The opening quote is from Marvin Minsky, "Communication with Alien Intelligence—In Memoriam: Hans Freudenthal," in *Extraterrestrials: Science and Alien Intelligence*, ed. Edward Regis (Cambridge: Cambridge University Press, 1985).

Cover: E.T. trying to connect.

Let's pretend, for brevity, that things are clearer than they are.
– Marvin Minsky

A PREEMPTIVE REVIEW

The book's author is called Hans Freudenthal. The book is called *LINCOS* and was published in 1960 by North-Holland Press (later absorbed by Springer Verlag). This is how one review of it opens:

The exploration of outer space has begun, and it is expected that serious scholars will begin to consider various problems associated with cosmic communications. In this book the author sets for himself the task of designing a language for cosmic communication.

—and closes:

The printing of the text maintains the high quality and standards which have been exhibited in the publisher's series entitled *Studies in Logic and the Foundations of Mathematics*. The reviewer warmly recommends this book to all who enjoy a delicious potpourri of mathematics, logic and linguistics.

The review, signed J.B., was published in 1952 by the *Technical Journal of the United States NSA*. It was originally classified, perhaps because it seems to have appeared eight years before the book it was about.

SPEAK WITH YOUR FINGER

How could E.T. speak English? Of course, he was designed to do it. Like most life-forms hailing from the distant galaxies of movies and sci-fi novels, E.T. was provided by his creators with strikingly close replicas of the human phonation apparatus and auditory system. Whatever his native language—or the Vogons', from Douglas Adams's *Hitchhiker* series—or the Gethenians' from Ursula LeGuin's *Left Hand of Darkness*—he, like most aliens, was fully equipped to learn and understand ours.

Superficially, this equipment seems to be relatively independent of the aliens' anthropomorphic look. H.G. Wells's slug-shaped Martians still have a drumlike membrane on the back of their head which acts as an ear of sorts; the Ariekei in China Miéville's *Embassytown* look like colorful giant arachnopods, but the slits on their limbs function like vocal cords. A humanoid form, as far as mere communication goes, is optional: a way of making alien characters more relatable to the public; or more compatible with the humans they are to have inter-species sex with, as in Naomi Mitchison's *Memoirs of a Spacewoman*; or easier to render on camera with an extra in a furry suit.

Not completely, though. A quasi-mouth and a pseudo-ear (as well as some form of intelligence) might be enough to speak a human language, provided they are compatible with its phonetics, but not to LEARN it. A new word can be learned by translation, which requires a pre-existing common language and is how we learn Latin, or by ostension — pointing at stuff and calling its name — which is how anthropologists learn tribal languages and how we learn our first vocabulary. The former way is, in principle, impossible for an extraterrestrial species, while the latter requires specific organs which go beyond the mere mouth-and-ear.

An alien in the form of a self-enclosed, perfectly smooth sphere might be able to perceive and reproduce the vibrations caused in the air by our speech, but it wouldn't be able to bind them to any parcel of world or experience. It wouldn't be able to segment speech into words and sentences, nor to understand in what context they are to be used. In this respect, the key to E.T.'s ability to learn English was not his mouth or his ears, but his finger.

COSMIC INTERCOURSE

What if he didn't have one? This was precisely the problem German mathematician Hans Freudenthal was pondering in the 1950s from his office in Utrecht, where he taught algebra and geometry after having fled Nazi persecution. For some time (this wasn't so rare in the space age) Freudenthal had wondered whether cosmic radiation was

a "linguistic phenomenon" — an attempt by some alien civilization to establish contact with other intelligent species out there.

Developments in astronomy had ultimately ruled this out, but the question lingered: how would that kind of contact be possible? Even assuming a broadcast was sent out in ways that made it unreasonable to discard it as a natural phenomenon, how could an alien race, persuaded that it must mean something, understand WHAT it means? A radar can act as both mouth and ear. It can't act as a finger.

Freudenthal was in a very favorable position to tackle this subject. For over half a century, the working meta-language of both algebra and geometry — namely, set theory — had been identified by mathematicians and philosophers as the scaffolding of natural language.

Set theory is a symbolic language originally introduced to describe the relations between elements of groups. The fundamental relation is ∈, "belongs to." For instance: at the moment of my writing, the room I'm in contains myself (V), Francesca (F), Stuart (S), a desk (d) and a lounge chair (l). So we could describe the following sets:

Room = {V, F, S, d, l}
Women = {F}
Men = {S, V}
Objects = {d, l}
Bertolotti-Bailey family = {S, F}
Stuff in the bay window = {V, d}
Stuff in the back of the room = {F, S, l}

Sets can also be defined as sums or subtractions of other sets, as in:

Room = Women + Men + Objects
Humans = Room – Objects

Elements, too, can be defined via the sets they are in, using the "intersection" operator ∩ that identifies the elements shared by two or more sets. For instance:

Men ∩ Bertolotti-Bailey family
univocally identifies Stuart, just as
Men - (Men ∩ Bertolotti-Bailey family)
univocally identifies me

What is worth noting here is that a set with only one element (say, the set of Italian men, which includes only me: {V}) is a distinct entity from the element it contains, V. This can be iterated: say, the set of all sets of Mediterranean men in that room only includes the set of Italian men, so: {{V}}. This amounts effectively to a way of "creating" additional objects: we started with V and defined {V} and {{V}}.

This apparently trivial ability has proven crucial, since it can be used to DEFINE numbers: the operation of "including in a set" behaves in a surprisingly similar way to the "+1" operation. If you start with the empty set ∅, you have:

∅ = 0
{∅} = the set with ∅ in it = 1
{{∅}} = the set with the set with ∅ in it = 2
and so on

This then provides a framework for speaking about the properties of numbers with a very high degree of generality, and with clear rules to prove theorems. This cannot be done in normal mathematical notation, since it only has ways to "name" individual numbers (5, π, 34/22) or to refer to undefined single entities (with variables such as x, y). But if you want to refer to a group of numbers sharing a relevant characteristic, such as "primes," "odd numbers," "numbers that can't be expressed by a fraction," etc., you will need more than that: you will need a meta-language, such as, in this case, set theory.

The set-theoretical analysis of language itself works somewhat similarly, considering every "object" the language can refer to as an element (say, atoms) and every word as the name of a set — either a set of a single atom, or a more complex one: I am the set of my atoms, but also of my limbs, for instance; my car is a set of atoms, but also of its parts. This has an extremely useful consequence, namely that it allows set theory to handle nouns, verbs, and adjectives as functioning in one and the same way. I am the set of my atoms; "red" is the set of red things; "to run" can be interpreted as the set of things that, at some moment, are running. There is a LOT more to say about this, but this is not the place to do it.

From Gottlob Frege to Bertrand Russell, Rudolf Carnap, Ludwig Wittgenstein, and W. V. O. Quine, a long line of logicians worked to reveal what they called the "logical form" of everyday statements. They would translate English phrases into set-theoretical formulae in order to reveal their inner workings, their rational core. Some considered this a merely grammatical endeavor, an attempt at tidying up the semantic mess grown with millennia of unruly linguistic evolution; others saw things more philosophically, and considered the analysis of language as a foil for the nature of human thought or even of reality itself, whatever that might be.

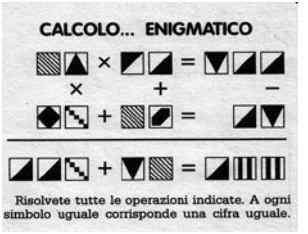
In any event, by the 1950s it was generally agreed upon that any meaningful language could be boiled down to a logical notation based on set theory. It seemed almost self-evident that this would also be true of the language of any intelligent alien life-form, at least if we presume its intelligence to entail a possibility of communication with humanity. Of course, the fact that a set-theoretical language could be understood by an alien, if any language could, does not mean it could be TAUGHT. This would require a common context and a way of pointing at it, which is precisely what one lacks when blindly shooting broadcasts into the interstellar void.

Freudenthal saw things differently. From his perspective, the alleged universality of set theory granted precisely the common context required for teaching any language — provided the initial lessons used set theory not only as a means of communication but also as a SUBJECT. His line of reasoning was that if every human language has a set-theoretical logical form, it follows that any alien we might hypothetically talk to would have to be able to understand some form of set theory. Hence, we already have a shared subject we can talk about — stuff we can POINT TO: the elements and theorems of set theory (and basic arithmetic) itself. The language, at least initially, *will be its own content.*

"It was in this way," Freudenthal writes in the preface to his *LINCOS*, the title a portmanteau for Latin *lingua cosmica*, "that I arrived at the problem of designing a language for cosmic intercourse."

CROSSWORD PUZZLES OVER THE SIDEREAL SPACE

A famous Italian crosswords magazine has a weekly puzzle that works pretty much as Freudenthal imagined his cosmic intercourse. It consists of several sequences of apparently random symbols, such as:



The reader is invited to decipher this system knowing that all formulae are well-formed and true. In this example, for instance, one can immediately understand that ◭ corresponds to "1," since in both the horizontal and the vertical multiplication, the digits it multiplies (◹ and ◪) result in themselves.

Freudenthal's program works exactly the same way. It begins by broadcasting repetitions of "beeps"—regular enough for a receiver to recognize them as intentional—in groups that will be taken to represent numbers. After a while, he introduces a new sound, ♑, separating identical sequences: this, with enough repetitions, will be understood as an "=" sign.

—
— —
— — —
— ♑ —
— — ♑ — —
— — — ♑ — — —
— ♉ — ♑ — —

In the same way, most mathematical operators are quite easy to present—one at a time and with enough examples to avoid any risk

of misinterpretation (in the last line I introduced the "+" sign). This idea is as simple as it is effective: since we assume aliens *will know mathematics,* we just have to make sure they recognize what we are showing them to be mathematics, and they will easily interpret any arbitrary LINCOS "word" as equivalent to whatever they use to call "+," "log," ">," and so on.

Of course, none of this would appear easy to anyone save for the most hardened logicians and mathematicians. But these are exactly the kind of people who would be working night and day on interpreting anything we might understand as communication from outer space, if we ever were to receive any such thing, and Freudenthal assumes the same would be true of an alien civilization. So essentially what he's doing is trying to speak to an extraterrestrial peer of his, with no shared language, with no channel of exchange other than for peeps and dashes radioed over millions of kilometers of void, and struggling to make his messages univocal enough to be sure they are understood. Freudenthal's way of doing this is to send crossword puzzles over the sidereal space.

OF GOOD AND EVIL

There's little point in talking to aliens if the most you can say is 2+2=4. But in Freudenthal's intent mathematics was a way of developing an initial vocabulary that subsequently could be extended to encompass almost everything any other language can be used to talk about. In Freudenthal's perspective, the terms of ethics, biology, human behavior, and even religion can be defined in purely mathematical terms, and in ways that to him seem almost painfully self-evident. "This," he writes, single-handedly refuting thousands of years of philosophical investigation, "may be a striking refutation of a prejudice which is very common among representatives of the humanities: value-judgments other than 'true' and 'false' are said to be beyond the reach of mathematical methods."

His method is to set up what he calls a "theater": a convention to broadcast conversations between fictional characters. The conversations, it goes without saying, are about mathematics.

I will skip the painstakingly ingenious ways Freudenthal defines the terms he now uses. Suffice to say they seem plausible. He sets up a "clock" on another frequency and uses it to refer to previous parts of his broadcast—"events." He defines a mathematical operator "?" that turns a formula into question, such as 4+4=?, and uses THAT to introduce speakers in dialogs that go like this:

☪: 4+4=?
✠: 8
☪: 3×2=?
✠: 6

Hence, Freudenthal's humans (✠ and ☪—or A, B, etc., from now on) are more or less defined, albeit initially, as askers and answerers of questions. This very simple exchange is followed by what could be either a stroke of genius or a masterful sleight of hand. Put yourselves in the aliens' minds and try to make sense of what follows ("True" and "false" are already defined, mathematically; "what you did" is my way of translating Freudenthal's reference to events.):

A: 4+4=?
B: 8
A: 👍

A: 5+1=?
B: 6
A: 👍

A: 6+3=?
B: 8
A: 👎

A: 4+3=?
B: 2
A: 👎

For the moment, "👍" and "👎" could be synonyms of "true" and

"false." Then, this happens:

A: 5+2=?
B: 6+1
A: "5+2=6+1" is true, what you did is 👍.
B: 7
A: "5+2=7" is true, what you did is 👎.

What do "👎" and "👍" mean now? Well, they apply to the "events" — namely, acts of speech. An act of speech is "👎" if it says the truth and is informative. An act of speech is "👍" if it is false or does not provide any meaningful information to the asker. These are, according to Freudenthal, mathematical definitions of good and evil.

WISE-PROOFING

It is interesting to note, here, that despite their form, these definitions are not "mathematical" at all. They use mathematics as a kid on a first date might use pop culture as a means of striking up a conversation; whose real content will not be a theorem or Katy Perry's latest album, but the social dynamics between the speakers. Hence, of course, the "definitions" of ethical values they purport to offer do not define anything.

A definition, in mathematics, introduces a new concept in an operational way. I can define the large cardinal "ω_α" as "a number higher than any natural number," and this will allow you to refer to a new object in meaningful and well-formed statements: "$\omega_\alpha > 9273455$," or "$34 < \omega_\alpha$." Before the definition you could not speak about this object — it didn't exist for you. You couldn't have formulated these sentences about it, because you knew of nothing they could be about. The definition enabled you to do it.

Freudenthal didn't offer anything like that. His definitions contain no clue as to how to use "👎" and "👍" outside of the few examples he provided. Of course, in his intention the aliens WILL understand those

terms in a much wider variety of contexts, but this is because they are supposed to know already what the terms are about: only, they don't know the names of the terms in LINCOS.

I was baking a cake at a friend's place the other day in Liverpool, and my host had to help me navigate the kitchen. At some point —translating the recipe from Italian— I asked him where the *lievito* was. The what? "You know, that white powder that comes in little bags." He duly brought me some yeast. Of course, I had not DEFINED yeast —my definition could have applied just as easily to baking soda or cocaine. I had merely provided him with pointers as to what I was referring to, within a context (baking) that circumscribed the array of possible targets (his food supplies).

Freudenthal is aware of this. He calls his method "quasi general definition," and claims, rightfully, that it is the form of definition we use to teach. What is a tiger? That, that, and that (pointing). What is an odd number? 1, 3, 5, 7, 9. This way of showing is based on the faith that the other party will make an effort to extend what you're giving them. I have no way of knowing you will be able to prolong the sequence of odd numbers to 11, 13, 15; and yet it is likely that you will. "LINCOS," he writes, "is moderately formalized, but we do not object to fully-formalized language. Foolproof languages have an importance of their own. I hope LINCOS will be wise-proof. Formalized languages appeal to the malevolent reader. The present book is addressed: *lectori benevolenti*." That is, "to the benevolent reader."

THE CONVENIENCE OF THE TERRESTRIAL READER

For someone so skeptical of formalization and foolproofing, Freudenthal's book is surprisingly formalized. While the first few chapters are written mostly in normal language, interspersed with brief examples of LINCOS expressions, as the book progresses its pages increasingly look like the example on the following page (from the chapter devoted to human behavior, which defines "promises" and "enough").

* *Ha* Inq *Ha* : *tt' x* Sci . ? Etc ·
↔ · *tt' x* Vul · Nnc *x* Inq ! *y* . ? Etc : → · *tt' x* Inq ! *y* . ? Etc *

3 30 1. * ʰ*Ha* Inq *Hb* · Utr : Nnc *Hb* Sci · ? *x* . t_1 t_2 Fit *x* |
Hb Inq *Ha* : Ver : Tan : Nnc *Hb* Vul :
∧ ⌜*t* . *t'*⌝ · ¬ : *tt' Hc* Sci · ? *x* . t_1 t_2 Fit *x* |
Ha Inq *Hb* : Nnc *Ha* Vul : PPN *Hb* Inq ! *Ha* · ? *x* . t_3 t_2 Fit *x* :
→ : ∧ ⌜*t* . *t'*⌝ · ¬ : *tt' Ha* Inq ! *Hc* · ? *x* . t_1 t_2 Fit *x* |
Hb Inq *Ha* : ˇ*v* . Nnc *Hb* Vul *v* · Mul > · ˇ*u* . Nnc *Ha* Vul :
Ha Vul · ¬ : *tt' Ha* Inq ! *Hc* Etc :
Eti : *Hb* Vul · ¬ ∨ ⌜*t* . *t'* . *y*⌝ . *Ha* Inq ! *y* Etc :
¬ Sat · ¬ ∨ ⌜*t* . *t'*⌝ *Ha* Inq ! Hc Etc :
Qia · Pot : ∨*x* · *x* ≠ *Ha* . ∧ . UPN *x* Inq ! *Hc* Etc |
Ha Inq *Hb* · Nnc *Ha* Pol *Hb* . ¬ ∨ ⌜*t* . *t'* . *y*⌝ Etc |
Hb Inq *Ha* . t_1 t_2 Fit *a* |
Hd Inq *Ha* · Utr : Nnc *Ha* Sci · ? *x* . t_1 t_2 Fit *x* |
ʰ*Ha* Inq *Hd* : Ver : Tan · PAN *Ha* Pol *Hb* :
¬ UPN *Ha* Inq ! *Hd* · ? *x* . t_1 t_2 Fit *x* |
Hd Inq *Ha* · Utr . Nnc *Ha* Inq ! *He* Etc |
Ha Inq *Hd* : Eti : PAN *Ha* Pol *Hb* ·
¬ ∨ ⌜*t* . *t'* . *y*⌝ . *tt' Ha* Inq ! *y* Etc ·
Erg : Nnc *Ha* Vul · ¬ ∨ ⌜*t* . *t'* . *y*⌝ . *tt' Ha* Inq ! *y* Etc *

The word written Pol (*fL* pollicetur = promises) means the verb "promises". Syntactically it behaves as 'Inq'.

The word written Sat (*fL* satis = enough) means "enough".

3 30 2. * *Ha* Inq *Ha* : *tt' Ha* Inq *Hb* :
Nnc *Ha* Vul · Etc : *h* Pst . *t'* · *Ha* Inq Etc :
↔ : *tt' Ha* Pol *Hb* · Etc : *h* Pst . *t'* · *Ha* Inq Etc *

Explicit definition of 'Pol'.

3 30 3. ($t_1 < t_2 < t_3 < t_4$)
* *Ha* Inq *Hb* : Utr Nnc *Hb* Sci · ? *y* . t_3 t_4 Fit *y* :
Hb Inq *Ha* Ver :
Ha Inq *Hb* : Nnc *Ha* Vul ·
Nnc *Hb* Inq ! *Ha* · ? *y* . t_3 t_4 Fit *y* :
→ : PPN *Ha* Inq ! *Hb* · ? *x* . t_1 t_2 Fit *x* :
Hb Inq *Ha* : Nnc *Hb* Vul · ˇ*z* . PAN *Ha* Vul *z* :
Ha Inq *Hb* Ben :
Hb Inq *Ha* : t_3 t_4 Fit *b* · ? *x* . t_1 t_2 Fit *x* :

Even more surprising, this use of formulae and symbols is basically *decorative.* The actual LINCOS Freudenthal had in mind would consist of radio signals, not words; the "written LINCOS" provided in this book merely consists of arbitrary strings of characters standing in for the actual modulation of radiowaves. This means that such characters can be ANYTHING, and where Freudenthal chose three-letter codewords derived from Latin such as Utr, Nnc, Sci, and Fit, he could just as well have written "whether," "now," "knows," and "happened," respectively.

Naturally, this could be true of mathematics, too — we could write "five" instead of "5" and "square root" instead of "√." In mathematics, formalism has a precise point: the use of symbols instead of words allows for the *syntactic manipulation* of strings independently of their meaning. If I have a mathematical expression of the form A = B, I know that I can replace any "A" in any other expression with a "B" while preserving its truth. This is possible regardless of my computing the value of either A or B, precisely because of the syntactic rules associated with the operator "=." In LINCOS, however, Freudenthal deliberately eschews this degree of formalization. We have seen, for instance, that he uses "=" in a way that does not imply substitutivity — otherwise his definitions of "good" and "evil" wouldn't have made sense.

But in this case, there is no point in mimicking the formalized aspect of mathematical language by using symbolic operators and three-letter codewords, when a version of plain English — maybe simplified, or interspersed with logical connectives — would have been enough. A malevolent reader will suspect that the only point in having hundreds of pages of stylized cipher is to make them appear a more serious intellectual endeavor than, well, "speaking to aliens" might suggest.

Another odd thing happens as the book progresses. In order to better conceive his quasi-general definitions, as we have seen, Freudenthal must put himself in the alien receivers' minds, just as I must be in my friends' kitchen in order for my "definition" of yeast to make sense. At times Freudenthal seems to have been there too long. On a few occasions, perhaps halfway through the book, he starts post-scripting

explanations of the more abstruse conventions, stating this is "for the convenience of the terrestrial reader." At other times, he himself genuinely seems surprised at the way LINCOS concepts map out — as if he weren't DEFINING them, but somehow unearthing them: after introducing ethical notions he remarks, "This criterion of goodness is not Kant's categorical imperative. It looks more like Shakespeare's, but this is a mere accident."

This gets even more marked as he goes on:

The words written Dec (*fL* decet) and Plt (*fL* placet) mean modalities of decency. I have not succeeded in finding unambiguous translations of these words. Perhaps "it is courteous" (French *courtois*, German *hilflich*) for "Plt," and "it is convenient" (French *il convient*, German *es schickt sich*) for "Dec" will do.

The only way to make sense of this particular paragraph, as of several others, is to conclude that Freudenthal considers LINCOS to be the source language, and scans human cultures to approximate the best translation.

Much of the published *LINCOS* (a second volume, announced in the first, never saw the press) goes on defining new concepts and words pretty much in the ways we have seen. It defines human actions (knowing, perceiving, promising) and the basics of terrestrial life — plants, animals, and the like. It defines thought as "imperceptible speech." It struggles to define light — no common unit of measurement is established, and relativistic mechanics are still too complex to tackle at that point — until a compromise is found between "that which carries information" and "the fastest thing there is." The final chapter introduces all the notions in classical physics (and some relativity on the side) in what amounts to a double-somersault of formalization — arbitrary three-letter glyphs standing for the bewildering notation of such as "Lorentz contraction" or "Laplace transforms." The relative positions of a few planets and stars are described in order to make it possible for a receiver to understand where we are and come visit.

This last part of the book is the most technically challenging for the reader, and probably for Freudenthal too, who laboriously reformulated the basics of physics for a hypothetical alien receiver by now well-versed in LINCOS. And yet Freudenthal himself seems to be less passionate about it. There are fewer digressions; his usual self-congratulatory tone gives way to defensiveness and doubt. At times, it's as if Freudenthal were aware that the enormous intellectual effort he was putting into this endeavor was very likely wasted, amounting at most to an abstract accomplishment in the history of formalized language — a sort of ultra-hard mathematical puzzle, the kind of sterile logical play he scorned as appealing to malevolent readers.

The part about human behavior was undoubtedly less complex from an engineering point of view, but it required creative solutions that had some sort of philosophical impetus in themselves. Freudenthal needed to boil down concepts to their essential elements and make those elements understandable — in the way that "good" and "evil" were understandable in the earlier example — to someone acquainted only with basic mathematical notions.

For instance: in order to define "human life," he comes up with "the arc of time between an individual's first perception and their last." In order to define "perceiving," he decides on "knowing something that nobody told you," since "telling," the primary verb in conversations, had already been introduced. These are definitions in the sense we saw before — useful only insomuch as their recipient is assumed to MAKE AN EFFORT to understand them, looking around their kitchen for whatever that white powder might be.

The book goes on alternating dialogues with Freudenthal's brief explanations of the concepts they are to introduce. The order makes sense from a didactic point of view (the concepts are introduced progressively, each defined through the previous ones), but gives rise to a weirdly hallucinatory table of contents. One can't help but wonder what an alien might think of a civilization that presents itself thus:

3 26 3	Average mental development of humans.
3 26 4	Animals cannot speak.
3 26 5	Hom, human. Bes, animals.
3 26 6 – 3 26 7	Demographic statistics of actual mankind.
3 26 8	Number of animals.
3 27 1	Short history of Fermat's theorem.
3 28 1	n^{e} Hom. n people. And so on. 1^{e} as indefinite article.
3 28 2 – 3 28 3	Ise, (speaking) to each other.
3 28 4	Alt, alternating.
3 29 1 – 3 29 2	Reasons why a person does not answer.
3 29 3	A person does not answer a question because he does not wish to answer. Vul, wishes. The only witness of an event can prevent other prople from knowing anything about the event. Vul.
3 29 4	A long talk. One of the actors complies with all wishes of another actor. Other persons are less obedient. Ccd, allowing.
3 29 5	Relations between Vul and Ccd.
3 29 6	One actor asks another to relay a message to a third actor who cannot be reached by the first directly.
3 29 7	An actor refuses to relay a message, but he agrees when he is asked more politely through another actor.
3 29 8	Understanding (Itg) defined as recognizing what the other want to say.
3 29 9	Somebody knows something if he says it whenever he wants to say it.

CRACKS IN THE FORMALISM

Interestingly enough, it would be impossible for a computer to understand these definitions. This was already true of "good" and "evil": a computer would see NO DIFFERENCE AT ALL between "5+2," "6+1," and "7," since the "=" sign implies absolute substitutivity. The idea that these expressions, *per se* identical, could be different AS ANSWERS implies an array of notions (an asker's intention; an answerer's duty to respect it) that could not be expressed by mathematical notation, nor perhaps by any notation at all.

Something similar happens for "perceiving," which we just saw defined as "knowing something that nobody told you." The problem with this is that "knowing" had been previously defined by Freudenthal as "having being told something in the past"—it was his way of establishing a lasting identity for the speaking characters of his theater. Hence, a computer would boil down the definition of "perceiving" to "having being told something that nobody told you," which would result in a contradiction in terms. Of course, in a way, every extension of our previous knowledge contradicts Freudenthal's definition of knowledge, but it would be impossible to differentiate, in a formal language, between this kind of productive contradiction and the kind that is entailed by 1+1=3. We just KNOW.

An even more extreme example comes in the very first chapter, where Freudenthal has to define the concept for "set." The problem is that set theory can only speak about things that are sets, just as arithmetic can only speak about things which are numbers. So, in order to introduce the notion ⌘, which in his intentions should come to be interpreted as "set," he first lists all the terms the alien receiver already knows, characterizing them as such:

1, 2, 3, etc., are ⌘
A, B, C, etc., are ⌘
✠, ☪, ☯, etc., are ⌘

Freudenthal's problem is that saying something like this would risk making the notion of "set" void (what's the point in a word that applies to everything?). Hence, Freudenthal had to come up with something that is NOT a set, in a language in which EVERYTHING is a set. This is his solution:

< is not a ⌘
+ is not a ⌘
= is not a ⌘

This is a great idea, and also a grammatical mistake. In set-theoretical notation, operator symbols CANNOT be used as subjects: these

expressions would be qualified as "non well-formulated," hence meaningless. They wouldn't compute — and a compiling software would tag them as fatal errors. Of course, someone willing to go beyond the fatal error would probably get what they're hinting at: that it is impossible to speak about something that is not ⌘, because what is not ⌘ is not part of the language. Any mathematician would recognize this as a blueprint for set theory (thus understanding ⌘ as meaning "set"), and any computer would crash.

These slips in the logic of Freudenthal's LINCOS — the cracks in the formalism, the ways it bends and twists — are what I personally find most fascinating about it. They also have, I believe, a legitimate philosophical value. Freudenthal has tried to stretch mathematical logic in order to encompass the varieties of human life. In order to do so, he's had to make some tacit assumptions. Taken together, these assumptions form a map — like a cast or a photographic negative — of the essential requirements an "intelligence" needs to have in order to communicate with us; how it has to be different from a mere calculator, in which ways it has to be like us. In a similar manner, someone could have tried to reconstruct the look and appliances in my friends' kitchen just by listening to my questions: "Is the flour in the compartment under the fridge?," "Are there any bigger glasses?," "Why is Liverpudlian water yellowish?"

So it turns out that ears, mouth, and even fingers aren't enough. First, there are other, weirder, more sci-fi requirements: Freudenthal needs to assume his interlocutors from outer space do not practice telepathy (which would be a way to know things without EITHER being told OR perceiving them) and that they do not have some form of hive-mind, which would render the notion of conversation meaningless. But mostly, there is the need for the other party to WANT to communicate. They must be willing to listen, note, decipher, and puzzle over holes and contradictions. They must be able to ignore their doubts — increasing with every apparent conundrum — that otherwise random cosmic radiation, which for a little while suggested a definite pattern of coherence, is indeed the logopedy of a distant scientist, not merely a projection of their own curiosity and desires.

Ultimately, then, what Freudenthal's project relies on is the fundamental premise that *his hypothetical receivers share his hope that some other life form exists out there, and that it is possible to reach it with set theory and radars, and that it is possible for them to understand us if only we think hard enough about what we tell them, if only they think hard enough about what they hear.*

The hope, that is, that they are not alone.

THE MUSIC TO COME

Let's give Freudenthal the final words:

Of course I do not know whether there is any humanlike being on other celestial bodies, and even if there were millions of planets in the universe inhabited by humanlike beings, it is possible that our nearest neighbor lives at a distance of a million light-years and, as a consequence, beyond our reach.

On the other hand it is not unthinkable that inhabitants of other planets have anticipated this project. A language for cosmic intercourse might already exist. Messages in that language might unceasingly travel through the universe, maybe on wavelengths that are intercepted by the atmosphere of the earth and the ionosphere, but which could be received on a station outside. On such an outpost we could try to switch into the cosmic conversation. It is not easy to state *a priori* how to distinguish messages from purely physical phenomena. But should the case really arise, we shall know how to answer the question: we should try to understand the message.

This, I suppose, intelligent beings in the universe will do if they receive our messages. They will try to decipher them and to translate them into their own language. This task might be easier than that of terrestrial decipherers who have to discover the key of a code. Indeed our objective is just the opposite of that of the sender of coded information. We want to communicate with everybody who might

receive our messages, whereas the sender of a coded message wishes to keep secret the information contained in his message. But in spite of our efforts even intelligent receivers might interpret our messages as physical phenomena, or as music of the spheres.

The beginning of this music would go: **beep**, **beep**, **beep** …

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