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revue d'étude du dialogue texte-image

N° 7 Illustration et discours scientifiques. Une perspective historique

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Logical Empiricism and Knowledge Visualisation: Isotype as a Universal Language for Social Statistics

Starting from the 1920s, the Museum of Society and Economy in Vienna produced an innovative technique in the graphic representation of social statistics. The authors of this method (Isotype), Marie and Otto Neurath, aimed at creating an accessible medium for a general audience, including illiterates and factory workers, in order to popularize the statistical treatment of social matters. They developed Isotype for the production of exhibition material and worked for its widespread use in teaching and publishing. This article analyses Isotype's philosophical background in the Vienna Circle's logical empiricism. The graphic language of Isotype will be examined in the framework of the international auxiliary language movement, of which two examples (Basic English and Interglossa) will be introduced, showing their common philosophical influences and structural traits.

Otto Neurath and the Vienna Circle

Logical empiricism emerged as an anti-metaphysical movement in the interwar period. Adopted by the Vienna Circle as an up-to-date version of the Enlightenment, the movement constructed its intellectual identity around a strong opposition between metaphysics and the scientific worldview. Most logical empiricists were freethinkers, social-democrats or socialists, although political analysis of metaphysics was more apparent in the left wing of the circle (and arguably a somewhat peripheral concern for logical empiricists), carried out chiefly by Rudolf Carnap, Hans Hahn, Otto Neurath, Philipp Frank and Edgar Zilsel. These members of the circle saw in metaphysics an irrational form of expression rooted in conservatism and attachment to the past social order. The logical empiricist program may be regarded as a polemical response to metaphysical trends associated with the right-wing policy of its time[1]. For logical empiricists, metaphysics excludes rational discussion on the basis of a neutral common ground due to its idiosyncratic and uncritical language. As opposed to this, the scientific worldview identifies itself as transformative and progressive, if not revolutionary. Its intercultural validity comes from its empirical basis, which constitutes a universal common ground for communication and decision-making. Inclusivity and the democratic accessibility of empirical discourse were the reasons why the Vienna Circle

[1] "The increase of metaphysical and theologizing leanings which shows itself today in many associations and sects, in books and journals, in talks and university lectures, seems to be based on the fierce social and economic struggles of the present: one group of combatants, holding fast to traditional social forms, cultivates traditional attitudes of metaphysics and theology whose content has long since been superseded; while the other group, especially in central Europe, faces modern times, rejects these views and takes its stand on the ground of empirical science. This development is connected with that of modern process of production, which is becoming ever more rigorously mechanised and leaves ever less room for metaphysical ideas. It is also connected with the disappointment of broad masses of people with the attitude of those who preach traditional metaphysical and theological doctrines. So it is that in many countries the masses now reject these doctrines much more consciously than ever before, and along with their socialist attitudes tend to lean towards a down-to-earth empiricist view" (Hahn & Neurath & Carnap, 1929, 317).

represented empiricism in philosophy, opposing sectarian philosophical stances and privileging informed mutual cooperation on a scientific basis.

Verifiability is the logical empiricist criterion of signification. Logical empiricists emphasized a demarcation between meaningful and meaningless statements in order to identify and discredit metaphysical statements. The empiricist criterion of meaning posits that a legitimate proposition should be reducible to its empirically verifiable truth-conditions. This excludes statements about God and other supernatural entities as well as any speculation which falls outside the domain of public experience (e.g. introspective statements relating mystical experience). Metaphysical, religious and moral terms are rejected because of the local limits of their validity. Since they are confined to a specific culture, these are often difficult, sometimes impossible, to translate, as opposed to scientific argument, which is, for Neurath, common to all nations[2].

From the verificationist theory of meaning follows the main thesis of Neurath's physicalism: the translatability of scientific statements into statements of daily experience, following the reducibility of the latter to "protocol-statements" (Neurath 1932/33) relating basic sense-observations. This assumption forms the basis of the physicalist pedagogy, in the framework of which Isotype, the graphic language for social statistics, was designed. As the language of intersubjective experience, the "physicalist jargon" includes not only scientific terms in a strict sense, but also more imprecise concepts of everyday language referring to physical objects that we talk about in ordinary daily life, like houses, trees, mountains or stars. Neurath's pedagogy is centred on these concepts (*Ballungen*, Neurath 1932/33), low in precision but high in stability, as a bridge between the language of everyday experience and the highly precise and sophisticated language of science. Indeed, as the expression of collective experience, such expressions are not only useful for verification of

[2] "What we call science may be regarded as the typical species of arguing which human beings of all nations, rich and poor, have in common. Discussions of sun, moon, stars, anatomy, geography, pleasure and pain may be carried out in any civilisation; theology and legal terms, on the other hand, are mainly local" (Neurath 1945, p. 229).

scientific theories: they also have a crucial role in ensuring continuity across theoretical changes, as well as in interdisciplinary communication and science teaching. The reason for this privileged status of *Ballungen* is their relative stability across succeeding generations and different civilizations.

Physicalist pedagogy starts from the learner's own realm of experience: time will be treated in terms of visible indications on a clock, heat in terms of data from thermometers, life in terms of behaviour of organisms. This technique is called by Neurath "humanization," as opposed to popularization which consists in paraphrasing scientific theories in simpler terms, without relating them to familiar experience. A gradual translation from the simplest concepts into more complicated ones has a very important psychological advantage: it keeps the uninitiated student from possible discouragement, since most learners with lower instructional backgrounds are intimidated when confronted with abstract language full of technical terms. Humanization following the principles of physicalism overcomes the inferiority complex which often inhibits people's learning capacities in adult education. That's why Neurath recommends avoiding general discussions about abstract entities at the start, preferring explanations in terms of observable behaviour instead.

Neurath's own teaching experience took place mostly in adult education. His audience was a general public, usually workers with little educational background and limited literacy. This restriction brought him to consider the use of alternatives to verbal language in education. Neurath observes that linguistic divisions do not only operate on a transnational level. Not only do different nations speak different languages, but even inside one language community intellectual jargon often remains inaccessible to lower classes. Furthermore, people attending evening classes are usually tired after a hard day working in a factory or office, and this situation diminishes their ability to focus on verbal explanations and fully benefit from them. Compared to spoken or written language, well-designed pictures have a more striking effect on the viewers. Even though their expressive power is limited compared

with words, they are easier to remember and more pleasant to observe and discuss. Neurath claims that pictures make a relatively egalitarian aid for instruction, since people tend to react to them in similar ways, and different levels of literacy or familiarity with sophisticated language do not have a divisive effect on the viewers[3]. This need for a graphic medium tailored for universal communication, especially in the framework of mass education, motivated Neurath's work in visual pedagogy.

Visualisation through Isotype

The Isotype method was designed by Otto Neurath's team in the Museum of Society and Economy. The museum, founded in 1925 with the help of the socialist municipality of Red Vienna, housed public exhibitions that aimed to instruct citizens about social and economic facts while popularizing quantitative methods in social sciences. Charts displayed in these exhibitions or in the publications ordered by the museum represented social statistics using the "Vienna Method of Picture Statistics" that later came to be known as Isotype (**I**nternational **S**ystem **o**f **T**ypographic **P**icture **E**ducation). Subjects included population statistics regarding age, sex, activity, habitation, demographic evolution, urbanism and accommodation. Some were more argumentative and aimed to show relations between income and health, or between income and longevity. Some charts expressed instructions about health and safety at work. Many of them showed statistical proofs of the improvements of the socialist municipality in housing and healthcare services, while others dealt with more general subjects like the national and global economy, the history of the workers' movement and trade-unionism. In the 1930s the museum collaborated with the Institute of Statistics in the Soviet Union (Isostat), where the Vienna method of picture statistics was officially

[3] "Just through its neutrality, and its independence of separate languages, visual education is superior to word education. *Words divide, pictures unite*" (Neurath, 1925, p. 217).

adopted for public instruction about statistics. Otto and Marie (Reidemeister) Neurath migrated to the Netherlands in 1934, and moved to the United Kingdom later, where they copyrighted the Vienna method of picture statistics and founded the Isotype Institute.

Isotype's method of representing quantities consists in the serialization of pictorial units: a definite quantity is associated with each pictogram, which is then multiplied to fit the amount in question. This method works like a mapping scale, and has the double advantage of maximizing countability and explicitness. To show its superiority to established infographical methods, Neurath gives 2 examples of a "bad system." **Figure 1** is a highly abstract chart which contains technical elements like coordinates, points and lines. Although useful in a professional context for its exactness, this method is not adapted to mass education because of its excessive technicity, making it beyond the grasp of people outside the professional community of scientists. **Figure 2** shows the number of people getting married in Germany from 1910 to 1926. It is meant for a general audience and the use of a pictogram aims to make the subject of the chart visual. But representing varying numbers with size variations in the pictogram limits the expressive power of the chart, since the visual comparison of the size of pictograms has a very restricted instructive value.

Figure 3 compares different methods of visualizing quantities. The first row shows 2 squares. By looking at this chart one can see that 2 is greater than 1 and only guess that B is greater than A, without being able to quantify these differences. The second row shows an improved method of dividing each figure in equal parts, so that now one can precisely say that A is six tenths of 1 and that B is four tenths of 2. Nevertheless, we can only guess that 2 is greater than 1. The third method corrects this by tracing the 2 figures from the same units, so that now one can also numerically compare 1 to 2 and A to B. Isotype opts for this method and uses pictograms as composition units. The additional advantage is the intuitive recognisability of the subject of the chart,

pictograms being conceived as stereotypical representations of general concepts.

The unemployment chart (**fig. 4**) compares the unemployment rates in the United Kingdom, France and the German Empire from 1913 to 1928 by using one single graphic unit, the pictogram of an unemployed worker. Each pictogram represents 250,000 unemployed people, the alignment of which produces a visual effect mimicking a queue in front of the unemployment office. Pictograms are simplified, stereotypical forms suggesting generality at the expense of individual variations. This stylistic choice is in conformity with Neurath's advocacy of quantitative methods in social sciences against individualistic tendencies. It has also a greater communicative effectiveness due to its use of minimalist symbols (mostly drawn as silhouettes, these are easier to identify and remember across a variety of diagrams). Naturalistic elements like perspective, lighting and irrelevant details are avoided in the drawing of pictograms in order to evoke the generality of the represented situation and focus clearly on the main argument. This functionalist aesthetics is opposed to decorative illustration. Each of the graphic elements in Isotype charts has a rational function, including colours. Neurath insists on the linguistic value of the charts as part of the argument and states that they are not mere side illustrations.

To fulfil its intended linguistic function, Isotype imitates the compositionality of verbal language. From a basic set of visual vocabulary which forms the picture alphabet, complex symbols are created by consistent combination (the combination of the signs for worker and coal results in a new pictogram for coal-worker). The compositionality allows a great expressive power while staying within the limits of a small vocabulary, which facilitates understanding the system. Standardization is a key element in the rational quality of Isotype and has a major function in increasing familiarity with the visual language throughout different contexts: that's why the same basic elements and visual syntax will be consistently used in all charts. In the

classification of products according to their economic use, a full black figure represents goods produced and consumed locally, a full black figure on a ship, exported goods, and a white figure on a ship, imported ones (**fig. 5**). The addition of a flame means destroyed product, and a sign enclosed in a box, product in stock. The chart for the coffee trade in 1933 (**fig. 6**) uses various forms of the pictogram for coffee in order to portray the world market for coffee. These conventions are respected for each product, although context can justify some deviations: for example, a flame will mean consumption when combined with a combustible good like coal.

Isotype succeeds in representing complex information with minimal graphism, thanks to its virtues of reductivism and consistency. In the chart of migrations from 1920 to 1927 (**fig. 7**), the standard pictogram for man is drawn in profile, with the figure carrying luggage and in motion, to represent migrating masses. Series of icons moving towards the country indicated on the left side represent immigrants entering that country, and series moving to the opposite side represent emigrants from that country. The graphic element under the feet of the migrants indicates the mode of transportation: a straight line for land and a wave for sea. Migration numbers, destinations and means of transportation are thus clearly indicated with consistent variations of the basic pictogram. The chart of automobiles produced in 1929 (**fig. 8**) compares the automobile production in America and Europe. The line behind the American workers represents mechanized production. As usual, several types of information are present in the chart concerning numbers of workers and products, and it is possible to compare the productivity of the two methods of fabrication. For the chart of home and factory weavers in England from 1820 to 1880 (**fig. 9**), the same pictogram for worker is used, the factory weavers indicated by the colour red, a traditional symbol for industry, and the symbol of a factory around them. The chart contains information about quantities of production and the number of home-weavers and factory-weavers over a period of 60 years, and it allows multiple comparisons.

Another guiding principle of Isotype is conservatism, which aims to increase its intuitive effectiveness by integrating familiar elements. Current graphic conventions like direction of reading and disposition of the countries on a map are respected, as well the current semiology: a toothed wheel stands for industry; a sickle, agriculture; a hammer, handicraft; a scale, trade. Colour use conforms to established colour symbolism, like green for agriculture or youth, grey for indeterminate or unorganized, red for socialism, trade-unions or workers.

Contacts with International Auxiliary Languages

Neurath's search for an intercultural medium for universal communication fits into the framework of the international auxiliary language (IAL) movement of his time. What he did for information design was also the subject of many constructive projects by interlinguists, who attempted to solve the problem of international communication in a globalizing world. Inspired mainly by humanist ideals of pacifism and equality, those linguistic projects privileged the use of common elements, at the expense of specific local expressions, simplicity in word construction, as well as minimalism and regularity in grammar to ensure ease of learning. The most emblematic and arguably the most successful of IALs to date, Esperanto has a major place amongst Neurath's inspirations for a universal visual language (which he referred to as a "pictorial Esperanto"). Although not conceived as an independent linguistic medium like these IALs, Isotype shares their motivation and general principles. An examination of two IALs related to Neurath's own work (Basic English and Interglossa) can show the affinities of his empiricist philosophy of language with the IAL movement.

Basic English

Despite having been conceived for a different purpose, Charles K. Ogden's Basic English uses a pattern similar to Neurath's. Basic is a condensed

version of Standard English with a reduced vocabulary of 850 words. This reductive mechanism of translating into Basic English by decomposition to chosen basic concepts reflects Ogden's empiricist ideal of language as a transparent medium expressing the empirical origin of abstract concepts[4]. Ogden calls this process "vertical translation," i.e. translation inside the same language into a smaller set of words. It is characterized by the elimination of verbs, replaced by an operator corresponding to a basic operational concept, possibly combined with a directive corresponding to a basic direction-word. There are 11 operators (*do, make, take, give, put, have, keep, let, make, be, seem*) and 20 directives (*through, from, to, over, under, by, at, against, up, down, about, among, across, on, off, after, before, between, within, out*) in total, with which Basic renders almost all the verbs of standard English (*to disembark* will be translated as *to get off a ship*; *to insert* as *to put in*; *to pass* as *to go by*; *to climb* as *to go over*; *to break a rule* as *to go against a rule*). Finally, irregularities in matters of spelling or conjugation are minimized in order to avoid unnecessary complications for beginners.

The reductive system of Basic English develops from Ogden's emphasis on empirical reduction for clarity and improved communication. Strongly influenced by the empiricist tradition, Ogden's philosophy of language plays a similar role to Neurath's physicalism in the conception of Isotype. As an inheritor of British empiricism, Ogden stressed the physicalist origins of abstract concepts and stated that abstraction develops metaphorically from concrete expressions relating to physical bodies, along the same vein as in Locke and Bentham. Another influence for Basic English was Bridgman's operationalism, according to which Ogden defined verbs primarily as physical operations in space. Hence the critical function of Basic English for native English speakers: vertical translation becomes reduction to empirical origins,

[4] "For the modern scientist and technologist, no less than Bergson or the man in the street, language is first and foremost an apparatus for dealing with things in space. What is 'there' to be talked about is primarily a nexus of individual bodies; and only through metaphor do we seem to be talking about other sorts of entities. All such metaphorical and fictional jargon is capable of translation, and for technological purposes must be translated, into something less deceptive" (Ogden 1936, pp. 192-3).

which results in the deconstruction of linguistic fictions[5]. The anti-metaphysical effect of eliminating misleading expressions is also an important motivation for Neurath in privileging visualization over verbal education[6]. The limits of the pictorial medium impose an empirical reduction, eliminating beforehand possible metaphysical developments. Value judgements, private experience, supernatural or religious beliefs cannot be expressed in a visual language - which makes visual language neutral compared to verbal language. By excluding such idiomatic expressions that divide people and hamper communication, visual language becomes a democratic medium for argumentation and education.

Neurath was aware of his common concerns with Ogden and praised Basic English as a good example of terminological reduction, to which he was himself inclined[7]. Some publications of the Isotype Institute were written in Basic English. Neurath also collaborated with Ogden's work by preparing *Basic by Isotype*, a visual glossary for Basic. In this book Isotype was used for teaching Basic words. Consistency in the choice of symbols, minimalist pictograms and their restricted number help create a clear visualization of abstract words. Contrast in repeated examples becomes more visible in a consistent picture system.

Teaching of colour-words in *Basic by Isotype* uses the technique of repetition of otherwise identical pictograms, in order to highlight the difference which corresponds to the colour-words indicated next to each pictogram. Consistency of the system and minimalism of symbols allow an easy detection

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[5] "If, as we maintain, manipulation of the minimum vocabulary gives practice in the analytic habit of mind which is essential to scientific thinking, and if the Basic words point to the concrete constituents of those fictional statements by which the sophisticated no less than the untutored mind is so frequently misled, its relevance at every phase of the educational curriculum cannot be questioned" (Ogden 1936, pp. 214-5).

[6] "Starting with 'icons' implies far-reaching limitations of language, but these limitations sometimes eliminate much danger. We are, e. g., not able to create an analogy to 'a through is walking through a through' in our picture language" (Neurath 1941a, p. 218).

[7] "Whether you like this remarkable piece of work or not, it at least teaches you the lesson that one can essentially reduce the variety of our vocabulary with a surprisingly small sacrifice of the variety of the subject matter" (Neurath 1941b).

of the common element in these 3 pictures of balls (**fig. 10**), so that the corresponding verbal element is associated with it, namely "ball." **Figure 11** shows red and black sticks: the comparison of these two groups highlights the common elements, such as "red," so that pictures teach the colour names unambiguously. Categories of size and form are also made explicit by making all other things equal. A concern for minimalism leads to the elimination of irrelevant details, which helps to deliver the message clearly.

Interglossa

Principles of reductivism and consistency are also used in another project for an international auxiliary language of Neurath's time. Lancelot Hogben's Interglossa was taught as "an auxiliary for a democratic world-order": the title reveals a social concern similar to Neurath's. For the purposes of precision and ease of learning, Interglossa was designed as an analytic language, lacking the inflexions of many European languages. Instead, Hogben prefers recognizable, fixed units of meaning. Reduction to units increases accessibility, but its main advantage is optimization for visual aids. Indeed, the handbook of Interglossa contains applications of Isotype to the teaching of the vocabulary. Hogben justifies his preference for an analytic language over an agglutinative one by emphasizing the possibility of using a picture language as a considerable benefit for an international auxiliary language[8].

Figure 12 introduces twelve new words in Interglossa with the help of two pictograms and two colours. The identity of a pictogram across its different uses clarifies the meaning of the associated words. The variation in numbers and colours repeated in different contexts helps the viewer get a clear idea of the words. For example, considering the similar structure of *bi melano*

[8] "An isolating language has a further advantage. It is easy to make every element explicit through visual aids. Thus freedom from lifeless affixes simplifies the task of instruction through the medium of the universal picture-language **isotype** without recourse to exposition in the home vernacular. We can therefore contemplate production of manuals for a world-wide market" (Hogben 1943, p. 17 [footnote]).

anthropi and *bi erythro anthropi*, one can spot the difference in verbal descriptions and associate it with the only obvious difference in the pictures: the colour.

Figure 13 teaches fifteen new words with the help of five pictorial symbols. Comparing the first two images, one spots the difference between them and associates it with the variation in their verbal counterparts: *oligo* and *poly*, which mean respectively "a few" and "many." The following comparison accentuates the opposition between *oligo* and *poly*. The same pictogram of two moving red men illustrates two opposing prepositions, *a* and *apo*: the image on the left depicts two people entering a movie theatre and the image on the right is the exact repetition of the same scene except for the location of the two men, who are depicted as going out of the movie theatre. The repetition of the same image makes it easier to notice the difference between them and efficiently teaches the new word.

Like Neurath, Hogben sees in the language of science an important material for universal communication. He accepts the continuity between everyday language and scientific language, which is especially due to the increasing introduction of technical expressions into ordinary language. This situation results from the globalization of science, including its products and its whole linguistic culture. Indeed, most scientific terms are not only international, but also universal in the sense that they are used by everyone in everyday language due to the growing place that technology is taking in modern times[9]. And they are traditionally constructed from Greek and Latin words, but Greek roots are usually more current and more familiar than their Latin counterparts. Another reason in favour of borrowing words from a dead language is their cultural neutrality, which is lacking in any of the existing natural languages. Also the compositionality and the rational construction of

[9] "In all countries where modern medicine, modern plumbing, modern agriculture and modern engineering penetrate, the vocabulary of science speedily makes its impress on daily speech. What was yesterday the jargon of the expert becomes an ingredient of the vernacular. Thus scientific nomenclature is international in a dual sense. It is everywhere the vocabulary of the expert and its components are daily invading the speech habits of widely separated communities" (Hogben 1969, p. 4).

scientific terms from these roots suit the purpose of an international auxiliary language, which aims to be economical: indeed, by combining Greek roots a great number of new words are constructed, and the transparency of their construction makes them clearly accessible. Concerning the use of natural languages, learning Interglossa also allows a better understanding of scientific concepts through the knowledge of their semantic components, and discovering the meaning of new words becomes a playful activity. Inciting the reader to discover relations in a chart by using an attractive visual medium was a similar concern in the design of Isotype charts.

Conclusion

As an alternative to verbal language, Isotype aimed to be a democratic medium of communication and embodied logical empiricism's cognitive values like universalism, intersubjectivity and democratic accessibility. Its concern for mutual understanding was shared by the movement for an international auxiliary language, two of whose practitioners, Ogden and Hogben, Neurath closely collaborated with. The three auxiliary languages shared principles of reductivism, consistency and familiarity. They all tried to reach as large an audience as possible by empirical reduction and insisted on the universality of scientific language as a model for international communication.

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