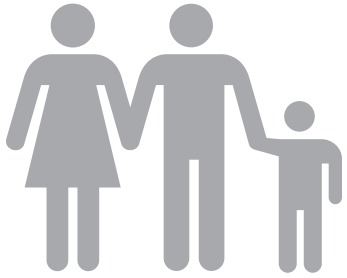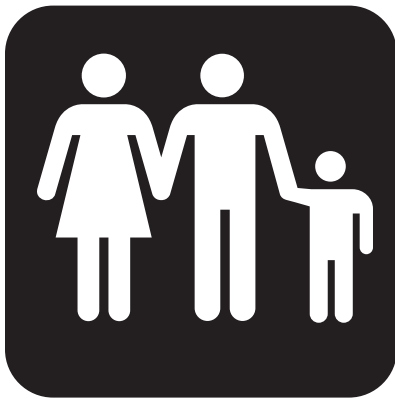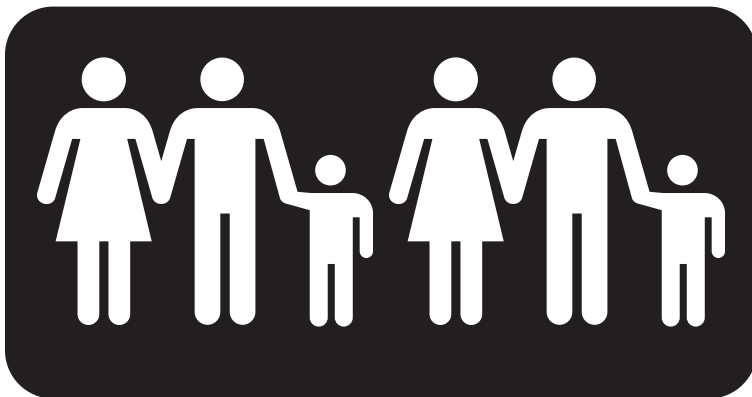1 Isotype icon represents 100 families

transformation design quandary:
Represent 128 families with 1 icon or 2 icons?

1 icon **under represents** the data by 21.88%

2 icons **over represents** the data by 56.2%

"Maria Neurath created an exaggeration of 56.2%
in favor of Williams' political agenda."

NOTE:
The family icons used above are
not ISOTYPE icons but are from
the publically available Hablamos
Juntos icon set designed in part
by students at the University
of Cincinnati.

Behind Isotype Charts:

The Design of

Number-Fact Pictures

Pia Pedersen, PhD

For more than 40 years, Marie Neurath designed ISOTYPE charts using pic-
tograms as graphical units to make a variety of information more accessible
for the layman. She was a transformer linking science and design by using
the benefits of both worlds to meet the public's interests. Significant insight
could be gained from this innovative work. However, many relevant aspects
of the transformation process remain elusive and are far too often imitated
and misunderstood as simply drawing 'rows of little men'.
      The purpose of this article is to demonstrate the use and imple-
mentation of pictograms by examining how Marie Neurath designed
'number-fact pictures'. A selection of specific examples from an in-depth
case study of Marie Neurath's sketches created while she was designing a
post-war exhibition in Bilston, England, in 1946 forms the basis for a discus-
sion of how pictograms were used as fractions, arrangement, and message
accentuation. These three aspects outline recurrent approaches and actions
of the transformation process that were shaped according to the situation
at hand. The paper provides an in-depth practical perspective on the work
and reveals how Marie Neurath, by shaping facts and using pictograms
constructively as convincing communication tools, deliberately guided the
reader towards a specific agenda.

Introduction

Austrian sociologist Otto Neurath (1882–1945) believed in pictures as a means of communication; attractive and informative pictures could help make information more accessible for the layman. Together with his associates he developed the now century-old graphic approach ISOTYPE (International System Of TYpographic Picture Education) in which pictograms[1] were the core component for designing a variety of information. What is interesting about Isotype charts is not only the famous and well-designed pictograms by the German Modernist artist, Gerd Artnz (1900–1988) – what many people think of as Isotype – but how the pictograms were applied and combined deliberately and distinctively according to the situation at hand.

Marie Neurath (1898–1986, née Reidemeister) dedicated her life to what the Isotype team called transformation – the process of assembling, selecting and configuring the factual information provided by the expert into a rough chart which was handed over to the artist who then did the finishing touches. As a link between expert and artist, Marie Neurath took on the responsibility of 'trustee of the public', choosing factual information in accordance with the public's interests. Today transformation may be seen as a way of thinking (Kinross and Neurath (2009), 7) or as information design (Burke, Kindel, and Walker (2013), 14).

Although the work of the transformer originated almost a century ago it still contains key lessons, such as the use and implementation of pictograms as aids of communication in 'number-fact pictures'[2]. These lessons, however, are challenging to explain in words, because the apprenticeship and integrative model of transformation has given the work some implied features. The Neuraths used their skills and experience to teach transformation, but no manual exists explaining how to transform.

In 1945, Otto Neurath was asked to assist in a slum clearance project in Bilston, a small industrial town in the 'Black Country' of the West Midlands in England. The social and political aims of the project – the Bilston Venture – culminated in a local exhibition that opened in November 1946. Twelve Isotype charts were created as a means to engage the slum dwellers in the planning project. The comprehensive sketching and collaboration process that was part of the preparations for the project provides a rare opportunity to shed light on the activities and practices of the Isotype transformer, particularly in relation to the design of number-fact pictures.

While Isotype has often been associated with its front figures, Otto Neurath and Gerd Arntz, recent re-evaluations of Isotype now give Marie Neurath's work significance (e.g. Macdonald-Ross and Waller (2000); Kinross and Neurath (2009); Burke, Kindel, and Walker (2013)). Robin Kinross, for instance, claims that the significance of Isotype lies "in the process of visu-

1.
The term 'pictogram' is employed to denote the individual Isotype pictures principally designed by Gerd Arntz. For the majority of cases these are icons, because they have a resemblance to the object they represent and the term pictogram is therefore suitable. Some Isotype pictures, however, are symbols because they have a form that does not bear a direct resemblance to the object or the concept they represent, such as the cogwheel that stands for industry.

2.
Term employed by Otto Neurath (see O. Neurath, 1936, 73).

ally configuring material" (Kinross and Neurath (2009), 6); yet, precisely this process remains obscure or is shown mainly though individual sketches. The Bilston Venture, more explicitly, has received little attention academically from a graphic design historical perspective. It was not part of the projects researched by *Isotype Revisited*[3]; it was not represented in *Isotype: Design and Contexts 1925-1971* (Burke, Kindel, and Walker (2013)) nor in *The Transformer* (Kinross and Neurath (2009)). Thus, until recently, the Bilston Venture has mostly been explored from other perspectives such as planning theory and education (Larkham (2006); Whyte (2007); Amati (2014)), philosophy of science (Nikolow (2004)) and cultural studies (Henning (2007)).

Marie Neurath claimed that one could understand what her work entailed by analyzing the process "from the table to the graph and from the graph to the Isotype chart" (M. Neurath (1955), 34). This was the purpose of a recent PhD project (Pedersen (2016)), whose findings form the basis for examining how Marie Neurath used pictograms in the process of designing number-fact pictures. The present article is based on a limited selection of all-inclusive material which scrutinizes practical details of Marie Neurath's work. Assembled from the Otto and Marie Neurath Isotype Collection, Department of Typography & Graphic Communication, University of Reading (henceforth IC), the Isotype material related to Bilston consists of data sheets, reports, letters, sketches and reproductions of the final charts in B&W. This material exemplifies how Marie Neurath worked from one sketch to the next and then discusses how pictograms were used as fractions, arrangement and message accentuation[4]. The present article provides a more practical perspective of the work that clarifies some of the everyday details (e.g. the selection and shaping of facts) that normally remain hidden in single pieces of archive material. This is important in order to avoid misconceptions of the Isotype work and, from a broader perspective, to further understand symbolic communication.

3.
A research project by the Department of Typography & Graphic Communication at the University of Reading.

4.
Note of source of pictures: All images are published with the permission of the Otto and Marie Neurath Isotype Collection, University of Reading.

Background

Otto and Marie Neurath had no background in design; they were scientists who approached graphic design as a means to meet social needs (Twyman (1975), 7). The purpose of Isotype was therefore not to make data decorative, but rather to generate a unified international pictorial language for educating the layman. It was in this context, in finding "the best way" to state something visually (Kinross and Neurath (2009), 9), that the characteristic pictograms and the idea of the Isotype transformer arose.

In its first five years (1925–) the graphic approach was subject to

5.
Originally Isotype was named the
Vienna Method (Wiener Methode
der Bildstatistik). The name Isotype
was coined in the mid-1930s by
Marie Neurath.

many revisions[5]; afterwards, it mostly underwent refinements and extensions. Likewise, Marie Neurath gradually grew into a transformer: From learning to select relevant statistics, she eventually became capable of seeing projects as a whole and transform in a way that created connections between charts by using the Isotype principles and rules constructively across media and culture. Thus, when Marie Neurath began to create the Bilston charts in 1946 she was transforming within predefined conventions and no longer focusing on developing a graphic approach. Otto and Marie Neurath were co-directors of the Isotype Institute in Oxford (1941–8). Isotype had by now gained maturity, won great international reputation and was even expanding into the realm of children's books and documentaries. The Bilston project was part of a stream of post-war Isotype projects on social welfare and planning, such as the booklets *Social Security* (1943) and *Social Insurance* (1944), and the documentaries 'World of Plenty' (Rotha (1943), Youtube) and 'Land of Promise' (1946).

Isotype rules of transforming

Otto and Marie Neurath saw transformation as central to the graphic approach both in its development and in everyday practice. Otto Neurath described transformation as "the first step from the statements of science to the pictures", a step that could not be explained by "the work of a man of science or of a designer" even though it was a combination of the two. It was a "delicate business" that required more than knowledge of the rules; it was a matter of "training in their use" (O. Neurath (1936), 8–9). The following statement elaborates this further:

> There are many transformation rules, some hundreds of them. Since the application of the rules cannot become standardized, but each new picture needs, as it were, a somewhat new invention of combinations, There is no possibility to transfer the rules in a simple way, one has to become acquainted with the whole structure of rules and to learn to weigh them from case to case, i.e. transformation needs rules plus much routine.
> (Neurath (1944)[6])

As implied here the essence of transforming lies in the way of combining rules according to the needs of the specific case. This was also confirmed by Marie Neurath who saw the rules as more as a help to "avoid mistakes than to find solutions" (M. Neurath (1947), 600). Marie Neurath compared an Isotype chart to an essay in which an argument could be presented in many different ways (ibid.). She was educated as a teacher of mathematics and physics which was echoed in the notion of the Isotype transformer who was often compared to a teacher. Transformation, as explained by Marie Neurath, was finding a way to extract the essential facts

of the material and put them into picture form (M. Neurath (1974), 136). This process involved tasks such as collecting, understanding, selecting and making the data understandable in the most efficient way. Marie Neurath saw transformation as a process of simplification involving deconstruction and reconstruction: "We must grasp a story thoroughly, then forget the terms in which we have learned it and rebuild it in the simple bricks which are at our disposal" (M. Neurath (1954), 34). When the transformation was complete, she explained, it had the form of a blueprint wherein "words, title, arrangement, type, number and color of symbols, caption etc." had been decided (ibid.).

The primary rule for creating such charts is letting one pictogram represent a certain number, whereas larger numbers are shown not by enlarging the pictograms but by adding a relevant number of pictograms of the same size (O. Neurath (1936), 71–72). Finding the right numerical unit for the pictograms was vital, and Otto Neurath stressed that it "had to be as great as possible but not greater than it could show a development or diversity in the numbers" (ibid. 79). As will be explained later, Isotype charts often have larger units and fewer pictograms than other charts using the same principle. In general, the Isotype rules guiding the transformer included the use of color, pictograms, signs and configuration, and they were the basis for creating an effective educational picture understood by casting no more than three glances: first, the most important points, second, the less important points, and third, the details (ibid., 27). Otto Neurath argued that "a simple picture kept in memory is better than any number of complex ones which have gone out of it" (ibid., 28), not because he disrespected statistical information, on the contrary; it was the basis to meet social needs. Marie Neurath stated that in spite of their apparent simplicity it requires some effort to understand Isotype charts (M. Neurath (1947), 603).

The Bilston Venture

In mid-1945, Otto Neurath was contacted by A.V. Williams, the Town Clerk of Bilston, who wanted his advice for the planning of a slum-clearance project. Williams was an active writer and member of the Labour Party and he was particularly interested in Otto Neurath's experiences from his involvement with housing in the 1920's Social Democratic Vienna. According to Marie Neurath "it was a matter of a plan for an exhibition to win over public opinion against the Conservative majority of the Council" (M. Neurath (1980), 84) – hence there was a political agenda behind Otto Neurath's involvement.

After the Second World War, the slums in Bilston were in such bad state that new town planning was an acute matter of health. Bilston was not damaged by the Blitz but by the effects of long-lasting coal and iron production as well as population increases. Workers were living under conditions so bad that the population's health was menaced and further aggravated by heavy air pollution. The extent of these problems was revealed in a civic

survey from 1944 that would guide the plans for the city.

Otto Neurath's answer to a successful slum clearance was visual education as a means to showing the slum dwellers a new and happy way of living. His idea was to organize an exhibition with charts and models, where the relevant questions in relation to the slum clearance would be displayed and discussed in a way that could arouse the slum dwellers' curiosity and participation in building a new community.

Under normal circumstances, Otto and Marie Neurath worked in close collaboration. However, a few months into the project Otto Neurath died and Marie Neurath was forced to complete the work alone. Marie Neurath's contribution to the project was 12 large multi-colored charts of 4 ft. square, created as mediation devices with four topics: The housing situation and future scheme (charts no. 1–4), planning conditions (charts no. 5–6), air pollution and health (charts no. 7–10) and finally leisure facilities (charts no. 11–12).

The exhibition opened in Bilston in November 1946, reaching the target audience directly in their neighborhood. However, shortly after its opening, the exhibition began to encounter political opposition and closed down. Likewise, due to a series of unforeseen events, the housing scheme was never completed according to the original plan. Therefore, as the exhibition became entangled in political and economic issues and a series of unfortunate circumstances, it is difficult to determine the influence and success of Marie Neurath's charts.

In practice

In 1944, before Isotype's collaboration with the Bilston Council, the city had hosted another exhibition named the *Bilston Civic Survey* in which Bilston's problems were outlined through maps and charts. The following example compares two charts – one from the *Bilston Civic Survey*, the other an Isotype chart. Both are based on the same statistical table *(figure 1)* and the principle of repeating pictograms of the same size; however they are very different in terms of graphics and statement.

Many differences emerge when comparing the two charts in Figure 2, where chart A is from the first exhibition and chart B from the second.

First, looking at the factual content, they both contain statistical data about the housing situation dispersed over the eight districts in Bilston. Chart A "Urban Blight" focuses on the unfit houses only (row A1) whereas chart B "Bilston – The Houses" includes four rows from the table (A1, A2, A3 and E13) displaying the whole housing situation in Bilston. In spite of this, chart A includes more pictograms than chart B because the chosen unit is lower. Each house pictogram stands for 10 houses, while in chart B they stand for 100 houses or families. Chart B might therefore include more

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Figure 1 table caption

SUMMARY OF HOUSING AND OVERCROWDING

AREAS 1 – 8

Area	1	2	3	4	5	6	7	8	Total
A. State of Repair and General Condition									
1. Houses unfit for habitation by reason of disrepair and sanitary defects	518	233	68	775	65	212	689	95	2,655
2. Houses in a reasonable state of repair but without proper sanitary amenities	205	80	88	358	51	293	65	36	1,176
3. Houses in a reasonable state of repair and with proper sanitary amenities	219	456	817	188	764	816	307	373	3,940
B. Age of Structures									
4. Houses 0 – 29 years of age	194	452	787	65	698	816	284	372	3,752
5. Houses 30 – 39 years of age	115	67	73	40	68	186	24	8	497
6. Houses 40 – 59 years of age	141	36	77	265	67	96	22	–	704
7. Houses 60 – 79 years of age	260	76	9	384	14	98	130	53	1,024
8. Houses 80 years of age and over	232	138	27	567	33	125	601	71	1,794
C. Houses Economic Life Exceeded									
9. Houses 60 years of age and over	492	214	36	951	47	223	731	124	2,818
D. Ownership									
10. Houses owned by Corporation	92	400	463	51	543	759	258	151	2,717
11. Houses privately owned	850	369	510	1270	337	562	803	353	5,053
E. Overcrowding									
12. Houses overcrowded	70	84	41	106	75	186	135	48	745
13. Houses occupied by more than one family	68	82	80	150	64	128	99	37	708
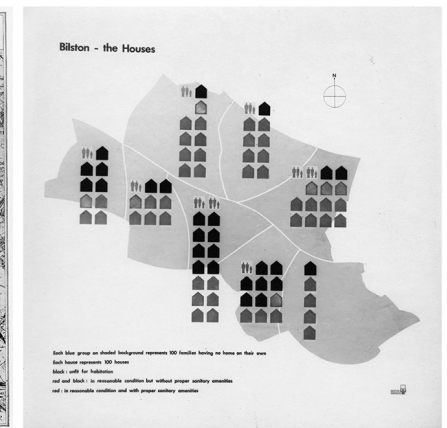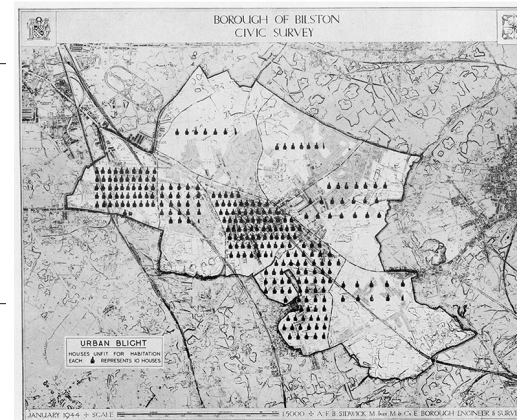
🍶 = 10 houses unfit for habitation

👪 = 100 families with no home of their own

🏠 = 100 houses unfit for habitation

🏠 = 100 houses in reasonable condition but without proper sanitary amenities

🏠 = 100 houses in reasonable condition with proper sanitary amenities

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data; however, it is less accurate because in order to reach the unit 100, the numbers have been substantially rounded off. The written information also differs; chart A contains more written information such as scale and date, while chart B only contains a title on top and a caption on the bottom. It should be mentioned that each of the Isotype charts was accompanied by short explanatory texts presented in a small exhibition pamphlet handed out at the exhibition entrance.

Second, looking at the graphics, the level of detail in chart B is generally reduced. The map is simply constructed around the contour of the districts. The same applies to the pictograms, where the house in chart B is simpler than the one in chart A. The additional data included in chart B results in an extra pictogram (the families) and color codes. When it comes to the implementation of the pictograms, in chart A they are cut into halves and placed at varying distances from one district to the next. In chart B, all pictograms are whole and placed consistently according to a grid.

By simplifying the graphics and cutting the number of pictograms, Marie Neurath creates a chart which is less accurate but raises a more complex question than chart A. Marie Neurath shows the overall picture from which the reader can create his own comparisons, associate himself with the gravity of the situation and comprehend the importance of the new housing scheme. Using the approach in chart A it would have taken four charts, which would then make the comparison between housing conditions difficult. Later on in the article it will become evident how the visual content in chart B is deliberately constructed to guide the reader in making the right conclusions.

Through a selection of examples, the purpose of the following section is to elaborate on the process from the statistical table to the final chart[7]. The examples are selected because they demonstrate some transformation approaches that are interesting in the discussion of how pictograms are used in Isotype charts.

7.
In previous research the Bilston material was thoroughly mapped in a combination of design historical analysis and information visualisation methods. For a thorough description of the method as well as the process for each of the 12 charts and the exhibition as a whole (see Pedersen (2016)).
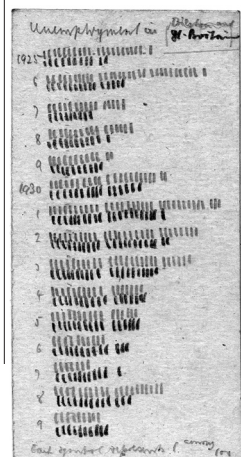
Example: Rows of little lines

Figure 3

Sketch titled "Unemployment in Bilston and Great Britain"

Source: Otto and Marie Neurath Isotype Collection, University of Reading

There is a similarity between what can be observed in Figure 3 and what Marie Neurath described as, "We must grasp a story thoroughly, then forget the terms in which we have learned it and rebuild it in the simple bricks which are at our disposal" (M. Neurath (1954), 6).

Figure 3 was never developed into a chart; however, it represents one of the basic steps of transformation that often would occur, not only in the Bilston case, but also in the additional material collection at the IC collection at Reading. It was an early step of materializing Isotype's principle of repeating pictograms. By drawing rows of small lines, squares or other forms Marie Neurath visually calculated and analyzed the data, the chosen units and their respective size.

Figure 4

The first sketches

Source: Otto and Marie Neurath Isotype Collection, University of Reading
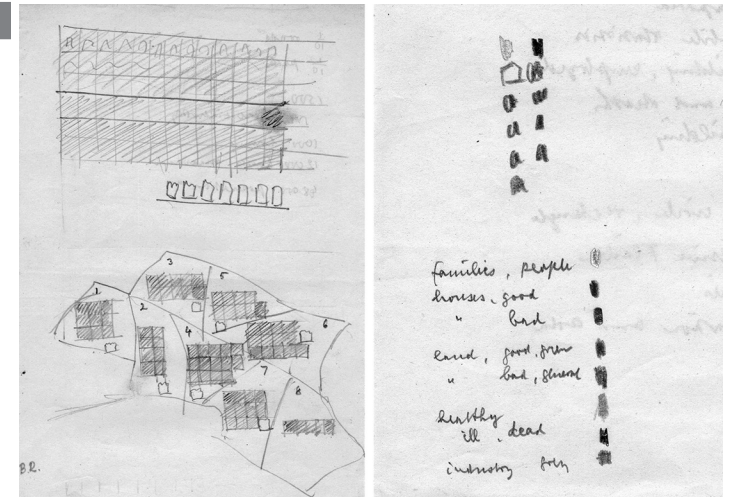
Example: Chart no. 1. Bilston –
The Houses

The process behind chart no. 1 is purely to illustrate how Marie Neurath proceeds from the statistical table to the final chart. This example presents a less complex process that is easier to comprehend than the rest of the charts. As mentioned earlier, Marie Neurath chooses rows 1, 2, 3 and 13 of the statistical table in Figure 1 to show the general housing situation in Bilston. In the first sketch *(see figure 4, left)* Marie Neurath already sets the pictogram unit to 100 houses and most probably tests it through the colored squares based on the totals. Below, on the same piece of paper, the squares are dispersed on the Bilston map according to the district they belong to.

Marie Neurath proceeds *(figure 4, right)* by trying out color conventions of the exhibition on the basis of the pictograms from chart no 1. The color conventions for all charts were thus decided upon while designing this first chart. In the first sketch, the color blue represents houses in a reasonable state, which is later changed in Figure 5, left, because blue was now chosen as the color for families. In Figure 5, Marie Neurath has applied the new color conventions, adding a title and a caption, and from this sketch it is easier to demonstrate how the numbers are rounded off. Looking at row 13 in the table *(figure 1)* the district numbers of families with no home of their own go from 37 to 150. On the sketch district 8 is the only district without a family pictogram, the rest have one family pictogram.

In the following sketch *(figure 5, right)* districts no. 4 and 6 suddenly have two pictograms instead of one, because Marie Neurath decides to exaggerate the gravity of the situation. In terms of statistical accuracy this means that 150 (district 4) and 128 (district 6) are rounded off to 200 families without a house of their own, which is a radical simplification of the original numbers.

A comparison between the two sketches in Figure 5 furthermore reveals how the pictograms become bricks to create an arrangement that conveys the message in the best visual way. The note "Housing facilities /
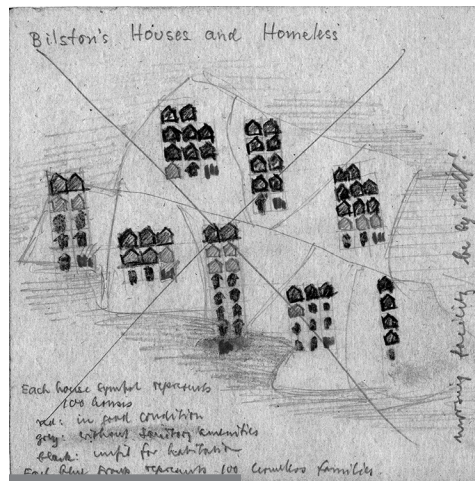
Figure 5

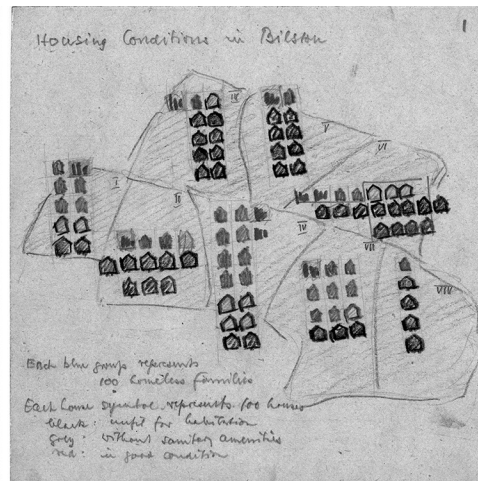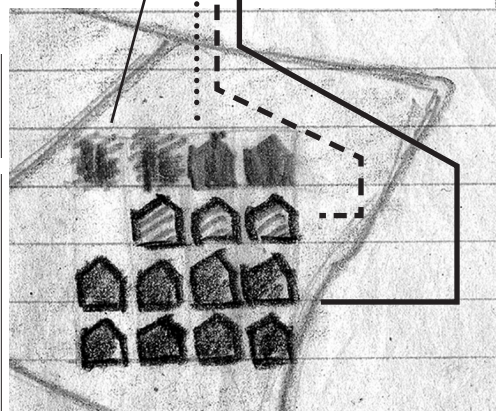The first attempt (left) is abandoned and a new version is created (right).

Figure 6

Final sketch for chart no. 1

Figure 6 detail (below) shows
blue - families with no home;
black (gray here) - unfit for habitation;
gray (with dark/red outline here) - without sanitary amenities;
red - in good condition.

Source: Otto and Marie Neurath Isotype Collection, University of Reading

be by itself!" on Figure 5, left reveals that Marie Neurath wants to change her approach to presenting the argument. From one sketch to the next the position of the homeless is changed from the bottom to the top. Likewise, in the caption the homeless are now on top. The opposite happens in the title where the homeless are removed; from "Bilston's Houses and Homeless" the title becomes "Housing Conditions in Bilston".

In the final sketch *(figure 6)* the title is further simplified to "Bilston – The Houses", which is neutral and straightforward. However, the position and number of pictograms are deliberately formed to highlight the gravity of the situation and thus guiding the readers' understanding.

Figure 7

Illustration of how Marie Neurath rotates pictograms while reformulating the title.
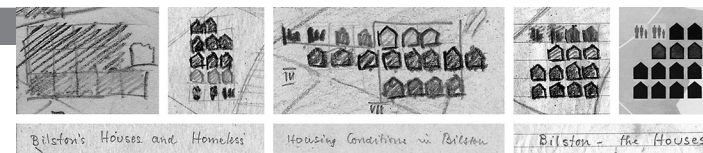
Figure 7 further illustrates how, from the first sketch to the last, the pictograms are rotated again and again while the title is altered three times (originally the title of the statistical table was "Summary of Housing and Overcrowding"). In the first half of the excerpts, as explained above, the pictograms are rotated to highlight the homeless; then Marie Neurath proceeds by arranging the pictograms in a more logical and aesthetical way. Here, in the middle excerpt, one can observe that Marie Neurath draws a square and crosses over some of the red houses outside. She reorganizes the pictograms in rows of four rather than two, most probably because it makes the comparison with the neighboring districts easier and because it creates a better graphical balance that also fits into the district.

In the final chart *(see figure 2)* the position of the pictograms is limited by the map and graphical grid, which at times means that they are decentralized and exceed the district borders. This reduces the aesthetic quality[8], but Marie Neurath succeeds in creating a chart from which the reader can learn about the housing conditions in Bilston and make comparisons on different levels: 1) different conditions within the district, 2) from one district to the next and finally 3) in the whole of Bilston. In the exhibition pamphlet the reader was presented with this text: "1. BILSTON, the houses good and bad. There are far too few houses. Many families have no house of their own. Are all parts of Bilston equally badly off? No; they are quite different. In the center 4 in 7 are bad, but in some parts only 1 in 5. What should be done? Take the bad houses away and replace them by good ones – but how?" The text thus guides and encourages the reader to look further into the chart and to engage with the planning discussion.

8.
The Bilston material does not reveal how Marie Neurath collaborated with the artist; however in general, the artwork finishing of the final charts does not reach the aesthetic quality perceived in the Isotype charts created when Gerd Arntz was part of the team (from around 1929–40).

Example: Chart no. 2. Bilston –

The Land and the People

The following sample of sketches created while designing chart no. 2 demonstrates how Marie Neurath uses some of the same approaches as example 2 in a different way. An early sketch titled "Bilston's Building Program" (not shown here) reveals that Marie Neurath's original plan was to show the planned use of land in Bilston by including the total numbers from chart no. 1, probably in an attempt to create a good connection. The idea is dismissed; instead Marie Neurath changes her approach and creates a comparative chart displaying the population in Bilston in the present and in the future use of land.
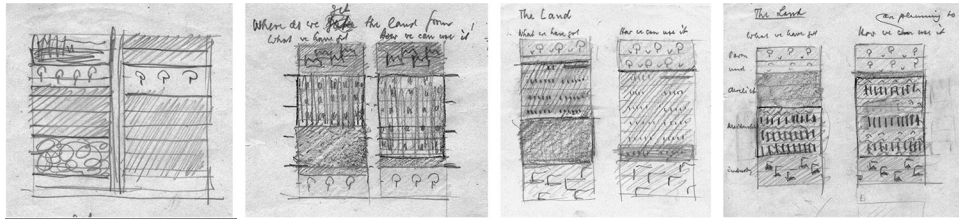
Figure 8

Sketches of the new idea

Source: Otto and Marie Neurath Isotype
Collection, University of Reading

First Marie Neurath creates a rough drawing of the new idea *(figure 8, first sketch)*, then proceeds with a more detailed drawing on the basis of different calculations. In the sketch, the total land is divided into ten sections displaying the relationship between (from above) the "industrial", "residential", "derelict" and "parks and open spaces". These are contrasted through two columns depicting "land we have got" and "how can we use it". The small lines in the residential part symbolize the population of Bilston – 31,248 people in total (Williams (1943), 14) – thus visualized through 30 lines each standing for 1000 people. Later, in the last sketch of Figure 8, Marie Neurath decides to arrange the pictograms on three lines; one line is equal to 10,000 people. Using green squares around the people in the second column *(continuing with figure 8, second sketch)* is probably to emphasize the added greens in the new scheme; it was rejected in the subsequent sketches.

Like in the process of chart no. 1, Marie Neurath searches for the best arrangement of the pictograms. For instance, from the first to the last sketch, the open land (green trees) is altered three times. A further look at the proportions between the types of land shows how she creates a logical arrangement that fits the visual statement she wants to convey. The industrial land (grey factories) stays unchanged in the new scheme, and by placing it at the bottom of the column it becomes devaluated. In addition, the three other areas are now easier to compare. Visually the open land stays almost unchanged in the new scheme (from 12.6% to 20%); however, in reality this would have been a significant increase, which is difficult to see from the present chart. In the final arrangement, the open land is placed on top thus becoming more noticeable. The result is an arrangement from which the reader can clearly notice that, by reclaiming the derelict land, houses in the new scheme will have more room. Furthermore, in the final sketch *(figure 9, left)*, Marie Neurath removes the derelict land of the future scheme (61 acres ≈ 3.3%), which enlarges the area of the residential space and accentuates the advantages of the new scheme.

Like in chart no. 1, while sketching the configuration, Marie Neurath alters the title several times, from "Where do we get the land from" to "The land" to the final title "Bilston The Land and The People". In contrast to chart no. 1, Marie Neurath decides to emphasize the people both in the title and in the visualization, most probably to underscore that this includes the whole population. The bulldozer symbol in the final chart was added because Williams (the Town Clerk) wanted to emphasize that the derelict land was almost reclaimed, that "these lands are actually under way" (Williams (17 July 1946)). He suggested a subdivision; however, to avoid complicating the

Figure 9

Final sketch and chart

Source: Otto and Marie Neurath Isotype
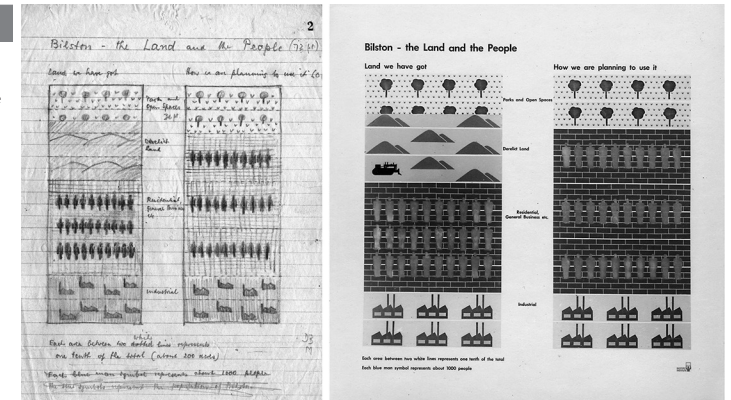Collection, University of Reading

chart further, Marie Neurath recommended the bulldozer.

In a simple manner, chart no. 2, displays the whole population in Bilston in the new and planned scheme, demonstrating how the new scheme will solve the housing situation. Again, Marie Neurath does not give the accurate picture, rather she shows a visual argument, created on the basis of her judgement of the statistics.

Example: Mixing charts no. 3 and 4

The selection and shaping of data was a complex and ongoing process with Marie Neurath searching for the relevant connections or contrasts that would make a meaningful visual argument. Occasionally she started sketching before having the data. Sometimes she questioned the data, and in order to get the most relevant message in the picture, she insisted on receiving the right data. This happened in the case of charts no. 3 and 4 where she wanted to show the housing needs according to family sizes and how these fit with the houses available and planned. However, when Marie Neurath starting sketching and examining the data she discovered a discrepancy between the planned houses and the needs according to family size. Their content was therefore discussed in detail with the Town Clerk (see Pedersen (2016), 164–70), and subsequently, with the right data, the content of the two charts was completely reorganized.

9.
On the sketch Figure 11, below left, one may notice some blue pencil corrections which correspond to the planned houses used in the following sketch, Figure 11, below right.

While reorganizing the content, the unit of the family and house pictograms were modified from 100 to 400 *(see figure 10)*. This modification resulted in a reduced number of pictograms, which gave more space to combine and add new data. As the arrows illustrate *(see figure 11)*, the "house sizes needed" from chart no. 4 were placed below the "sizes of families" in chart no. 3, while – in chart no. 4 – the "house sizes available" were vertically juxtaposed with new data, i.e. the "planned houses" according to house size[9].

Marie Neurath's way of reorganizing the content in these sketches demonstrates how the process could influence more than one chart. By

Figure 10

Excerpt demonstrating how modifying the content, unit and arrangement of the pictograms creates more space to create a comparative chart.

Source: Otto and Marie Neurath Isotype Collection, University of Reading
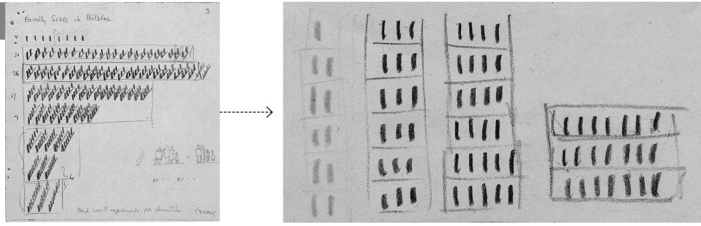

Figure 11

Left and middle: Four sketches created while designing charts no. 3 and 4. The arrows and outlines demonstrate how the content of charts no. 3 and 4 was reorganized. Right: Final charts no. 3 and 4.

Source: Otto and Marie Neurath Isotype Collection, University of Reading

Family Sizes in Bilston   Families and House Sizes Needed   Sizes of Families and Houses They Need

House Sizes Needed and Available   Houses we have got and which we are   House Sizes Available and Planned
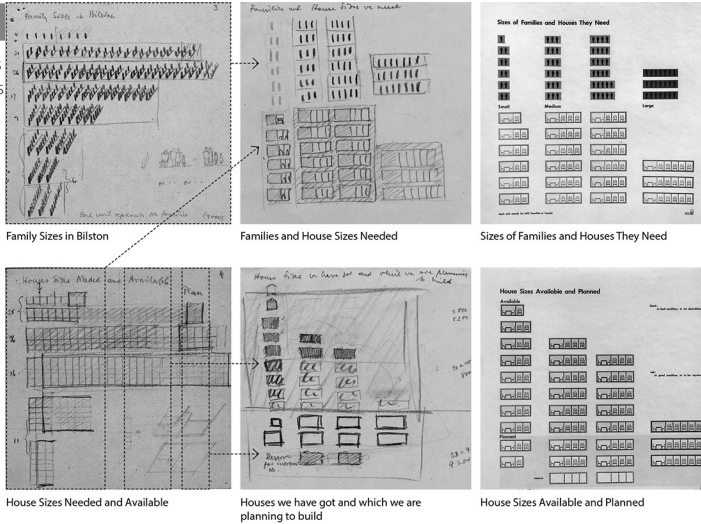   planning to build

Figure 12

Early sketches displaying that in the future districts there will be more sun.

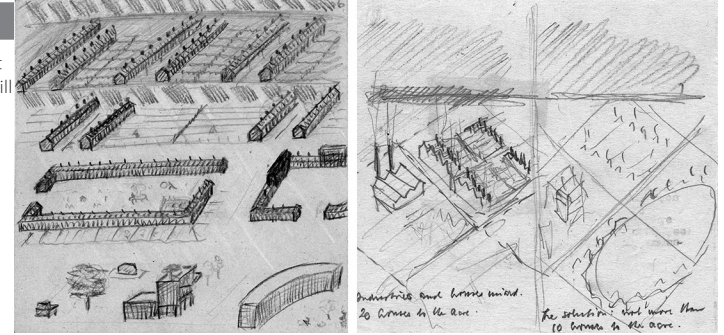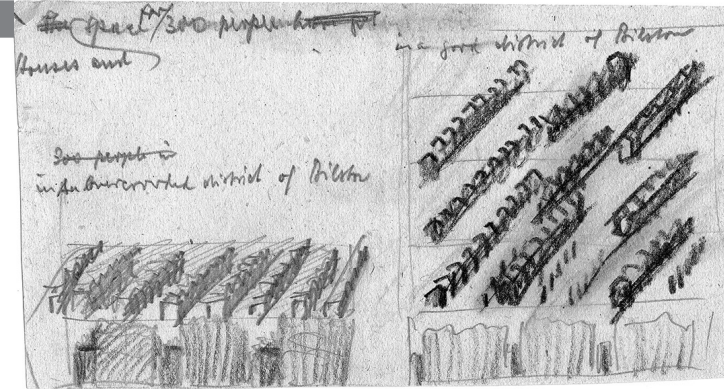Source: Otto and Marie Neurath Isotype Collection, University of Reading

Figure 13

Sketch titled "Houses and space for 300 people"

Source: Otto and Marie Neurath Isotype Collection, University of Reading

questioning data, modifying the units of the pictograms and mixing content two new and comprehensive charts arose that differ from the initial 'rows of little men' style seen in the two left sketches of Figure 11. The two final charts display comprehensive data in a simple way that lets the reader make his own interpretation. Hence in chart no. 3 the reader can see the numbers and sizes of families and what kind of house the different families need, and chart no. 4 illustrates how the houses to be built add to the actual housing situation. Marie Neurath furthermore elaborates on the story from chart no. 1 by showing how many houses are going "to be demolished", how many are "in good condition and how many are going to be repaired". By comparing the two charts the reader can see that there will be enough houses in the planned scheme. One may also notice how a house type is simply visualized through a square with pictograms indicating the numbers of living rooms and bedrooms.

Example: Chart no. 8. How 300 persons are housed in old and new parts of Bilston

Where the example of charts 3 and 4 illustrates how Marie Neurath would reorganize content on a more general level, the following and last example displays the reorganization of content on a more detailed level within a single chart.

The Bilston Council planned to build 4,000 houses with an average density of ten houses pr. acre. The purpose of chart no. 8 was to show that in the good districts there is more sun than in the crowded areas. In the early stages of designing chart no. 8, Marie Neurath tries to find a suitable way of contrasting good and bad housing densities. First, she makes four rows, showing more and more space between houses which allows more sun to reach the ground *(figure 12, left)*. In the following sketch, instead of the four rows, two columns now contrast an overcrowded area ("Industries and houses mixed. 20 houses to the acre.") with the future housing schemes ("The solution: not more than 10 houses to the acre") and each diagonal square representing one acre.

Marie Neurath then changes the content *(see figure 13)*. Instead of presenting the future scheme, the starting point becomes the actual housing situation, where one of the worst slum districts is contrasted with one of the best districts of the city. Through the use of straight instead of diagonal squares, it now becomes possible to include additional acres in the good district, an effective way to visually point out the added space between the houses. Furthermore, the people are now included, not only in the title, but also visually through three people pictograms each representing 100 people at the bottom of both columns.

In the following two sketches *(see figure 14)* the three groups of 100 people are transformed into four groups of 75. Furthermore, suns and a smoke cloud are added. Most significantly, the four squares from the bad

Figure 14

Two untitled sketches with small alterations

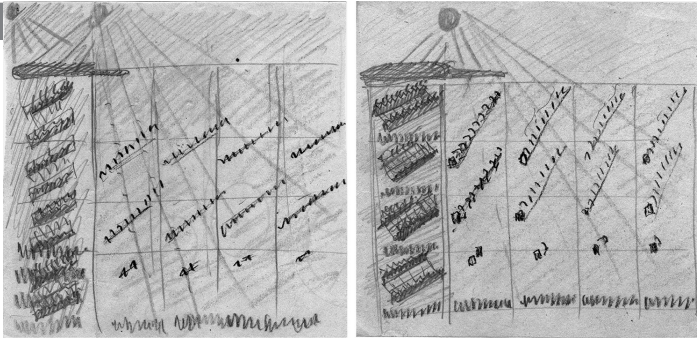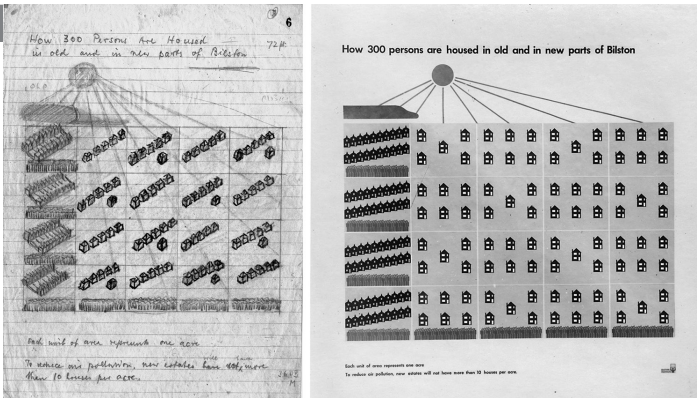Source: Otto and Marie Neurath Isotype Collection, University of Reading

Figure 15

Final sketch and chart

Source: Otto and Marie Neurath Isotype Collection, University of Reading

In the final sketch, Figure 15, left, now with the title "How 300 persons are housed in old and new parts of Bilston", the house pictograms in the good district have been equally dispersed into the different squares. The position of the houses is further improved in the final chart. Here Marie Neurath adds space between the houses and disperses them over the whole square. Altogether these small adjustments help accentuate the message further.

Through this chart the reader can see that the new parts of Bilston have less air pollution. Below, the caption reveals that there will be "no more than 10 houses to the acre" in the new scheme, hence the reader can easily conclude that the overcrowded areas will at least be half as crowded in the future scheme.

Chart no. 8 continues the story of former chart no. 7 "Air Pollution in Bilston" where the air pollution was contrasted with information about rickets (childhood disease due to a lack of vitamin D), showing that without sun children may get rickets. The smoke path thus creates a good connection to chart no. 7, and this illustrates another aspect of Marie Neurath approach, that it was important to construct a coherent exhibition narrative with clear connections between the charts, also in the detail.

Pictograms in number-fact pictures

Some of the approaches seen in the sketches may be distinct to this particular case that clearly was guided by the political agenda of the Bilston exhibition. In other less political Isotype projects, such as the children's books, there might not have been the same emphasis on highlighting certain parts. Furthermore, the examples constitute only a small part of the whole process of designing the 12 charts for the Bilston exhibition, and many details from the material and design historical context have been omitted. The presented picture of the process is therefore far from comprehensive; however, within the purpose of this article, namely to examine how Marie Neurath used pictograms for the design of number-fact pictures, the different examples clearly show how this was done. By breaking up the use of pictograms into three perspectives – *numerical units*, *arrangement* and *message accentuation*, the purpose of the forthcoming section is to outline some specific transformation approaches and principles.

Numerical Units

Marie Neurath's mathematical background echoes in her way of designing charts. At first glance this is particularly evident in the sketches with small lines or squares *(figure 3)*, where statistics were approached as units from the

district are now placed on top of each other, which creates a whole square, a simpler picture and a more straightforward comparison. However, there is a discrepancy between the original data and the number of squares now visualized in the good district, because the actual number should be 20 acres and not 16 acres for 300 persons. On the sketch in Figure 13 it is difficult to see the exact number of squares; however, a sketch created for another chart (no. 9 "Deaths in the First Year of Life in Bad and in Good Houses") reveals that Marie Neurath initially visualized 20 acres and included written information about the districts in question. In its new square form the 20 acres would need 5 rows, which would destroy the equal ratio four people pictograms between the contrasted districts. In order to solve the puzzle and make the data fit into the square, the solution was to leave out the four 'excess' acres in the good district. There is proof in the sketching material for chart no. 9 that Marie Neurath changes the specific information about the visualized districts into two unspecified districts. Thus Marie Neurath made her own interpretation of the numbers and must have determined that this was necessary in order to create the best educational picture.

From one sketch to the next in Figure 14, Marie Neurath proceeds with small alterations. One sun is removed and the four people pictograms in the bad districts are dispersed into each of the four squares. Here one should notice that the suns do not have a numerical value. They are 'Führungsbilder', i.e. guiding pictures, whose role is to help indicate the subject matter of a chart or differentiate between sections as the smoke cloud does.

early stages of the process in order to illustrate Isotype's principle of repeating pictograms. More generally, the chosen unit of the pictograms could vary significantly according to the given data, and it would often be modified/increased in the course of the process. When choosing or modifying the unit Marie Neurath always aimed at having as few pictograms as possible, which was a principle put forward by Otto Neurath (O. Neurath (1936), 79). However, this presented a challenge, because the larger the unit, the more difficult it would be to keep the diversity in the statistics. Numbers were sometimes shaped and rounded off so much that the pictogram landscape became too homogeneous, as in the example of chart no. 1, where Marie Neurath added pictograms from one sketch to the next in order to create a more diverse picture. "The purpose of teaching pictures", as Otto Neurath stated, "is to have an effect on the mind" (ibid., 62) and Marie Neurath created such an effect though the choice of the pictogram unit, and if the right effect was not achieved, she either adjusted the number of pictograms (according to the chosen unit) or modified the unit.

Arrangements

As the different examples illustrate, the arrangement in a chart is often closely related to the pictogram unit because it impacts the quantity of pictograms and therefore also the possibility of including additional data in a logical and structured manner. Marie Neurath stated that "comparison is vital in visual teaching" (M. Neurath (1955), 36), and in order to do so the value, number and position of pictograms was repeatedly modified while shaping the configuration: On a general level, often by making or restructuring axes, which helped create a logical and simple configuration; on a more detailed level, by rotating within a small segment of a chart, which helped make the parts fit the overall configuration and highlight the statement.

"The order of signs seen by the eye", as Otto Neurath stated "has to be in relation to the best order for keeping in memory marks in the mind" (O. Neurath (1936), 64). In so doing, the key way of constructing the arrangement was through the rotation of groups of pictograms or single pictograms. Rotation is a standard act of visualization; however, the way Marie Neurath did it was exemplary. By combining mathematical logic with educational and creative knowledge, the arrangement of the pictograms was altered in accordance with what the numbers indicated or what was important to emphasize. It was a process of simplification where the different types of rotations were steps in becoming more and more specific while also including contrasting data. These series of actions were a way of working towards a clearer visual statement and could also influence other charts as seen in the process of charts no. 3 and 4. Title and argument therefore did not necessarily fit from the beginning but were formed along the process. The use of color on the pictograms was also concentrated upon and part of

creating the arrangement. Even though Marie Neurath had chosen a color configuration for all 12 charts early in the process she would often reconsider the chosen color within the individual charts right to the end.

When analyzing the use of pictograms as arrangement, it is surprising to see how far Marie Neurath would go in order to create the right educational picture and statement. One thing is choosing a numerical unit that fits the Isotype principle of repeating pictograms; another is to deliberately add pictograms or omit information in order to make the information fit. In chart no. 8, for instance, Marie Neurath went as far as deleting a whole row. Marie Neurath took statistical information seriously. In order to create a good educational picture and decide what details could be omitted, it was crucial for her to understand the facts and have the right data. This was demonstrated in the example of charts no. 3 and 4, where she insisted on receiving the suitable data. On the other hand, the good educational picture was prioritized over the accurate one. In practice, what was "considered as essential and what as detail, which can be sacrificed in the process of simplification" (M. Neurath (1955), 34) is shown as a process that at times involved a rather free interpretation of the existing numbers.

A closer study of the use of pictograms as arrangement thus illustrates a process that may be compared to solving an equation or puzzle. Hence by making the pictograms come together they all fit within the whole in a logical way in accordance with the *right* visual statement.

Message Accentuation

One of the key features in Isotype charts is that "everything in the picture had to be useful for information" (M. Neurath (1971), 17). When Marie Neurath approached the solution to a configuration she would consider the relevance of every detail and search for ways to emphasize the message further. Items without teaching value would be removed. For instance, in chart no. 8 one of the two suns was omitted because only one was relevant to convey the message *(figure 14)*. Furthermore, without changing the overall configuration, small alterations in the position of the symbols were often performed in order to accentuate the meaning of the numbers. In the case of chart no. 8 Marie Neurath worked with the space between the house pictograms to make it as clear as possible that the district was spacious. Looking back at Figure 13 the space between the houses in the bad and the good district was similar; however, in each of the following sketches, while shaping the overall configuration, the detailed position of the houses is also reconsidered again and again. A different way of using pictograms was found in chart no. 2, where the bulldozer was added without a numerical value, to emphasize a scheme in action. Its function may be compared to a guiding picture.

In summary, Marie Neurath used pictograms to accentuate messages by reconsidering their importance and by making small alternations in their position.

Understanding the complex underlying pattern

Both in their design and implementation pictograms remain a challenging task; however, when done well, they become strong tools of communication. Isotype charts are still imitated and misunderstood as 'rows of little men' without going beyond Marie Neurath's very early sketches with rows of small lines, and it is therefore important that the graphic approach is properly understood.

The Bilston material suggests that pictograms were used constructively as numerical units that were *chosen* and *modified* in the course of the process, as arrangement by being *grouped*, *separated*, *juxtaposed, excluded* and *rotated* on different levels, and finally as message accentuation by being slightly *repositioned*, *reconsidered*, *added* or *deleted*. These recurrent actions and approaches are only a selection of the ones which can be perceived in Marie Neurath's process and are part of a larger and more complex pattern of use. In the beginning of the process, the Bilston charts were often visually complex while the content was simpler. Later on, the charts became visually simpler while the content became more multifaceted. Marie Neurath would switch between working on several charts at the same time to working only on a small part of a chart that needed more attention. In this way, by thinking through drawing, she worked towards a consistent exhibition character, from small visual details within a chart to the whole exhibition narrative. Her persistence existed on all levels: Right to the end of the process all aspects were evaluated and given importance, from the data to the configuration, the use of color, text, pictograms etc.

Considering the material in light of Marie Neurath's experience she was in a constant process of learning while designing, approaching each project and chart as unique even though she worked within a set of pre-defined conventions. Marie Neurath had a load of transformation experience from which she developed the Isotype principles in such a comprehensive way that they could be reused and interpreted in new ways according to the specific situation and material. Transformation therefore appears as a non-linear and multifaceted process, where the visual statement based on pictograms is not necessarily predetermined but arrived at.

Marie Neurath claimed that Isotype charts could "introduce people to problems new to them without influencing them in a particular direction" (M. Neurath (1947), 603). However, the Bilston material suggests that Marie Neurath did want to influence the Bilstonians in the direction of William's

social agenda. In addition to the choice of content and wording and the intelligible position of the pictograms the data distortions visible in the charts are indications of Marie Neurath's intentions. A comparison between the original and the visualized data in chart 1 shows that there was a maximum discrepancy of 56.2% (from 128 to 200 families). This exaggeration was made later in the process, when Marie Neurath added family pictograms. Thus, from a discrepancy of 21.88 % (from 128 to 100 families) Maria Neurath created an exaggeration of 56.2% in favor of Williams' political agenda. Likewise, in chart 2, derelict land was later omitted in the second row, which visually added space between the houses in the future scheme in an exaggeration of 6.25 %. In other circumstances, the original data suggests distortions with the purpose of creating good and logical teaching pictures. In chart 8, for instance, where Marie Neurath deleted a row, the area between houses in the new parts of Bilston was reduced by 23.81% to make the data visually fit into a square.

Either way, be it to create a good teaching picture or a convincing picture, Marie Neurath empowered the reader through simple pictures with relevant questions rather than statistically accurate information. This raises a more general discussion of how much the reader should and wants to be guided? When does the simplification override the truthfulness of statistical information? Such issues could partly be solved today, where the digital world provides the opportunity to create interactive charts, different levels of information or links to the exact figures. But this does not answer the question of who is in a position to judge and use content to create empowering numerical fact pictures. The latter was Marie Neurath's role, i.e. to be a trustee of the public, as opposed to the expert and the artist whose focus was on their professions rather than on the reader. Nevertheless, as seen in the Bilston project, she functioned as the trustee of the public only within the social agenda she believed in. Isotype charts *are* "telling us what to think", as Waller and Macdonald Ross state (Macdonald-Ross and Waller (2000), 192); to what extent it is acceptable and how we should balance science and design, information and attractiveness, and simplicity and complexity remains an open question.

With the different templates and applications floating around from which anyone can create automatically generated number fact pictures (e.g. isomatic.de) it will be increasingly important to demonstrate and verbalize how visual communication design may go beyond these applications and empower the reader. The small adjustments in the positions of the pictograms, for instance, that further accentuate the topic of the material are just one of the aspects which cannot be accomplished by following rules or generating charts automatically through apps and templates.

The work of Isotype thus presents a way to approach the visualization of statistics and also the reward of visual experimentation – a time-consuming process that needs to be taken into consideration. Another

aspect, not discussed in the present article but no less important, is that the work of Isotype highlights the importance of feedback and good teamwork across disciplines. Science and design came together through a predefined and unique team structure, and within the field of information design this is one of Isotype's strong legacies (e.g. Macdonald-Ross and Waller (2000)). The work thus also presents a way to explain and adopt an integrative approach through interdisciplinary teamwork.

Conclusion

By exemplifying the way Marie Neurath transformed a more practical picture of the use of pictograms in Isotype charts emerges. Pictograms were the core bricks to create proportions, relationships and connections in the overall configuration, to emphasize shifts and contrasts in parts and to accentuate a topic through their detailed positions. Although this paper is based on a limited selection of material one may conclude that Marie Neurath developed the Isotype principles so thoroughly that they could be reused and interpreted in new ways through her transformation actions and approaches. This confirms that what characterizes Isotype transformation is the pattern of employing the rules rather than the rules themselves. Marie Neurath's work furthermore presents an innovative example of how mathematical analysis and creative thinking processes can go hand in hand in constructive ways.

The practical examples of Marie Neurath's working method are relevant for any contemporary designer working within the field of visualization of information who wishes to create results that go beyond drawing 'rows of little men'. Among other things the examples point to ways of working with visual systems, to ways of selecting and organizing data, and to ways of using pictograms as communicative tools through visual experimentation.

In contrast, some questions regarding the twisting of statistical information emerge that should be considered by every designer. To create the Bilston charts, statistical information was found, shaped and visualized according to the ideas and purposes of a specific social agenda; and the content was even adapted to fit the arrangement of pictograms. The Bilston charts were therefore not only a tool for public education; they were also a tool for public involvement and propaganda.

The Bilston case study shows that even for an experienced designer like Marie Neurath transformation is a "delicate business" with ethical and moral dilemmas. In what circumstances, for instance, is it acceptable to twist statistics with the purpose of having the right "effect on the mind" of the reader, and who is in the position of being the 'trustee' and decide the good of the reader? Today, with the political polarization and fake news, designers will be confronted with similar ethical dilemmas. The digital world

has provided the opportunity to create, store and distribute data. Anyone has access to computer apps and templates that help create infographics and data visualizations, visualizations that are used as tools for argument and decision making. With reference to the lessons of the Bilston case, these circumstances suggest the need for practicing designers to be concerned with the authenticity of the data and the sources they choose or are asked to visualize. Designers need to be aware of the effects of their visualization choices and how these will affect the reader, because they might point in directions that are not directly inherent in the data. Designers could counter this by considering their own biases, the intentions of the client and most importantly whether their visualizations serve the good of the reader. Nevertheless, further discussion is needed as to the best approach for transforming information into visually intelligible and instructive images.

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