

Chapter 2

Problems of Logical Typing: The “One” and the “Unity”

Everything that is numbered depends on the one, and the one depends on nothing.

—Meister Eckhart

Abstract While we can count the oceans (or apples, elephants, money, etc.), we cannot do the same with the water (or sand, wind, temperature, etc.) in a meaningful way. However, we can instead measure the amount of water. It thus appears that we have to do with two, logically distinct types of information, one of which is discontinuous and subject to counting, whereas the other is continuous and subject to measuring. These accordingly correspond to the digital and analog information types, which respectively obey to the “on *or* off” and “more *or* less” logic. The distinction of logical types implies that these two types of information are in a relationship of perceptive exclusion, as evident in logical paradoxes. This problem of logical typing is ubiquitous, as it reflects our inherent incapacity to simultaneously perceive the discontinuity and continuity. The reality of this problem can be clearly traced back in the development of natural sciences. Most clearly however, the universality of the problem of logical typing revealed itself in the efforts to reduce the content of mathematical theories to formal logic.

Keywords One and unity • Logical types • Russel’s paradox • Indeterminacy principle • Complementarity principle • Formal system • Gödel numbers • Genome • Proteome

According to Frege (1884), there is an essential difference between “0” and “1”, and all the other numbers. While no quantity can be ascribed to “0”, the peculiarity of “1” is that it appears in two guises, once as signifier of a *number*, and once as a notion of *unity*. Put another way, in the former case the word “one” is a proper *name*, whereas the same word “one” used as a *notion* unifies all items and/or processes that either have common features, or universal organization. For example, we may say that all five oceans on the Earth represent a *unity* (are *one*) by virtue of being water. The caveat is that while we can count the oceans (or apples, elephants, money, etc.), we cannot do the same with the water (or sand, wind, temperature, etc.) in a meaningful way. However, we can instead measure the amount of water. It thus appears that we have to do with two, logically distinct types of information,

one of which is *discontinuous* and subject to counting, whereas the other is *continuous* and subject to measuring.¹ These accordingly correspond to the digital and analog information types, which respectively obey to the “on *or* off” and “more *or* less” logic (Wilden 1972). Again, as in the case of the chocolate window shown in Fig. 1.1, the distinction of logical types implies that these two types of information are in a relationship of perceptive exclusion, as illustrated in the examples of logical paradoxes below.

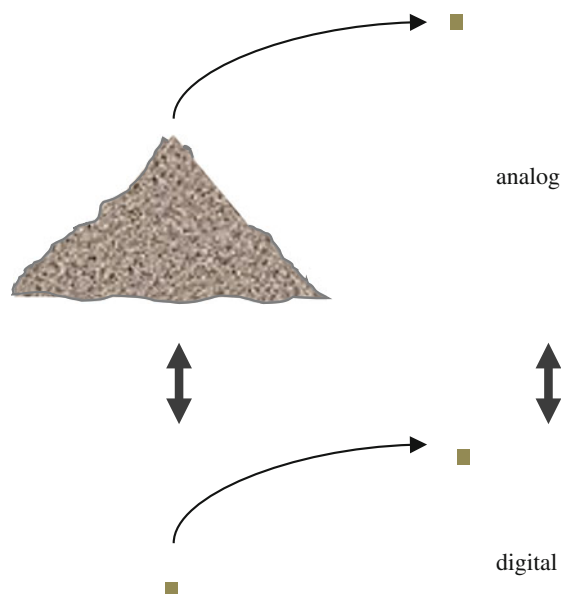
Confusion of Logical Types Beget Paradoxes

One appropriate example of the phenomenon of perceptive exclusion is the Sorites (heap) paradox attributed to Eubulides of Miletus (Fig. 2.1). Eubulides is successively removing individual grains from a heap (of grains), asking each time whether the remainder is still a heap. While at first the answer is affirmative, at some later moment (latest when only one grain is left over) the answer becomes *no*. Note that a *heap* (as a unity of grains) belongs to the analog type of information, which is subject to measuring or weighing. The *grains* could also be counted individually and thus, belong to the digital information type as well. The monotonous process of grain removal masks the smooth transition between the logical types, whereas the request of Eubulides to see the heap and the grains as *one and the same thing* creates a paradox by virtue of perceptive exclusion.

Still better examples of the phenomenon of perceptive exclusion are given by the so-called “self-referential” paradoxes (“self-referential” in this case means a sentence referring to itself). Let us take the paradox of Epimenides: “A Cretan says, that all Cretans are liars”. It follows that if he lies, he says truth, whereas if he says truth, he lies. It is easy to see, that the signifier “Cretan” appears once as a digital parameter (*one* unique “Cretan” making the utterance) and once as an analog parameter (regular member of the *class* of “Cretans” taken as a *unity*). So the sentence creates a paradox by imparting a double meaning to the signifier “Cretan”. This amounts to saying that 1 (taken as number) is equal to 1 (taken as unity) and ultimately that digital = analog. Both of these are obviously false statements equating logically incompatible information types. Thus, the double informational content hidden in the unique signifier “Cretan” causes a paradox by virtue of oscillation of the distinction between the logically incompatible types (Bateson 1979).

This confusion is even more clearly apparent in the simplified version of the Liar paradox: “This sentence is false”. In principle what is said here is that “This sentence is a false sentence”. Now it can be seen that the term “this sentence”,

¹At this point it is irrelevant that at sufficiently high resolution all the matter may appear corpuscular and thus regarded digital. We concern ourselves with the facts of immediate perception and not with abstract concepts of elementary particle physics.

Fig. 2.1 Sorites paradox

which provides digital information (since *this* sentence is indicated uniquely), is equated to the term “false sentence”, which provides analog information (since “false sentence” is a member of the class of all possible sentences). Thus again it is claimed that digital (sentence) = analog (sentence), and as we already know, this equation is false.

Russell’s Paradox

In a more subtle self-referential paradox constructed by Bertrand Russell, the assumption is that there are two kinds of classes of the things: those classes, which do not contain themselves as members and those that do. The former are called normal classes whereas the latter are non-normal. For example, a class of imaginable things itself is imaginable and so is a member of itself, thus being non-normal. Conversely a class of, let’s say, gentleman, is not itself a gentleman and so does not contain itself as a member. Such a class would be a normal class. Now let us assume that N is a class of all normal classes. The question is whether N itself is normal or non-normal. If N is normal, it contains itself because by definition N is a class of all normal classes. However, the classes containing themselves are by definition non-normal. Now, if N is non-normal then it contains itself, but by definition N contains only normal classes. So it appears that if N is normal, then N is non-normal, and if N is non-normal, then N is normal.

Now let us take a look at what happens with logical typing in this paradox:

Take a class N that contains all normal classes

Notice that the signifier N defines a unique class, and so belongs to the digital information type. Now let us pose question:

Is N normal or non-normal?

Notice that the answer is sought by assuming the *membership* of N either in normal or non-normal classes. So we infer:

If N (as unique class) is normal, then N (as member of a class) is non-normal

If N (as unique class) is non-normal, then N (as member of a class) is normal

Note that while N, as a signifier of a unique class, provides digital information, the same signifier N taken as a member of a class (either normal or non-normal) is conveying analog information. Yet, although the signifier N on the right side of the two statements above is actually determined with regard to its analog property (membership in a class—which particular class does not matter) it appears (by definition) under the guise of a digital signifier. Therefore we shall write:

If N (digital) is normal, then N (analog) is non-normal

If N (digital) is non-normal, then N (analog) is normal

None of these sentences appear paradoxical any more because spelling out N once as analog and once as digital signifier abolishes the perceptive exclusion—independent of whether the sentences themselves make any sense or not. Thus again, the paradox is created by perceptive exclusion of two logically incompatible types of information, concealed under the guise of the same signifier, N.

Bohr’s Complementarity Principle

We have two contradictory pictures of reality; separately neither of them fully explains the phenomena of light, but together they do!

Albert Einstein

The problem of logical typing is ubiquitous, as it reflects our inherent capacity to perceive the distinction between *discontinuity* (digital information) and *continuity* (analog information). The reality of this problem can be clearly traced back in the development of natural sciences. For example, in classical mechanics the dynamic laws describe the interactions between discontinuous entities (such as, e.g., heavenly bodies or particles) governed by forces of attraction and repulsion that mainly depend on the distance between the unchanging entities. Thus, all matter is considered as digital. Yet from the very beginning this view had difficulties to account for the phenomena of, for example, the optics, which could be described better by the wave properties of the matter. Indeed, later on, the field theory put the emphasis

on the structure of the space between the interacting entities (essentially, the wave properties of matter) rather than on the entities themselves, as most appropriate means for the description of optical and electrical phenomena. Since the intensity of a field is subject to continuous change, the concept of field embodies the analog property of the matter. As noted by Julian Barbour, the confrontation and reconciliation of the different worlds of particles and waves is one long ongoing saga. "It started with Kepler's optics, continued with the rival optical theories of Newton (particles) and Huygens, Euler, Young, and Fresnel (wave theory), and reached a first peak with Hamilton. It burst into life again in 1905 with Einstein's notion of the light quantum, then went through another remarkable transformation in Schrödinger's 1926 discovery of wave mechanics" (Barbour 1999). In other words, it appears that the emphasis on particular properties of the physical world oscillates according to changes of logical typing, that is, to idiosyncrasy of our observation.

In quantum physics the problem of logical typing can be made conspicuous with the example of Heisenberg's indeterminacy principle, stating that the more precisely the position of a particle is determined, the less precisely its momentum can be known, and vice versa. There are many accounts of this phenomenon but in any case, the unique position of a particle belongs to digital, whereas momentum (which is inversely proportional to the wavelength of the wave of a particle) to analog variables. The wave behavior (momentum) of a particle can be measured experimentally by bombarding it with a beam of photons, which in result become scattered, such that the momentum is determined by the energy of the scattered photons. The notable caveat is that with this measurement it is impossible to have better accuracy than with the momentum of a single photon. In turn, the position of a particle can be determined by deformation of the wave profile of an electromagnetic field in the presence of the particle and again, the accuracy cannot be greater than the wavelength of the given field. In short, the nature of the measuring device appears determinative for the observation. Observing in one way we obtain the probabilities for particle positions, whereas observing another way we obtain the probabilities for their momenta. This relationship embodies the uncertainty principle, because these two properties of a particle could not be measured simultaneously and with high accuracy (Anastopoulos 2008).

Put another way, the uncertainty principle appears to be an observational fact. Whereas there is no difficulty observing both the particle and wave properties of, for example, an electron separately, the problem arises when we are forced to conceive these properties simultaneously as *one and the same* thing. And even though we might invent new increasingly superb artifices to accurately measure both these (wave and particle) properties, by the virtue of perceptive exclusion we can nevertheless grasp these logically distinct types of information *only* in separation. This duality of perception motivated Bohr's ingenious notion of *complementarity*, purporting an existence of two mutually exclusive (essentially, analog, and digital) perspectives of the same phenomenon. These two mutually exclusive perspectives complement each other such that in parallel they exploit the full content of the phenomenon under the scope. Bohr argued, for example, that the measurement of the temperature of a system is incompatible with the knowledge of precise

coordinates and velocity of the individual molecules, because temperature is defined as an average of these velocities taken together (Heisenberg 1969). To put it in our terms, the temperature is an analog component, whereas individual molecules represent digital components of the very same system, thus providing complementary information.

There is no question that our empirical concepts of matter necessarily depend on the technical instrumentation and resolution capacity of the experimental setup, and sure enough our interpretations of natural phenomena will change with technological progress, providing novel and increasingly powerful tools for experimentation. However, it must be obvious from all that has been said so far that the mysterious property of the matter to appear under different guises made so explicit by ingenious discoverers of the uncertainty principle is a constitutional and fundamental property of our perception, grasping the logically distinct types of information only in separation.

Application of the Axiomatic Method to the Real World

Real is only the measurable.

Max Planck

Most clearly, the universality of the problem of logical typing revealed itself in strenuous efforts to reduce the content of mathematical theories to formal logic. This is perhaps because in contrast to experimental science, mathematics can operate using the “language” of the axiomatic method. For example, the entirety of elementary geometry can be founded on a limited number of *a priori* axioms that are accepted without proof, and serve as basic propositions from which numerous theorems can be derived. While the axioms of elementary geometry explicitly deal with the space, in the 19th century it was conjectured that in principle, any branch of mathematics could be founded on a limited set of axioms sufficient to deduce all the propositions in the given field. Such a system could be assumed consistent if it could be proved that it does not produce contradictory propositions (Nagel and Newman 2001). And although the final proof was lacking, it was expected (perhaps in keeping with the spirit of the time) that in principle, this was an achievable task. At the turn of the nineteenth century, David Hilbert made a remarkable attempt to provide an absolute proof of consistency by means of complete formalization of the axiomatic system. His idea was to drain the expressions of such a *formalized system* (FS) of all meaning and to regard them as empty signs. Put another way, the behavior of the (empty) signs in a formalized axiomatic system would be literally “exempted” from any dependence on their meaning, while still retaining the logical structure.

This approach can be explained by referring to the example of natural language, the syntactic and semantic properties of which provide logically different types of information. Syntax determines the structure of the rules of language and thus, the

way in which the words are assembled in sentences, but it does not determine the meaning of the words. This latter is the task of the semantics. However, although the syntax itself is meaningless, it is nevertheless possible to describe the *different configurations* of the symbols and their relationships in a meaningful way. In the case of Hilbert's FS these would be the different configurations of the *strings of signs* in logical propositions. Unfortunately, this approach posed a methodological problem, because producing meaningful statements *about* the FS required a *metalinguage*. Furthermore, this latter language, to be able to talk *about* FS, had to be different from that of the FS. Thus, in order to provide his proof Hilbert had to construct a *metamathematical* language. In the following passage I shall refer to the brilliant book of Nagel and Newman (2001), which is dedicated to this subject, and shall illustrate the nature of a metamathematical statement by using an arithmetical formula:

$$1 + 1 = 2$$

This formula consists of arithmetical signs and shows their relationship. Now, if we write:

' $1 + 1 = 2$ ' is an arithmetical formula

we will make a statement *about* the formula, which itself does not express an arithmetical fact and so belongs to *meta-mathematics*, because it confers a *meaning* to a certain string of arithmetical signs. In other words, the metamathematical statements contain the names and definitions used as *unique signifiers* of the formulas, but not the formulas themselves. Note that again, in the distinction of the arithmetical meaning of the formula ' $1 + 1 = 2$ ', and the metamathematical statement *about* it, we have a case of perceptive exclusion. If we use Bohr's metaphor this implies that these two languages to be consistent, have to be complementary in a similar way as are, for example, the temperature and the velocity of molecules in a physical system. Accomplishing this task is in no way trivial, and while Hilbert started the quest, the clarification of this question had to wait for about half a century for another ingenious mathematician—Kurt Gödel.

Gödel's Formal System

Two propositions are opposed to each other, when there is no meaningful proposition that affirms them both.

L. Wittgenstein

Gödel elaborated on *Principia Mathematica*, a fundamental work carried out in the beginning of the twentieth century by Russell and Whitehead, who by using a comprehensive system of notation managed to convey mathematical meaning to the FS.

Put another way, they succeeded in matching the mathematical truths to logical relationships of the strings of empty signs in the FS. By doing so, they hoped to reduce (and thus facilitate) the proof of the consistency of any large mathematical system (in particular the *number theory*—a branch of pure mathematics operating with integers) to the proof of the consistency of formal logic itself.

Gödel used the accomplishments of *Principia Mathematica* to fine-tune his calculus such that the logical “syntax” of the FS could be systematically mapped to meaning (Nagel and Newman 2001). Notably, the *meaning* in this case is the arithmetical truth mapped to the logical proposition. The peculiarity of this mapping can be illustrated with the example of a particular musical rhythm in which numerous melodies can be “mapped”, because the rhythm is not determinative of the melody. Now let us consider a natural rhythm, say for example, the wing beat of a flock of birds calling each other. Assuming that the birds have a particular (physiological) connection between the rhythm of the wing beat and calling frequency, the “melody” of calling would fit the wing beat best, giving it naturally a meaning. Note that by itself neither the calling belongs to the wing beat, nor the wing beat to calling (in fact, they both belong to the bird).

Gödel’s logical system thus shows a similarity to natural language, in that it consists of two types of information—the syntax (formal logic) and the semantics (mathematical meaning). Furthermore, since the syntax and semantics of the FS matched each other precisely, meaningful statements could be produced. Ideally, the system would be expected to be both *consistent* and *complete*. Recall that the consistency of FS is provided if it is impossible to generate both a particular statement and its negation from its axioms. The demand of completeness of the FS means that its axioms should be able to produce all the logical truths that are expressible in the system.

Gödel’s Mapping

However to provide a proof of consistency of his system, Gödel, as Hilbert before, faced the necessity of elaborating a metamathematical language capable of making definite statements about the FS. In particular, he aimed at constructing meaningful metamathematical statements that could be mirrored in the logical expressions (strings of signs) of the FS. For this purpose Gödel employed an ingenious mapping procedure by assigning a *unique* number to each elementary sign, each formula (i.e., sequence of signs) and each proof (i.e., sequence of formulas) in the FS. These numbers, representing large integers, are essentially tags constructed in accordance with particular rules (which should not detain us here), enabling the translation of any sign, formula, or theorem of the FS into a specific (Gödel) number. Thus, on the one hand, this “arithmetization” of complex logical expressions of the FS simplified their handling, and on the other, the expressions could be readily retrieved (essentially by prime factorisation of large integers) from the Gödel numbers—simply because the method of their construction was known (Nagel and Newman 2001).

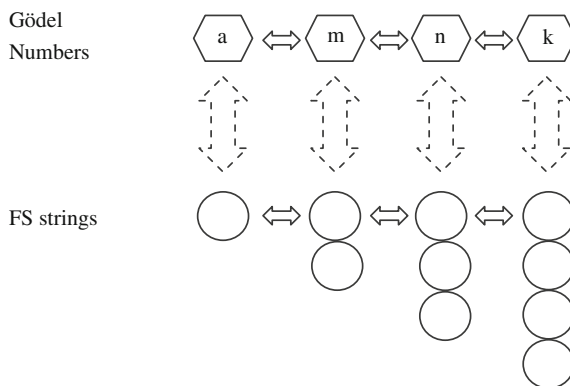


Fig. 2.2 Gödel's mapping. The symbols and strings of the FS are converted in Gödel numbers according to particular rules (*vertical double arrows*). The strings of the FS (*connected circles*) as well as the Gödel numbers are related to each other by transformation rules and arithmetical relationships, respectively (*horizontal double arrows*). The relationships between the Gödel numbers can be mirrored in the relationships between the FS strings

Importantly, since in this way unique (Gödel) numbers were associated with variable signs and expressions of the FS, this offered the opportunity to construct metamathematical statements *about* the expressions of the FS using the *arithmetical relations* between their corresponding (Gödel) numbers. This was achieved by mapping of metamathematical statements (i.e., the arithmetical relationships between the Gödel numbers) on the relationships between the formulas and theorems (typographical properties of the strings of symbols) in the FS (Fig. 2.2). Gödel thus succeeded in constructing meaningful metamathematical statements about FS that could be accurately mirrored within the strings of the FS, showing that by using metamathematical language it is possible to teach the FS to speak about itself! However, he also found that his FS produced contradictory statements—a proposition and its negation, and so by definition was inconsistent.

In addition, Gödel managed to construct metamathematically correct statements that could be mirrored in the strings of the FS, but could not be derived from the axioms of the FS themselves. Gödel's inference was that the FS is incomplete. Moreover, he showed that this incompleteness is *essential*, because the FS could not be cured by any extensions—new formulas revealing the same defect of the “extended” FS could be constructed ad infinitum. Thus, it turned out that the formal system not only did not, but it essentially could not provide the anticipated result. Yet, Gödel's proof was a truly remarkable achievement of logical thinking—he decidedly demonstrated the inherent limitations of the axiomatic method in its ability to grasp the real world.

Analogy Between the Formal System and the Genetic System

Two descriptions are better than one.

Gregory Bateson

Hofstadter (1979) observed that Gödel’s logical construction shows a “profound kinship” to the logical organization of the genetic system. A brief outline of this similarity is important in order to understand why Gödel’s mapping failed, especially in the light of the recent insights into the dual coding properties of DNA. While properties of DNA as the essential carrier of genetic information will be addressed in more detail in Chap. 4, it suffices to say here that in principle, according to the current conjecture (Muskhelishvili and Travers 2013), the variable mechanical stiffness and the corresponding three-dimensional configuration of the chromosomal DNA polymer represents the regulatory context, or the “syntax” of the genetic system. In turn, the unique genes expressing specific proteins involved in distinct cellular functions provide digital information and belong to the “semantic” component of the system that can be mapped on the DNA genome. The DNA molecule is thus a carrier of two types of information, akin to Gödel’s logical system, in which arithmetical relationships between the Gödel numbers are mapped to the “typographical” strings of the formal expressions. Furthermore, the Gödel numbers and the formulas in the FS are related by arithmetical relationships and transformation rules, respectively. Similarly, the chromosomal genes are connected by means of the transcriptional regulatory network, whereas the expressed proteins are connected by means of the protein–protein interaction network. In both cases the mapping obtains a meaning by relation—to arithmetical truths in the former, and to true genetic functions in the latter.

Moreover, Hofstadter emphasized the analogy between the translation of the Gödel number(s) into the particular expression(s) for which it stands, and translation of the particular string of DNA sequence into the amino acid sequence of a protein. Indeed, the individual proteins, by analogy to Gödel numbers, conceal the method of their production from the DNA by an identical set of rules. It is now possible to see that mapping of metamathematics (arithmetical relationships between the Gödel numbers) onto the relationships between the logical expressions of the FS is analogous to the process of mapping the interactions between the proteins on functional communications between their cognate genes (Fig. 2.3).

That is all very well. However, despite this striking similarity of logical organization, we know that Gödel’s FS is inconsistent and essentially incomplete, whereas we cannot readily say this about the genetic system of a self-reproducing cell. It can be rather said that in contrast to Gödel’s FS, the information contained in the genetic system of a simple cell is consistent, because it always reproduces a cell and not something else, and it is also complete, as at any instant all the possible

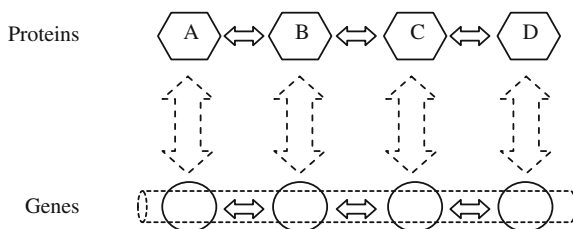


Fig. 2.3 The information stored in the chromosomal genes (the chromosome is indicated by *dashed tube* and the genes by *circles*) is converted into the proteins (A, B, C, D) by processes of transcription and translation, whereas the proteins in turn affect the gene expression (*vertical double arrows*). The genes are related to each other by rules of transcriptional regulation, and proteins are related by protein–protein interactions in macromolecular complexes (*horizontal double arrows*)

enzymatic reactions and macromolecular interactions of a given cell are “derivable” from the particular organization of its genome.

Differences of Logical Typing in the Formal and Genetic Systems

The essential difference between Gödel’s FS and the genetic system becomes obvious if we analyze them in terms of logical typing. The “syntax” of the genetic system—three-dimensional configuration of the continuous DNA polymer—provides analog information regulating genetic activity and specifying the pattern of gene expression (Muskhelishvili et al. 2010; Travers et al. 2012). The expression pattern itself represents digital information because it comprises unique messenger RNA sequences, which are translated into proteins of unique three-dimensional structure.² However, a single messenger RNA can act as a template for multiple rounds of translation, such that the proteins are produced in a wide range of concentrations.

Notably, the entirety of all produced protein in the cell represents the cellular *proteome*, which as a whole is righteously seen as a carrier of analog information (von Neumann 1958), notwithstanding its substantial compositional variation. The latter is due to the homeostatic regulatory mechanisms ensuring that in the course of environmental changes the overall composition of the cellular proteome remains optimally balanced according to the given physiological state.

This means that the supply of each individual protein species in the proteome, including the abundant DNA binding architectural proteins that shape the

²For the sake of simplicity the genetic effects of the noncoding RNAs are omitted, since this does not change the organizational logic of the genetic system.

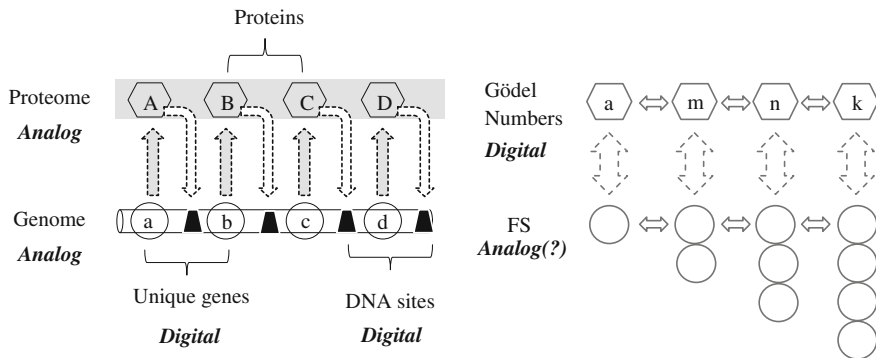


Fig. 2.4 Differences of logical typing in the genetic system (*left panel*) and in Gödel's FS (*right panel*). The proteome (gray rectangle) and the genome (horizontal tube) represent matching continuities, whereas the Gödel numbers and the FS strings do not. Specific DNA binding sites are indicated by the trapezoid areas

chromosomes, is instantly adjusted to the global cellular function. The changing composition of the DNA architectural protein components of the proteome directly modulates the chromosome configuration and thus mediates the transmission of information about the cellular physiological state to the genome. The coordinated impact of DNA architectural proteins on the three-dimensional structure, and hence the genetic activity of the chromosome, in turn feeds back into the proteome (Fig. 2.4, left panel).

This means that the organization of the genetic system is circular (Muskheishvili et al. 2010). The circularity is achieved by perpetual conversion of analog information (chromosome configuration dynamics) into digital information (gene expression patterns), and back into analog information (the proteome). Yet also the proteome generates digital information via its DNA binding components interacting with specific DNA sites, which in turn determine the chromosomal configuration dynamics and thus close the circle. The crucial point is that the cellular proteome represents a compositionally coordinated variable *unity* corresponding to the genetic activity of the whole chromosome, whereby it is the “coalescence” of the two analog information types (chromosome configuration and proteome composition) that coordinates the global genetic activity. The digital components of the genetic system (i.e., specific pattern of expressed genes mirroring the chromosome configuration, and the specific pattern of occupied DNA binding sites mirroring the proteome composition) mediate the coordination of information flow between the two analog components, forming one indivisible unity. In short, both the consistency and completeness of the system, or better to say, its self-referentiality, is achieved by a perpetual interconversion of logically distinct information types (the explicit details of this conversion mechanism will be addressed in Chap. 4).

Logical typing in the FS is quite different (Fig. 2.4, right panel). For convenience, let us assume that the meaningless strings of the FS related by a set of

transformation rules constitute a continuum providing analog information. Gödel translated these strings into unique (Gödel) numbers, which by definition provide digital information. Thus the situation appears analogous to the relationship between the global chromosomal configuration and the corresponding gene expression pattern. However, unlike the unique proteins, the unique Gödel numbers are not generated in different concentrations, such that there is no analog dimension to them. Furthermore, even though we assume that the purely logical structure of the FS represents some sort of a continuum or an operationally closed system (which, I guess, is a wrong assumption), the mathematical meanings conferred by Gödel to the strings of logical propositions in the FS represent discrete mathematical truths. Thus in fact, in Gödel's logical system, the digital information (unique Gödel number) is mapped onto digital information (explicit arithmetical meaning of a particular string of the FS), whereas in the genetic system the inter-conversion of digital information (that is, conversion of the effects of unique DNA binding sites into a specific pattern of gene expression) is coordinated by two coupled analog components—the proteome composition and the chromosome configuration. This means that in the “mapping” process of the genetic system everything is interdependent and obtains its true meaning only in the context of the coordinated whole. In contrast, whereas the arithmetical relationships between the Gödel numbers (that is, the statements of metamathematical language) can be mirrored in the FS, the mapping of each particular metamathematical statement is independent from that of the others. Since it appears that there is no limit to the extensions of the FS, and since most likely there can be no finite *universal* Gödel number (which by analogy to *proteome* could be called a *Gödelome*) to which *all* the other Gödel numbers could be equally related and thus coordinated as parts of a whole, the system will be prone to ambivalent formulas and mutually exclusive statements.

In other words the Gödel system, in contrast to the genetic system, lacks *unity*, which as we have argued above, is a prerequisite for engendering distinction and directional choice. Therefore in real world a creature having Gödel's FS as its brain would not survive. This also implies that any abstract logical system aided by the creative power of reason falls short of mirroring the organizational complexity of information stored in just a millimeter long DNA tape representing the “brain” of a simple unicellular organism.

References

- Anastopoulos C (2008) Particle or Wave. The Evolution of the Concept of Matter in Modern Physics. Princeton University Press
- Barbour A (1999) The end of time. Oxford University Press, Oxford
- Bateson G (1979) Mind and nature. A necessary unity. Hampton Press, Hampton
- Frege G (1884) Die Grundlagen der Arithmetik. Philipp Reclam jun. GmbH & Co, KG, Stuttgart
- Heisenberg W (1969) Der Teil und das Ganze. R. Piper & Co. Verlag, München
- Hofstadter DR (1979) Gödel, Escher, Bach: an eternal golden braid. Penguin Books, New York

- Muskhelishvili G, Sobetzko P, Geertz M, Berger M (2010) General organisational principles of the transcriptional regulation system: a tree or a circle? *Mol BioSyst* 6:662–676
- Muskhelishvili G, Travers A (2013) Integration of syntactic and semantic properties of the DNA code reveals chromosomes as thermodynamic machines converting energy into information. *Cell Mol Life Sci* 70:4555–4567
- Nagel E, Newman JR (2001) Gödel’s proof. New York University Press
- Travers AA, Muskhelishvili G, Thompson JMT (2012) DNA information: from digital code to analogue structure. *Philos Trans Math Phys Eng Sci* 370(1969):2960–2986
- von Neumann J (1958) The computer and the brain. Yale University Press, New Haven
- Wilden A (1972) System and structure. Essays in communication and exchange. Travistock Publications Ltd., London

DNA Information: Laws of Perception

Muskhelishvili, G.

2015, VIII, 92 p. 24 illus., 10 illus. in color., Softcover

ISBN: 978-3-319-17424-2