x' and the names of sports have been substituted for 'y' in 'x plays y'. And it determines a real range consisting of the pairs $<f$, 'x plays y'$>$, where $f(x)$ is a child of Cecilia, and $f(y)$ is a sport.

Second, how-questions of this sort *select a component* of the queried particular for evaluation. Compare responses to "How was Madeleine's chess-playing this morning?":

A: "Very well: she won every game."
B: "It took *forever*! I thought it would never end."

Here Response A takes the selected component to be the *chess-playing* component of *Madeleine's chess-playing this morning*. Response B, on the other hand, takes the selected component to be the event's time, its duration in particular. By contrast, the response, "Too early: We had to leave the house at six-thirty just to get there on time," takes the selected component to be not the event's duration, but its inception.

A question's component selection can be more or less open. It might be *completely open*, for instance, in the sense that an acceptable answer could provide a qualitative description of *any* of its components. Conversely, it might be *partially closed*, in the sense that a description of some component is ruled out: "I didn't mean the *time*! I meant how was her *playing*?"

Third, these questions *specify an evaluation scheme*, which can be understood roughly as a function from the set of queried particulars (with selected components) into a set of *evaluation sentences*. More precisely, let $\{a, b, c, \ldots\}$ be a set of *q-terms*, terms which designate the queried particular and selected component. Call the open sentences $V_1(x), \ldots, V_n(x)$ the scheme's *value matrices*. The question's evaluation sentences are what result from substituting q-terms for variables in the scheme's value matrices: $V_1(a)$, $V_1(b), \ldots, V_2(a), V_2(b), \ldots$. These sentences constitute the range of the nominal alternatives presented by the question. The real alternatives can be defined as pairs $<f, V_i(a)>$, where f is a function assigning to the sentence $V_i(a)$ a proposition. Intuitively, in other words, the real alternatives presented by the question are the propositions expressed by the sentences in its nominal range.

Consider an example. Let $Eval_{PRO}$ be an evaluation of prowess with the value matrices 'x is excellent', 'x is good', 'x is fair', and 'x is poor'. Suppose question (11) specifies $Eval_{PRO}$ as the evaluation scheme, and let 'Madeleine's chess-playing this morning' be a term designating the queried particular and selected component (the *playing*, say). In that case, the question's nominal range is the set of evaluation sentences {'Madeleine's chess-playing this morning was excellent', 'Madeleine's chess-playing this morning was good', 'Madeleine's chess-playing this morning was fair', 'Madeleine's chess-playing this morning was poor'}, and its real range a set of propositions corresponding to these. Suppose, on the other hand, that (11) instead specifies $Eval_{STY}$ as the evaluation scheme, where the latter's value matrices are 'x is positional' and 'x is tactical'. In that case, the question's nominal range is the

set of evaluation sentences {'Madeleine's chess-playing this morning was positional', 'Madeleine's chess-playing this morning was tactical'}, and the question's real range is the set of corresponding propositions.

In light of the foregoing, then, we can say the following: let E_k designate an evaluation scheme; let e designate a queried particular, and let c designate the selected component(s);[3] a how-question of manner could be put by an interrogative with the form

How is c of e relative to E_k?

The question's subject has three components: the evaluation scheme, the queried particular, and the selected component. The real alternatives it presents have the form

c of e is V_l

where 'x is V_l' is a value matrix of E_k. Since direct answers consist at least partly in a selection from among the real and nominal alternatives determined by a question's subject, a direct answer to this sort of question will have something like the form

c of e is V_l relative to E_k.

The subject of (11), then, consists of the evaluation scheme $Eval_{STY}$, the queried particular *Madeleine's playing chess this morning*, and the selected component *playing chess*. The real range determined by this subject will consist of propositions along the lines of *The playing component of Madeleine's chess-playing this morning was tactical relative to* $Eval_{STY}$. And its nominal range will consist of sentences expressing propositions in its real range. Likewise, the subject of (10) consists of the evaluation scheme $Eval_{GRO}$, the queried particular *your garden's growing at t*, and the selected component *growing*, for a time t understood in context (e.g. *after you added fertilizer*, *this summer*, *this week*). Its nominal range is, say, the set of evaluation sentences {'My garden grows well', 'My garden grows poorly',...}, and its real range is a set of propositions corresponding to these.

Consider now what how-questions of this sort presuppose. The question *How is the c of e relative to* E_k? presupposes at least the following:

(i) e exists;
(ii) c is a component of e;
(iii) E_k can take c of e as an argument;[4]
(iv) There is at least one true proposition in the real range determined by the question's subject.

[3] Some form of notation could be introduced to designate open or closed selections of components or schemes. For instance, if $\ldots\xi_j\ldots$ designates a selected component, $\forall_i\xi_i$ could be used to designate a completely open selection, and $^{-}\xi_j$ could be used to designate a selection closed to ξ_j. Similarly, the specification of the evaluation scheme can be more or less open in just the way the selection of components can. Someone might inquire about my garden, for instance, without having any very specific type of evaluation in mind. A completely open scheme specification could be represented as $\forall E$. A specification satisfiable in terms of either scheme E_j or scheme E_k could be represented as $E_j \vee E_k$; a specification closed to E_j could be represented as $^{-}E_j$, etc.

[4] In the case of open evaluation specifications, presupposition (iii) amounts to the claim that there is at least one scheme which can take c of e as an argument.

In that case, the following count as corrective responses to (11); they challenge presuppositions (i), (ii), and (iii), respectively:

(a) Madeleine didn't play chess this morning;
(b) 'Madeleine played chess this morning' refers to a song not an event;
(c) *Yellowish* is not a category in terms of which chess-playing can be evaluated.

Let us return now to the point about determinables. Consider a how-question with the subject consisting of the evaluation scheme $Eval_{DT}(R)$ the queried particular $[a_1, \ldots, a_n; R; t]$, and the selected component R, where $Eval_{DT}(R)$ is an evaluation scheme with matrices $V_1(x), \ldots, V_m(x)$. Suppose that D1–D4 are true for each V_i and V_j substituted for P_i and P_j if R is substituted for P^*. In that case, call $Eval_{DT}(R)$ a *determinacy scheme*, and say that the question *asks for a determinate of R*. The claim I mentioned at the outset of this discussion can now be stated as follows: *Some how-questions specify determinacy schemes*; they *ask for determinates* of some description. Consider (9). It asks for a determinate of color. Its subject consists of the scheme $Eval_{DT}(color)$, the queried particular [*Tom*; *having color*; $\forall tCt$], and the selected component *having color*. $Eval_{DT}$ (*color*) has the value matrices 'x is red', 'x is yellow', etc. The nominal range it determines would then be {'Tom is red', 'Tom is yellow',...}, and its real range would be the set of propositions corresponding to the elements in its nominal range.

The idea, then, is that certain how-questions select a component of a queried particular for evaluation such that (a) that component is expressed by a determinable predicate, and (b) determinates of that predicate are the value matrices of the determinacy scheme specified by the question.

Determinate predicates might themselves be determinables, as 'crimson' is a determinate of 'red', which is in turn a determinate of 'colored'. Likewise with 'human', 'mammal', and 'animal': the first is a determinate of the second, the second of the third, so that 'mammal' is both a determinate predicate and a determinable. In addition, a determinable predicate might have determinates belonging to diverse *determinacy families*. Consider:

"How does Madeleine play chess?"
"Very well."
"No, I mean does she play *tactically* or *positionally*?"

Here 'very well' designates a determinate way of playing chess. 'Tactically' does the same, but the two descriptions are not mutually exclusive; Madeleine could be a very good tactical player. Here, the n-tuples {'very well', 'poorly',...} and {'tactically', 'positionally',...} belong to different determinacy families, which according to D4 are sets of mutually exclusive predicates. Determinates of P^* belong to different families if D4 fails to apply to them.[5]

[5] Imagine the following answer to the question *How did Madeleine play chess this morning?*: "Madeleine played positionally and very well." An answer of this sort suggests a counterexample to the analysis of determinacy families just presented. After all, doesn't an answer of this sort imply that the families corresponding to $Eval_{STY}$ and $Eval_{PRO}$ are not mutually exclusive? In fact this conclusion does not follow. The utterance, "Madeleine played positionally and very well," expresses what could function as a complete

Consider another example. Suppose (7) is understood in such a way that the response, "With a mixture of revulsion and determination," is appropriate. In that case, (7) might be understood as asking for a determinate of mental condition. It queries not Judith's killing Holofernes at some time, but Judith's mental condition at the time she killed Holofernes. It might be put more happily as, "What was Judith's mental condition as she killed Holofernes?" Its subject consists of the evaluation scheme $Eval_{DT}$(*mental condition*), the queried particular *Judith's being M* while killing Holofernes*, and the selected component *M**. Here *M** is an determinable—left implicit in the context of the original utterance—which expresses her mental condition, and $Eval_{DT}$(*mental condition*) is a determinacy scheme with value matrices such as '*x* is repulsed yet determined'. Formulating a matrix that conforms to D4 might require a good deal of work. The descriptor '*x* is frightened' is not excluded by '*x* is repulsed yet determined', and yet it seems that both might be included in an answer that describes Judith's mental condition. Consequently, the determinate predicates conforming to D4 would probably have to be long conjunctions each of which included either '*x* is frightened' or '*x* is not frightened' as a conjunct. Hence, we can imagine value matrices with the form

$$M_1(x)\& \ldots \& M_n(x),$$

where the M_i would be predicates such as 'is determined', 'is frightened', 'is repulsed', so that the resulting matrices would satisfy D4.

I want to suggest, then, that the semantics of certain how-questions postulate a conceptual structure along the lines of D1–D4 for the evaluation of queried particulars. The presuppositions of such questions parallel those discussed earlier. Take *a* to be a queried particular, *R* its selected component, and $Eval_{DT}(R)$ the specified determinacy scheme with value matrices $V_1(x), \ldots, V_m(x)$. So the question *How is a relative to* $Eval_{DT}(R)$? presupposes at least the following:

(i) *a* exists;
(ii) *R* is a component of *a*;
(iii) '*R*' is a determinable predicate, and 'V_1',. . .,'V_m' are determinates of '*R*'.
(iv) There is at least one true proposition in the real range determined by the question's subject.

5 Analytic how-questions: method, means, and mechanism

Consider now another type of how-question:

(12) *How does one dance a swing?*

Footnote 5 continued
answer to either of two questions. The first conjunct constitutes a direct answer to a question that specifies the evaluation scheme $Eval_{STY}$; the second conjunct constitutes a direct answer to a question that specifies the evaluation scheme $Eval_{PRO}$. Depending on which evaluation scheme the question specifies, one conjunct answers it directly, and the other provides additional (unnecessary) information—cf. answer (c) to question (2) above.

In colloquial English, questions of this sort are often expressed in the second person: "How do you dance a swing?" I want to consider the type of how-question to which the following would be an appropriate response if accompanied by a demonstration:

> "One dances a swing as follows: Hold your partner's hand like this; then go one-two-three, one-two-three, back-step like this; one-two-three, one-two-three, back-step, and so on."

This type of question asks for the *method* whereby something is done. I want to suggest that a question of this type, and of the closely related type which asks for a *mechanism*, involves an analysis of an activity in terms of a series of steps which constitute it. I want to suggest, moreover, that how-questions asking for the *means* whereby something is done can be understood on this model as well. I will call how-questions of this sort *analytic how-questions*.

Analytic how-questions typically concern not a queried particular so much as what I will call a queried *activity*. We can represent this perhaps by extending the model we used earlier for tropes. Compare:

(a) Madeleine's chess-playing this morning;
(b) Madeleine's chess-playing

Expression (a) designates an event; it has the form

[*Madeleine*; *playing chess*; t]

Expression (b), on the other hand, designates what I have been calling a 'trope'. I introduced the notation $\alpha\forall tCt$ to designate all and only those times satisfying a certain condition C. Consequently,

[*Madeleine*; *playing chess*; $\forall tCt$],

would designate Madeleine's chess-playing at all and only those times satisfying a (perhaps empty) condition C. We might introduce a similar device $\forall x_1 \ldots \mathrm{x}_n$ ranging over individuals in order to designate an activity, R:

$[\forall x_1 \ldots x_n; R; \forall t]$.

The activity of playing chess, for instance, can be represented as

$[\forall x$; *playing chess*; $\forall t]$,

which designates chess-playing whenever and by whomever. For the sake of exposition, however, I will henceforth omit the special notation ('$\forall x$', '$\forall t$', '[', ']', etc.), and will simply refer to queried activities using gerund clauses such as '*playing chess*'.

Consider now (12). Its subject, I want to suggest, has two components: the queried activity, *dancing a swing*, and an *analysis scheme*, $Eval_{MT}$, which can be understood as a function from the queried activity into a set of *method analyses*. We can say that an analysis scheme *generates* method analyses. Let $\{a, b, c, \ldots\}$ be a set of q-terms which designate the queried activity. Let $< s_1, \ldots, s_n >$ be an n-tuple of *subactivity descriptions*, and let R_{MT} be a relation $R_{MT}(< s_1, \ldots, s_n >, x)$, where x ranges over $a, b, c, \ldots$. Call the result of substituting a q-term for x in $R_{MT}(< s_1, \ldots, s_n >, x)$

a *method analysis of the queried activity*. Hence, $R_{MT}(<s_1, \ldots, s_n>, a)$ is a method analysis of a, $R_{MT}(<s_1, \ldots, s_n>, b)$ is a method analysis of b, etc. Intuitively, R_{MT} is what constitutes the "stephood" of the subactivities designated by $s_1, \ldots, s_n$. Those activities are related to the queried activity as steps in a method for its performance. We can call them *contributing steps*. Method analyses constitute the range of the nominal alternatives presented by the question. As before, the real alternatives presented by the question can be defined as pairs $<f, S(x)>$, where $S(x)$ is a method analysis of x, and f is a function assigning to $S(x)$ the proposition that the activities described in $S(x)$ are a method for performing x.

Consider a simple example taken from a section in a home improvement book entitled "How to Replace an Incandescent Light Fixture". The section presents a series of numbered steps:

1. Turn off the power and remove the old light fixture following the directions for standard light fixtures.
2. Attach a mounting strap to the electrical box, if box does not already have one.
3. Connect the white wire lead to the white circuit wire, and the black wire lead to the black circuit wire using wire nuts.
4. Pigtail the bare copper grounding wire to the grounding screw on the mounting strap.
5. Attach the light fixture base to the mounting strap using the mounting screws.
6. Attach the globe, and install a light bulb.
7. Turn on the power at the main service panel.[6]

We can take these steps to provide a candidate answer to the question

(13) *How does one replace an incandescent light fixture?*

The question's subject consists of the queried activity, *replacing an incandescent light fixture*, together with the analysis scheme $Eval_{MT}$. It determines a nominal range of method analyses including the following:

> $R_{MT}(<x$ turns off the power and removes the old light fixture following the directions for standard light fixtures, x attaches a mounting strap to the electrical box, if the box does not already have one, x connects the white wire lead to the white circuit wire, and the black wire lead to the black circuit wire using wire nuts, x pigtails the bare copper grounding wire to the grounding screw on the mounting strap, x attaches the light fixture base to the mounting strap using the mounting screws, x attaches the globe, and installs a light bulb, x turns on the power at the main service panel$>$, replacing an incandescent light fixture).

And the question's real range consists of propositions corresponding to elements in its nominal range. We can assume that there might be several schemes for generating method analyses of a queried activity—different vocabularies, for instance, for describing contributing steps.

[6] This list is adapted from *Basic Wiring and Electrical Repairs* in the *Black and Decker Home Improvement Library*. Minnetonka, MN: Creative Publishing Int'l (1990).

The presuppositions of a how-question of method again parallel those considered earlier. If A is the queried activity, and $Eval_{MT}$ the specified analysis scheme, the question *How A relative to* $Eval_{MT}$? presupposes at least the following:

(i) A can exist (i.e. it is possible for some thing(s) to engage in that activity at some time).
(ii) There is at least one method analysis of A generated by $Eval_{MT}$.
(iii) There is at least one true proposition in the real range determined by the question's subject.

Consider, then, the question

How$_{MT}$ *does one construct a four-sided triangle?*

where the 'MT' subscript designates that this is a how-question of method. The response,

"One can't construct a four-sided triangle,"

is corrective. It implies that presupposition (i) is false. By contrast, to the question

How$_{MT}$ *does one move one's leg?*

the corrective response,

"One just does!"

implies that presupposition (ii) is false: there is no step analysis for moving one's leg relative to the type of scheme used in generating step analyses of activities like dancing a swing or changing a light fixture.
In English answers to how-questions of method are sometimes expressed with a by-clause as in:

"One replaces an incandescent light fixture by first. . ."

where the . . . is filled in by the subactivity descriptions of a method analysis. By-clauses are nevertheless neither necessary nor sufficient for introducing steps in a method. A how-to book might introduce a method with simply, "How to X: (1). . . (2). . ." Conversely, by-clauses can also introduce steps in a mechanism, and means to ends, as in the following cases:

(14) *How*$_{MK}$ *does the human visual system register electromagnetic energy?*
"The human visual system registers electromagnetic energy by converting the energy of a photon into the chemical energy released by a change in the molecular conformation of rhodopsin."

(15) *How*$_{MN}$ *does one apply for a New Jersey driver's license?*
"One applies for a New Jersey drivers license by filling out the pink and yellow forms found at the back of the queue and then presenting a valid passport, a driver's license from another state, and three supplementary forms of photo identification together with proof of in-state residence, a notarized birth certificate, and a blood sample to this counter."

Here the 'MK' and 'MN' subscripts indicate, respectively, a how-question of mechanism and a how-question of means. The subscripts 'MA', 'MT', 'CR' will henceforth indicate how-questions of manner, of method, and of cognitive resolution, respectively.

Despite the status of by-clauses vis-à-vis answers to how-questions of these sorts, it might be helpful schematically if we take the form of direct answers to them to include by-clauses. So for the queried activity A, a direct answer to *How A relative to* $Eval_{M^*}$? has the form

A relative to $Eval_{M*}$ by $s_1, \ldots, s_n$,

where the assumption is that $R_{M*}(< s_1, \ldots, s_n >; A)$. Here '$M^*$' is a variable ranging over *MT*, *MN*, and *MK*. We can call the form

By $s_1, \ldots, s_n$

a *truncated* direct answer, and call $s_1, \ldots, s_n$ the answer's *core*.

The logic of how-questions of means differs little from that of how-questions of method. Consider again question (15) which queries the activity *applying for a New Jersey driver's license*. Its subject consists of this activity and the analysis scheme $Eval_{MN}$, which generates *means-end analyses*. Let $\{a, b, c, \ldots\}$ be a set of q-terms which designate the queried activity. Let $< s_1, \ldots, s_n >$ be an n-tuple of subactivity descriptions, and let R_{MN} be a relation $R_{MN}(< s_1, \ldots, s_n >, x)$, where x ranges over $a, b, c, \ldots$. Call the result of substituting a q-term for x in $R_{MN}(< s_1, \ldots, s_n >, x)$ a *means-end analysis for the queried activity x*. Hence, $R_{MN}(< s_1, \ldots, s_n >, a)$ is a means analysis for a, $R_{MN}(< s_1, \ldots, s_n >, b)$ is a means analysis for b, etc. Means-end analyses constitute the range of the nominal alternatives presented by the question. The corresponding real alternatives can, again, be defined as pairs $< f, S(x) >$, where $S(x)$ is a means-end analysis for x, and f is a function assigning to $S(x)$ the proposition that the activities described in $S(x)$ are a means for accomplishing or performing x. The question *How A relative to* $Eval_{MN}$? presupposes at least the following:

(i) A can exist (i.e., it is possible for some thing(s) to engage in that activity at some time).
(ii) There is at least one means-end analysis for A generated by $Eval_{MN}$.
(iii) There is at least one true proposition in the real range determined by the question's subject.

Intuitively, R_{MN} is what constitutes the relation of means to end. The activities described by $s_1, \ldots, s_n$ are related to the queried activity as a means to its accomplishment. As before, we can call each a *contributing step*, but emphasize that the way these steps contribute to the queried activity, their relation to it, R_{MN}, is different from the relation of contributing steps to the queried activity in a method analysis. The difference is easier to understand than it is to characterize. Entering a car is part of the means to driving it; shifting from first gear to second is part of the method. Gripping the handle, inserting the driver tip in the screw head, and twisting the tool clockwise or counterclockwise constitute the method for using a screwdriver, but except for certain special circumstances (in, say, a cooperative living arrangement in which tools must be "checked out" from a tool shed as from a public library) there is no means to using a screwdriver; one simply uses it. Consider likewise:

(16) *How$_{MT}$ do porcupines mate?*

(17) *How$_{MN}$ do porcupines mate?*

An answer to the first might begin:

"First, the female signals her readiness. Then the male. . ."

A response to (17), however, is liable to be corrective:

"Whad'ya mean *how*? They just *do* it!"

Likewise, we might expect the teacher of a middle-school sex education class to answer

(18) *How$_{MT}$ do humans mate?*

by reference to a suitable anatomy textbook. Middle-school parents would be justifiably concerned, however, if the teacher also tried to answer

(19) *How$_{MN}$ do humans mate?*

by providing students a list of escort services.

John Searle tries to capture the distinction between method and means in terms of a distinction between causation and constitution:

> The two most important structural forms in the internal structure of actions are the causal by-means-of relation and the constitutive by-way-of relation. If I fire the gun by means of pulling the trigger, the relationship is causal. Pulling the trigger causes the gun to fire. If I vote by way of raising my arm, the relation is constitutive. In that context raising my arm constitutes voting. . . In that context the bodily movement constituted or counted as the action in question (Searle 2001: 51–2).

Searle doesn't tell us here what causation and constitution are supposed to be. The plausibility of the distinction he draws is based on his examples. We might go a step further than Searle, however, and say that in the case of a method for performing some activity *A*, necessarily *A* and its contributing steps occur at the same time; that is, necessarily, *A* begins when its contributing steps begin, and it ends when they end. This is not the case with means. Means and ends might occur synchronically, but they need not. Blood-doping is a means to better race performance, for instance, but better race performance occurs *after* the racer has doped his or her blood. By contrast it is not possible that a certain method of running might occur before or after the activity of running itself. Likewise, showing a valid passport before boarding an international flight is a means to international travel, but it often occurs before the travel itself.

How-questions of mechanism such as (14) are similar to how-questions of method in that they ask for contributing steps which necessarily occur at the same time as the queried activity. The difference between a mechanism and method, however, is that the steps of a method tend to be *actions*, whereas the steps of a mechanism do not. *Gripping* the screwdriver, for instance, *inserting* the driver tip into the screw, and *twisting* it are all actions, so are *holding* a partner's hand and *stepping* one-two-three-one-two-three. Altering the molecular conformation of rhodopsin, by contrast, is not

an action (at least not in this context), nor is metabolizing the sugar ingested at lunch, nor again converting chemical energy to mechanical energy in an internal combustion engine.

The logic of how-questions of mechanism parallels in other respects the logic of how-questions of method and means. Let $Eval_{MK}$ be an analysis scheme which generates *mechanical analyses*. Let $\{a, b, c, \ldots\}$ be a set of q-terms which designate the queried activity. Let $<s_1, \ldots, s_n>$ be an n-tuple of subactivity descriptions, and let R_{MK} be a relation $R_{MK}(<s_1, \ldots, s_n>, x)$, where x ranges over $a, b, c, \ldots$. Call the result of substituting a q-term for x in $R_{MK}(<s_1, \ldots, s_n>, x)$ a *mechanical analysis for the queried activity x*. Mechanical analyses constitute the range of the nominal alternatives presented by the question, and the corresponding real alternatives can be defined as pairs $<f, S(x)>$, where $S(x)$ is a mechanical analysis for x, and f is a function assigning to $S(x)$ the proposition that the activities described in $S(x)$ are a mechanism for performing x. The subject of the question *How A relative to* $Eval_{MK}$? consists of the queried activity and the analysis scheme $Eval_{MK}$.
A how-question with this form presupposes at least the following:

(i) A can exist (i.e., it is possible for some thing(s) to engage in that activity at some time).
(ii) There is at least one mechanical analysis for A generated by $Eval_{MK}$.
(iii) There is at least one true proposition in the real range determined by the question's subject.

Again, intuitively R_{MK} constitutes the relation of mechanism to queried activity, a relation that differs in the aforementioned way from the relations involving means and methods.
Consider some examples of typical how$_{MK}$-questions. The answer to the first is taken from a college-level Biology textbook:

(20) How$_{MK}$ do enzymes catalyze chemical reactions?
[T]he active site of an enzyme is unoccupied and its substrate is available... [T]he substrate enters the active site and attaches by weak bonds. The active site changes shape to fit snugly around the substrate... The substrate is converted to products while in the active site. The enzyme releases the products, and its active site is then available for another molecule of substrate (Campbell 1996, p. 100).

The second example is taken from an encyclopedia article:

(21) How$_{MK}$ does a jet engine operate?
[A]ir is taken from the atmosphere, compressed in a centrifugal or axial-flow compressor, and then fed into a combustion chamber. Here, fuel is added and burned at an essentially constant pressure with a portion of the air... The stream of gas then leaves the turbine at an intermediate pressure (above local atmospheric pressure) and is fed through a nozzle to produce thrust (From 'gas-turbine engine' in Encyclopaedia Britannica 2006).

A final note before discussing some philosophical applications for the logic of how-questions: Sometimes a how-question of cognitive resolution can be answered

by answering a how-question of another sort. Sometimes, in other words, the key to resolving the tension in a scene is to provide an analysis of an activity which implies that some member of the scene is false. Consider an example:

(22) How$_{CR}$ will you be able to move the Steinway into your new apartment (given that the apartment is on the eleventh floor, the piano is too large to fit in the elevator, and the stairs are narrow)?

In this case, describing a method can resolve the tension in the scene:

> "I will be able to move the Steinway into my new apartment because I will follow this procedure: First, I will remove the legs. Then I will stand the piano upright on its straight side on top of a moving blanket. Next, I will construct a ramp of sorts in the middle of the stairs out of long boards. Then you, and I, and some others will carefully haul the piano up the ramp to the landing, and repeat the process on each subsequent flight of stairs."

An answer along these lines effectively falsifies the question's probability assumption, and thus satisfies the request for cognitive resolution.[7]

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[7] I'm grateful for helpful comments I received on an earlier of this paper from two anonymous referees at *Synthese*.