Linguistic Mechanism, Physical Mechanism, and Secondary Non-r.e.ness of the Physical World

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Abstract

Starting from linguistics and ending up with physics, this paper develops the idea of distinguishing between primary non-r.e.ness *and* secondary non-r.e.ness *for physics, linguistics, logic of mind, and cognitive science in general. Briefly, a natural language is primarily non-r.e. (non-recursively enumerable) if (L1) it obeys certain non-r.e. rules; (L2) the human species can effectively command these non-r.e. rules; and (L3) only primarily non-r.e. intelligent species can effectively command these non-r.e. rules. By contrast, a natural language is secondarily non-r.e. if (L1) holds regardless of (L2) and (L3). In a way of parallel, the physical world is primarily non-r.e. if there is a sub-system S of the physical world and a non-r.e. rule R such that (P1) for any intelligent species (observer) there is no evidence against the assumption that S has R as one of its own laws; (P2) there is an intelligent species which can effectively communicate with S concerning R (receiving information from S concerning the execution of R, following R, etc); and (P3) any intelligent species satisfying (P2) is itself primarily non-r.e.. By contrast, the physical world is secondarily non-r.e. if (P1) holds regardless of (P2) and (P3). This paper argues that the physical world and the conceptual world can be secondarily non-r.e. only, in spite of all the apparent counterevidence. That is, only (P1) holds, while (P2) and (P3) both fail. Three major target references are made of J. Hintikka[2], N. Chomsky[1], and Penrose[5].*

1 Introduction

Starting from linguistics and ending up with physics, this paper develops the idea of distinguishing between *primary non-r.e.ness* and *secondary non-r.e.ness* for physics, linguistics, logic of mind, and cognitive science in general. Briefly, a natural language is primarily non-r.e. (non-recursively enumerable) if (L1) it obeys certain non-r.e. rules; (L2) the human species can effectively command these non-r.e. rules; and (L3) only primarily non-r.e. intelligent species (i.e., those who are themselves primarily non-r.e.) can effectively command these non-r.e. rules. By contrast, a natural language is secondarily non-r.e. if (L1) holds regardless of (L2) and (L3). In a way of parallel, the physical world is primarily non-r.e. if there is a subsystem S of the physical world and a non-r.e. rule R such that (P1) for any intelligent species (observer) there is no evidence against the assumption that S consists of R as one of its own laws; (P2) there is an intelligent species which can effectively communicate with S concerning R (receiving information from S concerning the execution of R, following R, etc); and (P3) any intelligent species satisfying (P2) is itself primarily non-r.e.. By contrast, the physical world is secondarily non-r.e. if (P1) holds regardless of (P2) and (P3). This paper argues that the physical world and the conceptual world can be secondarily non-r.e. only, in spite of all the apparent counter evidence. That is, only (P1) holds, while (P2) and (P3) both fail.

By linguistic mechanism we mean the thesis, a special consequence of Church's thesis, that the linguistic capacity of the human species is limited to r.e.ness (recursive enumerability). Under this understanding, there is apparently a direct contradiction between linguistic mechanism and Hintikka's claim that English as a natural language is non-r.e..([2]1977) As we see it, Hintikka virtually recognized this contradiction through remarking on the "striking consequences" of his result in theoretical linguistics. According to him, his non-r.e.ness result presents "a clear-cut counter-example to generative grammar", whose essence is "an explanation of grammaticality

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through an algorithmic generation process."([2], p. 169) It would certainly be going too far to say that Hintikka had actually intended to resolve this contradiction by rejecting linguistic mechanism. Nevertheless, he didn't offer any solution to the apparent contradiction other than declaring limitation of generative grammar.([2],[3]) The lack of explicit discussion of this contradiction is also striking in Chomsky's response to Hintikka's paper. Chomsky denied the methodological significance of Hintikka's result, largely for two reasons: that "the fundamental concepts are grammar and knowing a grammar", whereas "language and knowing a language are derivative"; and that "there is nothing in 'the concept of language' (whatever that maybe) that rules out Hintikka's conclusions..."([1], p. 126). Clearly, the relevance of these two reasons to the above contradiction is far from being spelled out. In spite of Hintikka's and Chomsky's neglect of the apparent contradiction, we consider it imperative to squarely approach this matter. Recently, Penrose made an extensive presentation of arguments for the non-algorithmicness (i.e., non-r.e.ness) of both the mind and the physical world, causing great controversy.([5],[6]) Had the contradiction created by Hintikka's paper been known to him, he might have referred to this topic as well, and would have done so to the benefit of both (or rather all) sides of the issue.

In this paper, we try to resolve the apparent contradiction by exploring the possibility and justification of resolving or say realizing non-r.e.ness within r.e.ness. In Sec. 1 we go through Hintikka's argument and try to pinpoint a sense, dubbed the secondary sense, or the sense of secondariness, which is the only sense in which Hintikka's argument and linguistic mechanism could both be maintained; in Sec. 2 we expand on the idea of the dependence or supervenience of the secondary attribution of non-r.e.ness upon the primary attribution of r.e.ness, giving in passing an interpretation of Chomsky's view which matches our own view; in Sec. 3 we try to apply our ideas to the physical world, seeking to render Penrose's non-algorithmicness claim plausible within mechanism in general.

2 From Hintikka's argument to Hintikka scenarios

For our present purposes, we need not be concerned with the details of Hintikka's paper. (Readers who are uninterested in linguistics may want to skip the following up to Definition 1.) Hintikka's argument can be summarized as the following :

H1 The universal quantifiers 'any' and 'every' in English have different scoping rules. Let a sentence containing occurrences of 'any' be called an A-sentence, and let the sentence resulting from the replacement of the occurrences of 'any' by that of 'every' in that sentence be called the corresponding E-sentence. An A-sentence and its corresponding E-sentence may not be identical in meaning due to different scoping rules for 'any' and 'every'. (For example, the following two sentences, cited by Hintikka, have different meanings: a. "If any member contributes, I'll be happy." and b. "if every member contributes, I'll be happy.")

H2 The *any* thesis: An A-sentence is grammatical if and only if it is not identical in meaning to its corresponding E-sentence, which is grammatical.

H3 An A-sentence and its corresponding E-sentence are identical in meaning if and only if they, or more exactly, their formal (first order) translations respectively, are logically equivalent.

H4 A decision problem, i.e., the problem of logical-truth, or more exactly, nonlogical-truth (non-provability or invalidity), of first order logic can be reduced to the *any*-problem, i.e., the problem of non-equivalence between the A-sentences and the E-sentences.

H5 Since the problem of nonlogical-truth is unsolvable, so is the *any*-problem; and so the fragment of English consisting of grammatical A-sentences, and hence the whole English, is non-r.e..([2])

From the above epitome we see that Hintikka's argument can be divided into two parts: the hypothetical part consisting of H1 to H3 and the deduction part consisting of the rest. Since we think that the deduction part of Hintikka's argument is beyond question, (see [2], pp.165-7 for detail) we need only go through the hypothetical part.

We choose to check H3 first. H3 can be viewed as a hypothetical assumption. The appropriateness of H3 was first challenged by Chomsky ([1], p. 125) and then defended by Hintikka ([3], p. 244). Chomsky's point was that granted that H1 and H2 were true, we could avoid H3 and its consequences by revising H2, whereby the phrase 'identical in meaning' is replaced by the phrase 'identical in form', "as differences in form are checkable". As Hintikka pointed out,

however, this revision does not work as Chomsky intended. The reason in a nutshell is that there are sentences which are non-identical in form while still logically equivalent. This reason alone makes Chomsky's suggestion intuitively unacceptable. On our view, the appropriateness of H3 is not crucial to the tenability of Hintikka's argument. For, clearly, if Hintikka replaced the phrase 'identical in meaning' in the formulation of the *any*-thesis by the phrase 'logically equivalent' or more suggestively, 'logically equivalent under formal first order translation', then he could totally omit H3 in his argument. There seems to be no reason why the original *any*-thesis is preferable to the above revised one.

We now consider H1 and H2. H1 and H2 are two general hypotheses based on empirical evidence. The two hypotheses are related. For while it is obvious that H2 is essential for Hintikka's argument, H2 would be vacuous without H1. As Hintikka noted, they could possibly be falsified by further empirical observations. Nonetheless he thought they were likely to be true; and in fact we do agree with Hintikka on seeing the possibility that there is empirical evidence which, other than the above two points or not, can be used with points like H3 and H4 to ensure points like H5 in Hintikka's non-r.e.ness argument. At the very least, as Chomsky pointed out, even if it happened that no actual natural language offerred any such evidence, we could after all 'make up' 'stipulations' to *artificially* make a natural language non-r.e. simply by revising it in a certain way.([1], p. 127) Since the concept of natural language does not rule out the idea of forming a natural language partially by artificial and conscious efforts as indeed standard languages are, we seem to have sufficient grounds for disregarding the concern about a possible falsification of the *any* thesis and the scoping rule hypothesis.

The case becomes especially interesting when we focus our attention on the subtlety of effectivity. So far we have checked H1 and H2 from largely the same perspective, without any concern for effectivity. However, there is a difference between H1 and H2 with respect to effectivity. The enforcement of H1 is r.e.-effective, for the scoping rules in question are, so far as we know, r.e.-effective in the sense that there is an r.e. procedure by which to determine in any concrete case the scope of a quantifier; whereas by contrast the enforcement of H2 is non-r.e.-effective. (Here we try to avoid or postpone as much as possible an appeal to Church's thesis, viz., equating the effective with the r.e.-effective. Also if Hintikka or anyone else identified a further scoping rule for 'any' that were not r.e.-effective in the above sense, then H1, with its contents modified accordingly, would be the same as H2 with respect to effectivity.) Now, given that the demonstration of an attribution to English may or may not essentially involve a rule that is non-r.e.-effective, we may very well dishtinguish these attributes as such. That is, an attribution of English is r.e.-effective if its establishment need not involve any non-r.e. rule, and it is non-r.e.effective otherwise. Generally and correspondingly, we distinguish two senses in which a natural language might be non-r.e.:

Definition 1 A natural language NL is primarily non-r.e. (or non-r.e. in the primary sense) if and only if

(L1) (the linguistic non-r.e. institution condition) the grammaticality of NL consists of (obeys) non-r.e. rules;

(L2) (the linguistic non-r.e. cognition condition) the human species can effectively command (or follow) these non-r.e. rules; and

(L3) (the linguistic non-r.e. exclusiveness condition) only non-r.e. cognitive systems may fully and effectively describe or account NL.

By contrast, NL is secondarily non-r.e. (or non-r.e. in the secondary sense) if and only if (L1) above holds regardless of (L2) and/or (L3).

We choose the words 'primary' and secondary' partly for lack of a better terminology, and partly in deference to John Locke, a British philosopher of the 17th century. Locke is known as the first influential philosopher to espouse the idea of distinguishing between two kinds of properties of the nature: the primary and the secondary, with the secondary regarded as only supervenient upon or reducible to the primary. Without concerning ourselves with the details of Locke's original argument, the main purpose of our paper can be expressed as investigating the extent to which (and a framework in which) non-r.e.ness may be explained as supervenience of r.e.ness, in a sense yet to be explored. From the above definition, clearly, (L2) holds iff linguistic mechanism fails; moreover, (L3) holds iff cognitive mechanism fails. Here, cognitive mechanism states that the overall cognitive (or logical or rational) capacity of the human species or any other intelligent species is limited to r.e.ness. If we take for granted that non-r.e. phenomena can be described and accounted for within whatever cognitive systems, then clearly, mechanism holds iff whatever describable and accountable are describable and

accountable in certain r.e. cognitive systems. Now, since linguistic mechanism is a special consequence of mechanism in general, we see that in so far as natural languages are concerned, there exist primarily non-r.e. natural languages only if mechanism fails.

Once we explicated the above concepts, the real meaning of Hintikka's argument should become very clear. His argument shows only (or at most) that (L1) holds for English, it does not imply anything directly as to (L2) or (L3). Although Hintikka cited many examples showing that the English usage with respect to 'any' complies with the *any*-thesis, none of them have anything to do with (L2) or (L3). He didn't show, and he didn't attempt to show, that there is an effective procedure which the human species could follow to solve the *any*-problem correctly and systematically; neither did he show or attempt to show that the non-r.e. aspects of English can only be described or accounted by non-r.e. cognitive systems, though he seemed either to have overlooked the subtle question whether non-r.e.ness can be fully described by r.e. systems, or have taken for granted the negative answer to the question. To quote him: "Hence generative grammars alone cannot offer a complete account of grammaticality." ([3], p. 244) Notably, Chomsky agreed with Hintikka on this point. ([1], pp. 126-8)

Since primary non-r.e.ness implies secondary non-r.e.ness, the distinction between the two would be justified only if the latter did not imply the former. If this were the case, then, for example, English could be secondarily non-r.e. because it could be defined by certain non-r.e. rules, such as the *any*-thesis, whereas the human species would in principle be either unable to enforce them effectively and hence unable to command English effectively, or unable to describe them thoroughly because they were limited to r.e.ness. As our conception of the scenario of a natural language being merely secondarily non-r.e. is induced by Hintikka's argument, let us call such a scenario a Hintikka scenario. The picture of a Hintikka scenario really looks counter-intuitive. For, given as granted that a natural language is by definition instituted by human beings, the possibility of Hintikka scenarios means that human species can institute and fully describe a natural language for their own use while being in principle unable to command it effectively. A number of questions arise about Hintikka scenarios, concerning their logical possibility, conceptual and pragmatic beneficiality, conditions for their realizability, etc. We try to expand on these questions in the next section.

3 Expansion on the secondary non-r.e.ness of a language

In this section, we try to show that Hintikka scenarios are logically possible if linguistic mechanism and cognitive mechanism hold, conceptually beneficial sometimes, pragmatically unavoidable sometimes, and even logically necessary under certain conditions of r.e. completeness or the like.

For logical possibility, on the one hand, clearly, if cognitive mechanism and hence linguistic mechanism holds, then the non-r.e. effectivity condition and the non-r.e. description condition must both fail. On the other hand, it is well known that in the formal context it is always possible to define (but not to enumerate or specify in every detail or the like) non-r.e. objects, (sets, functions, rules, etc), and do so effectively, within certain r.e. systems. This means, informally and for our concerns, that non-r.e.-rules can be instituted and described within human minds (or within equivalent formal systems if you like to equate them) with their logical capacity limited to r.e.ness, under the condition that they are not required to be followed effectively. That is, the non-r.e. institution condition (L1) *can* hold at the same time both the non-r.e. effectivity condition (L2) and the non-r.e. description condition (L3) fail.

Here, we must make a note on effectivity of following a rule. When we say that an intelligent species can follow a rule effectively, we mean that there is a fixed, static, but not necessarily deterministic, procedure such that the species can follow it to enforce (execute) the rule in each and every case in the application domain of the rule. Thus it is conceivable that for a given non-r.e. rule, although there is no single procedure such that an r.e. species can effectively follow it to enforce the rule everywhere in the application domain of the rule, nevertheless within any arbitrary finite sub-domain of the application domain of the rule, or more generally, within the domain of any r.e. sub-rule of the given non-r.e. rule, there is a fixed procedure such that an r.e. species may follow it to enforce the rule (or the corresponding sub-rule) in that domain, effectively. The noneffectivity of following a non-r.e. rule by an r.e. species can be equated to the noneffectivity by the r.e. species of choosing or enumerating those finite or r.e. sub-rules that in conjuction would be equivalent to the given non-r.e. rule. This note shows that there is no contradiction between the non-r.e. effectivity of following a non-r.e. rule by an r.e. species and the r.e.-effectivity of following any finite or r.e. sub-rule of the given non-r.e.

rule by the r.e. species.

For conceptual clarity, we emphasize that when an attempt is made to construct or reconstruct the grammar of the language, it may be simpler to summarize a given language by instituting certain non-r.e. rules in order to accommodate certain grammatical data taken as initial conditions even though linguistic mechanism is being assumed. For example, suppose in the case of 'any' in English it so happens that all samples (in excess of one million) examined so far comply with the *any*-thesis. Then it would certainly be conceptually convenient and simple to accept the *any*-thesis as a rule of English. There is no guarantee that it would not be violated by further samples. However, if the samples examined so far are summarized by a given r.e. rule, then this r.e. rule will have roughly the same chance of being violated by further samples if its application domain is beyond the given samples. (Note also that a rule would be trivial if its application domain is finite.) In this hypothetical case, the *any*-thesis is very likely much simpler than any r.e. rule with respect to the first one million samples or so. Besides, since the formation of a natural language may very well involve and be affected by some conscious effort, the decision that we make now in choosing a rule to summarize the known samples of the 'any' usage in English may actually redefine English for all future samples of the 'any' usage in accordance with the *any*-thesis.

As for pragmatic unavoidability, historically at least, some non-r.e. rules may have been instituted for various natural languages without being known to be non-r.e.. For example, the *any*-thesis or the *ever*-thesis could well have been recognized before the age of contemporary theory of computability. Also since the problem of discriminating between r.e. rules and non-r.e. rules is not r.e.-effective, there will still be chance for non-r.e. rules to be instituted for some natural language, even though a conscious effort is constantly made to prevent such a chance.

So far all we have shown, together with Hintikka's argument and Chomsky's make-up stipulations, is only the general logical possibility of Hintikka scenarios. Now we would like to consider tentatively and specifically the conditions, necessary or sufficient, linguistic or not, that would together entail the existence of Hintikka scenarios for a natural language.

A first and minimum condition is of course linguistic mechanism, for otherwise the non-r.e. effectivity condition (L2) may well be true, making Hintikka scenarios impossible, given that it is simply unthinkable that cognitive mechanism (regarding (L3)) would fail whereas linguistic mechanism (regarding (L2)) could hold. Relatedly, then, a second condition is mechanism in general. For otherwise linguistic mechanism would fail, to say the least. Moreover, the falsity of cognitive mechanism would imply that some non-r.e. systems would be essentially stronger than r.e. systems, or in other words, there would exist phenomena, possibly of non-r.e.ness, which can be described by non-r.e. systems but not by r.e. systems.

A third condition, which may be the most crucial of all, addresses the human cognitive capacity, and hence we call it the capacity condition. That condition says that the human cognitive capacity must be strong enough to describe or account non-r.e. phenomena such as non-r.e. rules. while still limited to r.e.ness. This condition is indeed satisfiable. Here we introduce a new concept: r.e. completeness.

Definition 2 A logical system is r.e. complete iff all r.e. functions are representable in it.

In the above definition, we intend the notion of representability to be the one, or like the one, by which Gödel incompleteness results can be achieved for first order formal systems. There is in [8] 157-161 a discussion about recursion completeness (and its consequences) which is the same thing as r.e. completeness here. Also in the definition we can replace 'a logical system' by 'a theory', 'a cognitive system' or their like without affecting the essential validity of our reasoning. An observation of r.e.-completeness, which could be remarkable in one sense while trivial in another or controversial in still another, is that an r.e. complete system can have all functions, non-r.e. or not, represented within itself, to the extent to which they are representable in principle. In [8] Q. Yu has argued that r.e. completeness systems are representationally maximal in the sense that they can have anything representable within them which is representable in principle. According to Yu, if mechanism holds, then r.e. complete systems are rationally or cognitively maximal systems. Since r.e. complete systems can themselves be r.e., witnessing the theory of Peano Arithmetic or the axiomatic set theory ZFC, the capacity condition is compatible with cognitive mechanism.([8], pp. 157-161) Here, we note that the human cognitive capacity may not need to be so strong as r.e.-complete just in order to insure Hintikka scenarios. However, what a minimal cognitive capacity could be in this regard is a technical question, and we shall not be concerned with such technical questions before settling down to the more basic principles.

As a fourth condition, we specify what we would like to call the representational condition: that is,

non-r.e.ness can only be realized in conceptual (logical or cognitive) representations or reflexions. From the above discussion, the representability of non-r.e. rules within r.e. conceptual systems is guaranteed, so for the plausibility of the representation condition we neen only show that non-r.e. linguistic rules cannot be realized otherwise, in the actual linguistic practice, for example. Since non-r.e.ness comes necessarily with infinity, any non-r.e. rule of a natural language cannot be found or established by any finite linguistic phenomena. If someone, say an adherent of either Hintikka or Chomsky, argues that there is an infinitary Platonic world which realizes the supposed non-r.e. rules, we shall then answer that since finite linguistic phenomena are compatible with a wide range of different possible Platonic worlds, some of which do not (platonically) realize the supposed non-r.e. rules, the burden is left to our opponent to exclude those possible worlds which he does not like. There is no Platonic God offering revelation at this point. Note that the representation condition as explained above is not vacuously satisfied, for its satisfiability does exclude certain other senses in which non-r.e. rules could conceivably be said to be realized. We would like to say that the role of the representation condition is just to restrict the sense of non-r.e.ness realization.

With regard to the relation between non-r.e.ness and generative grammar, the representation condition also helps show why it is rather simplistic as Chomsky does, to admit with Hinitkka that non-r.e.ness must be beyond generative grammar. The point is that generative grammaticality matches r.e.ness; although primary non-r.e.ness, if realizable at all, is by definition beyond r.e.ness, secondary non-r.e.ness, which is the only possibility already shown to be realizable, can be represented within r.e.ness, and hence be resolved or reduced into r.e.ness. A straightforward conclusion drawn from this is that Hintikka's non-r.e.ness result has no force implying the inferiority of machines to human species with respect to linguistic capacity.

Let us call the above four specified conditions the non-object conditions, for they are not concerned directly with language objects themselves. Given these non-object conditions, we are still short of logical sufficiency to ensure a Hintikka scenario. For all these non-object conditions are jointly compatible with the existence of primarily r.e. natural languages, so to speak. On the one hand, it would be trivial to claim that these conditions plus (L1) in Definition 1 guarantee the existence of Hintikka scenarios; on the other hand, we haven't succeeded in proving that a nontrivial condition could replace (L1) in the above claim. So we can only speculate about the possible object conditions for Hintikka scenarios here. An easy guess is that a meaningful object condition should essentially involve what might be aptly called recursion complexity, semantic complexity, etc, of languages, yet to be studied. For example, being semantically closed, which was discussed by Tarski ([7]), may be a candidate for semantic complexity. Now, to show one of our attempts, we include the following speculation.

As the notion of r.e. completeness is pertinent to theories *per se*, whereas we want something parallel to it while pertinent to objects *per se* and to be described by theories, we introduce the notion of r.e. description completeness.

Definition 3 An object (system) OS is r.e. description complete iff any first order theory T of L that fully describes OS is r.e. complete.

Objects which are r.e. description complete and those which are not both exist. For example, since Peano Arithmetic as an object system is r.e-complete for it has been proved that all r.e. functions can be represented in it, any language, natural or formal, of which the description imperatively consists in part of the full theory of Peano Arithmetic is r.e. description complete. By, contrast, any finite object is not r.e. description complete. Informally, if a natural language is r.e. description complete, then it is r.e. complete too in some transformed sense yet to be specified, for in that sense all the r.e. functions can be represented in it. We shall not attempt to investigate that transformed sense in this paper. Also we leave aside the technical details of the concept r.e. description completeness and the concrete question whether English (or some other actual natural language) is r.e. description complete.

Using the above concept, we speculate that

> If a natural language is r.e. and r.e. description complete, then it consists of Hintikka scenarios.

To support our speculation, we give the following reasoning:

(a) There are consistent and r.e. complete theories, or so we assume.

(b) If a theory is consistent and r.e. complete, then it has an r.e. sub-theory that is r.e. complete.

(c) If a theory is r.e., r.e. complete, and consistent, then it is representationally maximal in the sense that it can represent anything that can in principle be represented in any way, assuming Church's Thesis and mechanism.

(d) From (c) above, if a theory T is consistent, r.e., and r.e. complete, then all the non-r.e. objects (concepts) up to isomorphism can be defined in the theory.

(e) Let NL be any natural language that is r.e. description complete, and T be any r.e. sub-theory of the theory of NL that is r.e. complete. From (c), T is representationally maximal as it is consistent, r.e., and r.e. complete. Now let X be any non-r.e. object. Then there is (can be given) a definition of X up to isomorphism in T. The reference of X is then supposed to be found in the object system described by T, which is NL, so X is attributed to (or associated with) NL within (according to) T. Moreover, the attribution of X to NL is necessary in the sense that it is the case for all reasonably complete theory of NL, whereas when these reasonably complete theories are restricted to r.e.ness (indicating the constraint of linguistic mechanism), the realization of the attribution of X to NL is consistent with linguistic mechanism.

The above reasoning is supposed to show two points: 1. if a system such as, especially, a natural language is complex enough so as to be r.e. description complete while still limited to r.e.ness, then it will exhibit non-r.e. phenomena to some intelligent species. 2. if an intelligent species is r.e. complete though still r.e., then it will be able to effectively observe or identify non-r.e. phenomena of a given system, especially, a natural language, yet will be unable to effectively command them.

Needless to say, the above reasoning needs much further refining, justification, and explanation if it is to be worth anything at all. For example, the points used as assumptions in the above reasoning such as (b) need to be clarified, to say the least; and other links or gaps between or within these steps are to be supplied. Nevertheless the above reasoning might be ultimately yield some insight into Hintikka scenarios and their necessity. Specifically, the idea of r.e. description completeness may need refining and may be too strong as a necessary condition for a language to admit of Hintikka scenarios. It can be loosened, perhaps in different ways. It is also worth mentioning that, the above reasoning, if eventually acceptable, shows more than Speculation 1 states. Tt shows that a natural language which is r.e. description complete consists of the Hintikka scenario involving ***any*** non-r.e. set or rule up to equivalence. This sounds unlikely and counter-intuitive for the time being. For all this, we think that it points in the right direction for locating the proper conditions in that regard, that is, by gradually increasing the degree of description complexity (to be defined and refined, and maybe with description r.e. completeness as its limitation) of the language in question, we shall eventually reach a point at which the language exhibits Hintikka scenarios.

In the above, we have shown that Hintikka scenarios are at least logically possible in the linguistic world. Since non-r.e. properties involved in a Hinitkka scenario can always be explained as derivative from r.e. properties, linguistic mechanism can be protected by the idea that r.e.ness and r.e. completeness or something like it together are sufficient to ensure secondary non-r.e.ness.

We now would like to *re*-interpret Chomsky's view about Hintikka's position in terms we have established in the above discussion, aiming for a match with our own view. We hope our interpretation would help to reach a correct explanation and evaluation of Chomsky's original ideas in this regard, without pretending that Chomsky originally intended them as we interpret them now. When Chomsky said that the concept of language does not rule out Hintikka's results, he could mean that the concept of language allows within itself the possibility of Hintikka scenarios without implying anything more than that. Also when he emphasized that the concepts of grammar and knowing a grammar are fundamental whereas that of language and knowing a language are but derivative, he might just have been saying something like the following: Since languages are but conceptual derivatives of grammars, it is sufficient as well as essential that grammars, r.e. or not, can be instituted and described by and through effective linguistic means, which are r.e. under linguistic mechanism and cognitive mechanism, in spite of the fact that the correspondent resultant languages may be non-effective, because grammars that are effectively institutable and describable are not necessarily effectively commandable or enforcable. It is of course an open question whether and to what extent the above interpretation is approporiate, independent of whether our view is itself plausible or not.

4 Possibility of the physical world being secondarily non-r.e.

Assuming there is some truth in our reasoning about Hintikka scenarios, we try in this section to carry over that reasoning to the physical world, to show that the physical world may be secondarily non-

r.e. while primarily r.e..

An initial difficulty in this regard is that whereas a natural language is a proper component/aspect of the physical world, something which can be observed and commanded by something else outside of it, the physical world is not so, it is meant to be all comprehensive, making a predication of condition (L2) and (L3) in Definition 1 to it meaningless. Fortunately, there seems to be a way out of this difficulty. The way is to assume the legitimacy of defining the status regarding r.e.ness of the physical world in terms of that of its sub-systems and their relative intelligent species. We adopt this assumption, and call it *the thesis of composition*. In addition and accordance to the thesis of composition we also make the assumption, called *the thesis of observability closure*, that a sub-system in a given status exists iff that sub-system can be observed (verified, experienced, etc) as such; and that any such observation (verification, experiencing, etc) involving an object and an observer can itself be observed retrogressively without limit. Here, we take the observationalist position, which we believe is shared by a majority of physicists, that phenomena that are unobservable in principle are physically meaningless. Obviously, the above two theses and the observationalist position need refinement and justification. However, here we just rely upon our belief that as working assumptions they can be made clear and meaningful. We fully acknowledge that our following ideas hinge upon these assumptions.

Now, expressly, we introduce the following definition:

Definition 4 The physical world is primarily non-r.e. iff there is a sub-system S of the physical world and a non-r.e. rule R such that

(P1) (the physical non-r.e. reality condition) for any intelligent species (observer) there is never evidence against the assumption that S has R as one of its own laws;

(P2) (the physical non-r.e. effectivity condition) there is an intelligent species which can effectively communicate with S concerning R (receiving information from S concerning the execution of R, following R, being able to observe and tell whether R is violated in S, etc);

(P3) (the physical non-r.e. exclusiveness condition) any intelligent species satisfying (P2) is itself primarily non-r.e..

By contrast, the physical world is secondarily non-r.e. iff (P1) holds regardless of (P2) and (P3).

Obviously, the above definition is very coarse. We enclose some explanatory notes for it as follows, fully recognizing that these notes themselves are incomplete and need further explanation.

First, (P1) is parallel to (L1). We define the physical institution of a non-r.e. rule of the physical world as the lack of counterevidence because (a) from the thesis of observability, the truth of an assumption about the physical world is equivalent to the non-falsification of that assumption. In this sense, even (L1) should be more adequately understood in the spirit of (P1). Moreover, (b) should (P1) instead be understood or revised after the pattern of (L1), the whole Definition 4 may well be revised accordingly and still fit with our general purposes.

Second, we keep Definition 4 in line with the thesis of observability by taking the presence of intelligent species in a certain relationship as essential component of the definition. In doing so we do not suggest that intelligent species be in any special status in contrast to the other parts or components of the physical world with respect to effectivity. Here, observation need not mean more than interaction.

Third, in contrast to Definition 1, there is in Definition 4 no indication of a non-r.e. rule being instituted by an intelligent species. This is only because we think that normally a physical rule is not supposed to be instituted by any intelligent species. However, insofar as rules of *sub-systems* can be instituted or imposed by outside executive forces, we would like to revise the definition accordingly, without affecting its implications for our concerns.

Fourth, there is a circularity in Definition 4 concerning the primariness of non-r.e.ness. On our view, this circularity is not vicious. In connection with the thesis of observability closure, this circularity could just mean that the primariness of non-r.e.ness of the physical world must be closed under cognitive observation or physical interaction.

There is a surprising implication from the primariness (or equivalently, secondariness) circularity under a special understanding of effectivity. The understanding is that an intelligent species can follow a non-r.e. rule effectively iff it can follow the rule as effectively as any other intelligent species. (We shall not dwell on this point. See [8], pp 157-62. for a related discussion.) The implication with this understanding is the insight that the question of whether non-r.e.ness of the physical world is primary or only secondary is essentially unsolvable in the sense that both possibilities are compatible with our understanding and evidence available with respect to the PS-issue (the issue

of primariness versus secondariness). We view this insight as a significant progress in our understanding of the PS-issue and the highest point reached in this paper. Obviously, if this insight is correct, then mechanism in general and Church's thesis are irrefutable.

By the way, related to the discussion of the above paragraph, we may also revise clause (P2) of Definition 4 so that the determinant condition for primariness of non-r.e.ness is solely restricted to a single clause, i.e., (P3) of Definition 4. The desired revision of Definition 4 (specially concerning (P2), (P3), and (P4)) is the following:

Definition 5 The physical world is primarily non-r.e. iff there is a sub-system S of the physical world and a non-r.e. rule R such that

(P1') (the physical non-r.e. reality condition) The same as (P1);

(P2') (the physical maximal effectivity condition) there is an intelligent species which can communicate with S concerning R (receiving information from S concerning the execution of R, following R, being able to observe and tell whether R is violated in S, etc) *as effectively as any other intelligent species*;

(P3') (the physical non-r.e. exclusiveness condition) any intelligent species satisfying (P2') is itself primarily non-r.e..

By contrast, The physical world is secondarily non-r.e. if (P1') and (P2') hold regardless of (P3').

It is worth noting that (P2') above assumes that there is maximal effectivity regardless of whether it is r.e. or not. This assumption may also raise its other interesting issues. This assumption seems acceptable to us, at least for the time being. Putting this assumption aside, we can see that Definition 4 and Definition 5 are equivalent. We present Definition 5 mainly in order to highlight the non-vicious circularity of non-r.e.ness.

The above notes, although far from being sufficient, help show that Definition 4 is parallel to and a refined generalization of Definition 1. Now, let us call the possibility of the whole physical world being merely secondarily non-r.e. the Church scenario. We can reason roughly the same way as we did for Hintikka scenarios that the Church scenario is the case iff the following conditions hold:

- Physical mechanism;
- Cognitive mechanism;
- Cognitive r.e. completeness for some intelligent species;
- Physical r.e. description completeness for some sub-system of the physical world; and
- The representational condition as was given in section 2.

As we mentioned before, physical r.e. completeness and cognitive r.e. completeness may be more than is required to secure the reality of the Church scenario. In fact, if our reasonings about the Hintikka scenarios and the Church scenario are revisable for correctness, then every possible non-r.e. set, rule, phenomena, etc, should be instituted somewhere in the physical world as its secondary properties, a case we would like to call the Complete Church scenario.

From the above discussion, it is very clear that if our idea and reasoning about the Church scenario is basically correct, then non-r.e.ness as an attribution of the physical world may very well be only in the sense of secondariness and hence be supervenient or dependent upon r.e.ness plus r.e.-completeness or its like which is in the sense of primarinesss. This conclusion is above the details of Penrose's. Nevertheless we are confident that, had Penrose succeeded in demonstrating non-r.e.ness in the mind or the physical world, which we are not convinced of ([4]), we can show that it may well be in the sense of secondariness only. If so, we may may call primary non-r.e.ness the Emperor's New Spirit.

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