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Symbols and icons in diagrammatic representation

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The notion of the icon — that is ultimately related to the Platonic process of *mimesis* which Aristotle then broadened from a chiefly visual representation to embrace all cognitive and epistemological experiences — has been subjected to much analysis in its several varieties and manifestations, yet some seemingly untractable theoretical question remain. Thomas A. Sebeok (1976: 128)

The distinction between symbolizing, i.e., representing concepts or propositions, and simulating allows a simple description of (a) representations where symbolizing and simulating coincide ("iconic symbols", like in pictograms and onomatopoetic words), (b) representations realizing simulating and symbolizing functions by separate elements (as in charts and graphs), and (c) representations combining figural symbols with linguistic symbols, such as logical pictures. These figural symbols seem to derive their form from spatial metaphors. A more specific assumption was tested in two experiments: the more precise the mapping between logical picture and spatial metaphors in the text, the higher the efficiency of this two-dimensional analogy in reducing the cognitive load of the text. The experiments had to meet the requirement of an equivalent "meaning" of the text-picture combinations to be compared. In both experiments the data of the guessing-tests used for measuring the "cognitive load" showed the expected tendency.

Designers of instructional "text-picture compositions" are well aware of the fact that the text should explicitly refer to the pictures and that the pictures' labels and keys should explicitly correspond to the written or spoken text.

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The present study draws attention to the "non-explicit" and often hidden ways of correspondence between language and "picture language" and to findings indicating that the comprehensiveness of instructional materials may well benefit from a conscious cultivation of such implied correspondences encouraging the "internal" mapping between propositional thinking and mental modeling.

The relationship between *symbolicity* and *iconicity* is discussed as a conceptual framework for exploring the semiotic status of "external" representations used in specific texts (Section 1). We proceed then to analyze the differential roles of iconic symbols (Section 2.1), charts and graphs (Section 2.2), and logical pictures (Section 2.3). In terms of this framework, logical pictures turn out to be not iconic but symbolic.[1] These pictures are an excellent material for an empirical investigation of the efficiency of an esthetic principle of text-picture composition which, according to our findings, enhances the intellegibility of instructional texts (Section 3). The "visualization of metaphors" is not only interesting because of its possible "literary quality" (Pape 1996: 344), but also because of its potential for instructional material.

1. Relations between semiotic concepts

The terms "symbol", "icon", and "index" are often used in the sense of disjoint classes of signs. According to this customary approach, the symbol is **arbitrary** (and therefore non-iconic) and refers to its referent **exclusively** by convention (e.g. Boeckmann 1994: 43), while the icon refers to its referent by similarity and the index by being "physically" connected with its referent. This approach seems to result from an attempt to implant Saussurean ideas like the "arbitrariness" of the symbol into the Peircean terminological framework, or the other way round (Kress and van Leeuwen 1996: 5). But where in such a classificational system is the place for onomatopoetic words like "cuckoo" and for pictograms? And where is the place for pictographic characters (documented for instance in Fazzioli 1988: 24, 191) like those for *rén* 'man' or *shui* 'water' in Chinese?

In Peirce's numerous writings one can find only very few sentences (e.g., Peirce 1908, 1976 edition, III/2: 887) that make one think of disjoint classes of signs, and these sentences become ambiguous if one looks at his use of the terms "symbol", "icon", and "index" within sentences where they clearly denote different aspects or functions — instead of classes — of sign. A few examples from the 1976 edition, IV: "An *icon* can only be a fragment of a completer sign" (p. 242); "but a symbol, if sufficiently complete always involves an index, just as an index sufficiently complete involves an icon" (p. 256). The problems mentioned above can be removed (see below) if one adopts the view that Peirce's distinction between *symbol, icon* and *index* is a distinction between **functions** of a *sign.* But there remains the problem that neither mere similarity nor mere "indexicality" can be sufficient for *sign.* Similarity is a necessary condition for the *icon* and for *iconicity.* But everything resembles something else, everything is — in one or other respect — more or less similar to something else. Should we, therefore, view a certain coin as an icon of another coin, or a certain dog as an icon of another one? Obviously, a more restrictive use of the term is necessary. Only if similarity is established by simulating, imitating, picturing or modeling activities, is this — within a still rather broad definition (see Version I below) — a sufficient condition for *sign* and for *iconic* sign.

Indices represent, according to Peirce, "their Objects by virtue of being in fact modified by them, as a clinical thermometer may represent fever, or a letter attached to a figure of a triangle may from its position represent an angle of the triangle" (Peirce 1908, 1976 edition, III/2: 887). But we interpret every "object" with respect to something else, with respect to contingencies and correlations, origins and authors, causes and effects, conditions and consequences. Any "object" of perception is indicating something else in the perceiver's mind. This indexical interpretation, and the evaluation of indices in order to improve indexical interpretation, is what our cognitive system does incessantly. If any object of perception is classified as a *sign* because of its indexical properties, then there are no non-signs left, and the concept of *sign* gets empty. On the other hand: "if all things work as indices, this is also true for those things we still regard as a sign. Thus, and only in this sense, indexicality is a 'necessary' and inevitable feature of symbols and icons" (Fenk 1997: 218). So it might be useful to distinguish "natural indices" — such as the footprints on the ground (cf Peirce 1906: 496)[2] or the lightning indicating the thunder that will follow — from "artificial indices", and to concede only the latter the status of a sign. But "artificial indices" obtain this status not "by virtue of being in fact modified" by their objects (see citation above), but through their function of simulating and/or symbolizing. If true, the elimination of the "natural index" from sign-specific functions boils down to the elimination of the index in general: only two sign-specific functions are left over.

The distinction between "artificial index" and "natural index" — though not eliminating the latter from sign-specific functions — seems to have some parallels in Peirce. According to Sebeok (1986: 49), for Peirce we have an index when there is "a direct dual relation of the sign to its object independent of the mind using the sign … Of this nature are all natural signs and physical symptoms", and "symptoms of disease" have, like "signs of weather", "no utterer". In another article, Sebeok (1995: 224) talks about instances of what we call "artificial indices": Designations, like "deictics of various sorts, including tenses", are viewed as "one of the main classes of indexes" and, in Peirce's words, as "absolutely indispensable both to communication and to thought". It is worthy of notice that deixis and tense are functions of (linguistic) **symbols**.

Many "artificial indices" can be classified as instances of *symbol*, like the relative pronouns, "which, although symbols, act very much like indices" (Peirce, 1976 edition, IV: 243), and like the "arrows" representing *time* or *amplitude* in Cartesian diagrams (see Section 2.2). And the "letter attached to a figure of a triangle" is an — of course artificial — label that is in the corresponding text or formula used as a symbol for this certain figure. In the simple measuring instruments mentioned — the weather cock, or the clinical thermometer — our "natural/artificial" distinction would amount to a distinction between components: the digits on the scale of the thermometer are of course symbols; and the cock is an icon or an iconic symbol. However, the actual length of the mercury column and the actual direction of the weather cock are in fact "modified" by their "object" (temperature, direction of wind) and are therefore "natural indices".

A simple and sound concept of *iconicity* (Fenk 1995; 1997: 230) seems to be possible (a) if we accept neither mere similarity, nor mere indexicality, nor "indexical similarity" (e.g. between foot and footprint, between a tree and its reflection in the water) as a sufficient condition for *sign* and (b) if we first of all separate two different functions of sign:

X: the function of **simulating**
Y: the function of **symbolizing**, i.e., of denoting concepts or propositions.

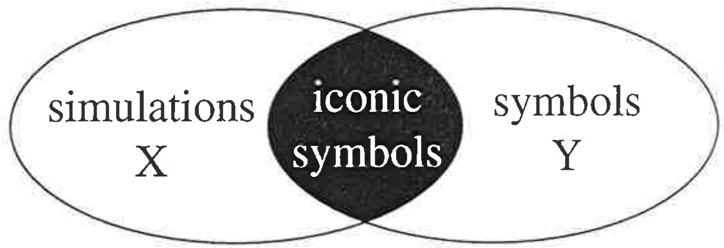

Figure 1. *Simulations and symbols forming non-disjoint classes of representation*

There are two ways of defining *iconicity* (see Figure 1) as a property of a sign:

VERSION I: We accept not only function Y but also function X as a **sufficient** condition for *sign*, and the whole set of instances realizing function X as *iconic*. The "overlap" of X and Y ($X \cap Y$) might then be called "iconic symbols" (see Figure 1).

VERSION II: We regard function Y as a **necessary and sufficient** condition for *sign*: Something is a sign if and only if it represents a certain meaning, i.e., if and only if it is used as a symbol. Iconicity is established only in representations realizing both the simulating and the symbolizing function ($X \cap Y$).

In the more restrictive Version II, iconicity is no more than a possible attribute of symbols, and nothing but a symbol can be iconic! Strange to say that this radical Version II already appears in outline in Peirce's remarks quoted in the second paragraph of this section. We may add that, according to Peirce, "A pure /…/ icon asserts nothing" (Peirce, 1976 edition, IV: 242). If a "pure" icon asserts nothing, it cannot have any truth value. This corresponds to Jorna's remark that "Pictorial representations in contrast to propositional representations do not have a truth value" (Jorna 1988: 178). Only symbols can form propositions and predications. And predication is often viewed (cf Fenk-Oczlon 1983) as a language universal or even as constitutive for *language*.

Both versions of defining iconicity allow a simple description of *iconic symbols* such as onomatopoetic words: A symbol (function Y) is iconic if it realizes function X as well. And both conventions lead to some striking consequences when used for the description of logical pictures and of text-picture compositions (see Section 3).

2. Different types of the interaction between different sign-properties and different sign-elements

2.1. *Iconic symbols: Symbolizing falls together with simulating*

As already mentioned, simulating and symbolizing fall together in iconic symbols, such as onomatopoetic words, or pictograms which are "self-explaining" to a certain degree and moreover familiar because of their frequent use. Their "rule-based use" (for the term see Keller 1995) within certain contexts makes these simulations symbols with a relatively unmistakeable meaning within these contexts. The well known heart pierced by Amor's arrow, to give an example, is iconic, but is an iconic **symbol** because of its rule-based use as an equivalent of "fallen in love". Even if one doesn't know that it is Amor's arrow that has pierced the heart, the rule-based use of this figure prevents us from interpreting it in the sense of "got killed (by an archer)" instead of "fallen in love".

In many cases of simulation we can not count on the self-explaining properties and/or familiarity of the simulation. We need — in addition — unequivocal symbols in order to make these simulations unequivocal symbols. In Figure 3, for instance, the smilies attached to the serial position curves are "explained" in the key of the figure. And in a geographical map, ○ and △ may be introduced in the key of the map (i.e., by conventional symbols used to establish a new convention) as symbols denoting "broad-leaved trees" and "coniferous trees" and are, moreover, picturing the treetops of these trees in a very schematic but discriminating way. Deeper blue representing deeper water is also iconic, but what it precisely means is again a matter of symbolic representation. Since the very same blue may represent a depth of 1500–2000 metres in a map of the Pacific and 150–200 metres in central European lakes shown on another page of the same atlas, we need linguistic and/or "paralinguistic" (here: mathematical) symbols within the map or in the corresponding key to establish the conventions that the very same colour means "1500–2000 metres" on page x and "150–200 metres" on page y.

The iconic symbol (e.g. a certain blue colour in the map) might, in principle, be substituted by (para)linguistic equivalents directly in the map ("depth: 1500–2000 m"), though it is more common to attach the single data to the corresponding contour line. Traffic signs on the road or in the airport can be substituted by their linguistic equivalents as well ("sharp turns ahead", "keep right", ...). In some cases this would even increase the unequivocality, but only for those who are acquainted with the relevant language, and — in already familiar signs — at the expense of the speed of identification.

Symbols denote concepts, and concepts cannot be directly simulated. Thus, what is simulated in iconic symbols will never be precisely that which is represented by these symbols. The simulation will always be exemplifying and metonymic in character: The spoken word "cuckoo" simulates not more than the cry of the "objects" falling under the concept *cuckoo*. The high-heeled shoe on the door to the ladies' washroom pictures only one particular item of clothing worn only by some women. And the roebuck within the red triangle of the traffic sign signalling "Caution, deer path!" simulates only a male example of one of several species which might be a danger for the car driver.

The semiotic status of representations is not a matter of degree, but a matter of function. If in a text-processing program the picture of a waste-paper basket or the picture of a refuse bin realizes the same function as the word "delete", then these pictures are *iconic symbols* (in the sense of both Versions of defining *iconicity*) or *icons* (in the sense of our Version II). In Fischer's (1997) study based on Goodman's (1968) "theory of symbols" they are classified as "icons" as well, and icons are classified as "elements" of "notational" or "written schemata" (Fischer 1997: 93).

According to DeMatteo (1992: 200) American Sign Language is *iconic* in the sense that similarity is established by conventional rules and that the sign's meaning is not simply a function of similarity. Holzinger and Dotter (1997: 138) assume that signed languages, as compared to spoken languages, are universally provided with a broader range of possibilities for more or less abstract strategies of iconic coding because of their use of the visuo-spatial channel. I am tempted to assume that "logical pictures — like the Ogden and Richards triangle — complete texts in the way gestures complete speech" (Fenk 1994: 46) and that signed languages use dynamic forms of all types of representation discussed in our sections 2.1–2.3: from iconic symbols (2.1), through representations realizing simulating and symbolizing function by separate elements (2.2), up to symbols originating from spatial metaphors (like the "times before, or ahead, or in front of us"), or symbols — here: elaborated and standardized gestures and mimic expressions — originating from the very same analogical/topological thinking as these spatial metaphors (2.3 and end of Section 2.2).

In every iconic symbol, i.e., in every "icon" in the sense of our Version II, simulating and symbolizing are only conceptually separable. In this respect, iconic symbols differ from the representations characterized in the following section.

2.2. *Representations realizing simulating and symbolizing function by separate elements*

In charts and graphs, simulating and symbolizing are realized by separate elements, and the simulating element simulates its "object" (process, event, thing ...) in that it realizes an isomorphism between representation and what is represented. Within our examples of such simulative representations we find a great variety in at least two respects. Firstly in the difference between our perceptual representation of the simulative representation and our more or less "direct" perceptual representations of the represented. And, secondly, in the accessibility for, translation into linguistic or paralinguistic expressions. This accessibility depends on the complexity and density of information in the simulative element.

While the blue colour representing a depth of 1500 — 2000 metres in a map of the Pacific is standardized in this part of the atlas, the contour lines bordering this level have to resemble certain features of the surface of the terrain. Therefore their form has to be "adaptive". And again we need symbols somewhere in the map which inform us about the absolute distances to sea-level and about the "vertical" distances between the contour lines. And while the blue colour can easily be substituted by "1500 — 2000 m" between the contour lines, the contour lines themselves and the pattern of contour lines cannot be reduced to or substituted by those symbolic expressions needed in order to be unmistakeable for the interpreter. They could in principle be substituted by a table adjoining an immense number of measured data of depth to their geographical coordinates (degree of latitude, degree of longitude). Any analogical representation can be digitalized, and digital representations are in many cases the database on which the analogical representation is built up. But such a pure data table, though useful for some technical and statistical procedures, would not be as efficient for quick orientation and communication as our map's analogical plus digital representations.

Looking down from an airplane we can identify the river we know from the map, its mouth into the Pacific and the adjoining coast line. We can see the correspondences between landscape and map representation. But in the landscape there are no contour lines. In the mountain, from bird's-eye view, there are at least some correspondences between contour line information and the results of my visual range estimation — the nearer the details of a mountain, the higher. But offshore I cannot detect the gradation of the blue colour representing different depths in my map. Though the map resembles something which I cannot see, the contour lines in the map-representation of the Pacific are isomorphic representations. What they represent is indirectly — via measurement — connected with our perceptual system, and is — in principle — also accessible to our visual system. Near the shore we sometimes can see the gradation of blue and a more or less unsharp line between the shades. And if we could manipulate "sea-level" — as we actually can in a reservoir — the outline of the lake or the "coast line" of the Pacific would take on the forms of our contour lines in the map.

Another ingenious format combining symbolic constituents with more or less directly simulating elements (see end of this section) is known as "Cartesian diagram". Line graphs, in particular, are subject an increasing number of psychological investigations (e.g. Rinck and Glowalla 1993 and 1994, Gobbo 1994, Maichle 1994, Gattis and Holyoak 1996). The x-y-coordinates, often attached with an arrowhead, symbolize dimensions like "weight" or "time" as well as the direction in which we have to see an increase of the dimension in question. "Time" is in line graphs of this type and in recordings of barographs and sonographs, other than in the non-Cartesian Figure 2, represented as a straight-"forward" dimension. If the coordinated measured values in the diagram represent the gain of weight of a baby from week to week within the first month of life, we can easily present the data (weight after the first week, second week, etc.) in words or digits. But the higher the density of data, the higher the cost of this transformation, and the higher the cost for the interpreter of the table in detecting trends, periodicities and patterns. To point out such trends and patterns is the great advantage of line graphs and of diagrams coordinating the changes (and the dispersion) of two variables. Jacobs' (1994) experimental results seem to meet these general considerations. He found an advantage of bar charts and line graphs as compared to presentation in table format, and "an increase of this advantage with complexity of the task" (Jacobs 1994: 73).

Figure 2a is another example of representations in which simulating and symbolizing are realized by different elements. It is a diagram combining simulative elements ("icons" in the sense of our Version I) with symbols: arrows, which here depict the temporal order of developmental stages. In Figure 2b the situation is different: now the combination is of different symbols, namely words and arrows.

Before investigating such pictures composed of different symbolic elements in the following sections, let us discuss a possible argument questioning the symbolic function of arrows in our visual displays. Are the arrows in Figures 2a and b really symbols? Or are these arrows, or the arrowheads at least, rather icons? Or indices indicating for instance the direction in which the author of the diagram wants us to "read" the diagram?

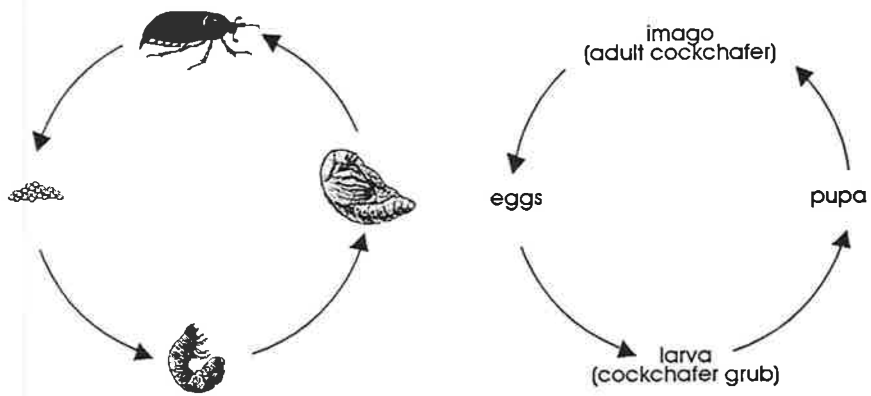

Figure 2.
(a) The diagram on the left combines simulative with symbolic elements
(b) The diagram on the right combines different sorts of symbolic elements

These arrows are indexical in the sense of Peirce, because in Peirce the examples for "indexicality" extend from "natural" indices like the footprints of a man and the indications of a weather-cock or a clinical thermometer to relative pronouns. According to our classification, these arrows are of course

"indexical", because any perceptual object, whether it is a sign or not, has indexical properties. And if the two triangles or the short lines at the end of the longer line are the relics of picturing an arrowhead and are interpreted in the sense of such pictures — as is suggested by the use of the term "arrow" for these elements of the diagram — the "arrows" are iconic, too, so that we should classify them as **iconic** symbols. Why symbols? We have learned to use and understand them as functional instructions, like the stretched arm of a policeman on duty and like certain linguistic expressions, such as prepositions and conjunctions. The arrow points somewhere, saying "this direction", "this way", "from here to there", "from X or after X **follows** (spatially, chronologically, logically) Y", with more or less standardized form and specified meaning — as is the case with the meaning of "follow" — in different contexts (such as formal logics, Cartesian diagrams, traffic signs, dictionaries, etc.). In a Cartesian diagram, symbols — linguistic labels like "f(requency)" or "time", "t", "sec" — make the x/y coordinates symbols: the "blank" figural dimensions get representations of certain conceptual dimensions and variables by virtue of these linguistic labels. If the linguistic labels of the curve or of the dimensions are replaced by a simulating representation — e.g. the picture of an iron weight instead of "weight (in kg)"— and if this simulation is not a well established iconic symbol, then it is again up to the linguistic format (e.g. the words in the key of the diagram) to make the simulation an equivalent of linguistic expressions (like "auditorily" vs "visually presented" in Figure 3).

In order to fulfill its pointing function the "arrow" often has to take on forms which are absolutely incompatible with (the trajectory of an arrow and) the form of an arrow used for shooting. Not only can we find — e.g. in most of the figures in Nakuma (1997) — arrows with two arrowheads pointing in opposite directions. The "arrows" in our visual displays (see Figure 2) need not even be "straight as an arrow". About fifteen figures with unstraight arrows can be found in Wildgen´s (1994) book on "Process, Image and Meaning", and in Logie (1995) one finds unstraight arrows much more often than straight ones. The "arrow" in a tourist map following the path from the railway station to the museum may run around several corners. And the "arrow" used to illustrate the principle of a feedback-loop may be elliptic or circular. In our diagrams 2a and b the arrows again form a circle, this time alluding to the spatial metaphor of the "life cycle" of insects, and maybe also to the "topography" of this particular insect's life cycle, in which

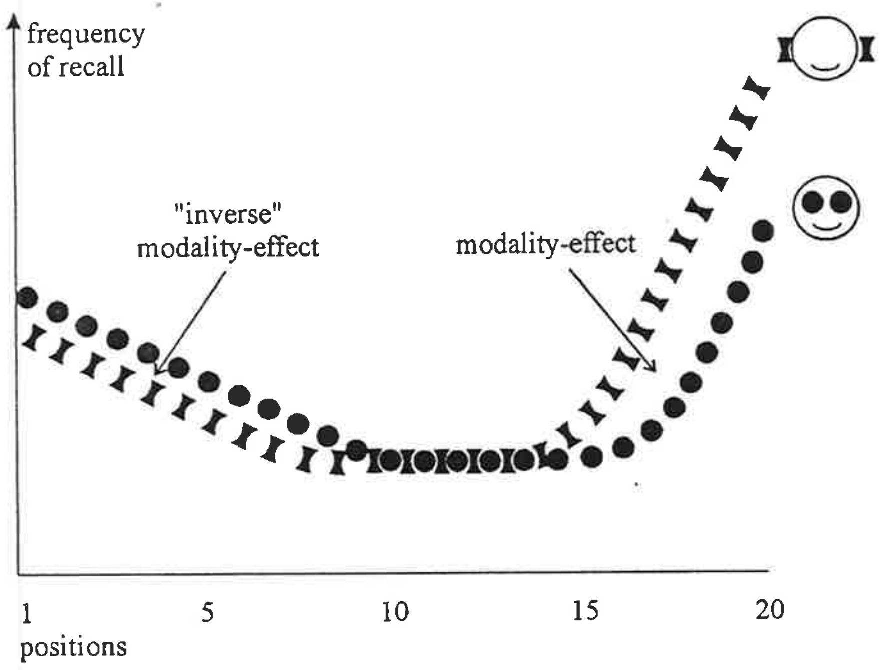

Figure 3. *Serial position curves in immediate free recall of either visually or auditorily presented words* (from Fenk 1981: 223; modified)

only the adult insect lives above earth. (Facing the diagram lying on the horizontal table, this allusion to "under earth" will work especially in cultures where there is a convention to interpret as "lower" or "deeper" what is nearer to the reader.)

Assuming that our curved pointers (illustrating the way to the museum, the feedback-loop, the life cycle) are descendents of drawings of arrows and are symbolic now, we might view this change from the "motivated" representation to an almost "arbitrary" representation as an instance of symbolification. But if so, it might appear as a very untypical case of symbolification for two reasons:

- As soon as a certain representation is used as a representation of a certain concept or proposition — as soon as it is associated with a certain meaning — simulating is no longer as relevant as during the process of establishing this representation as a meaningful sign (Fenk 1987). The cost for simulating activities will be reduced when the sign is frequently used. This loss of simulative properties will — like the loss of transparency in word formation (Fenk and Fenk-Oczlon 1993: 21) — be compensated for by higher familiarity of the sign. But while this economic "erosion of iconicity" (Haiman 1985: 157) usually is viewed as a process essential in "symbolification" and "lexicalization" (Keller 1995: 168), the situation might appear to be completely different in our "arrows" forming a circle or running around corners: **these "deformations" of a straight arrow can hardly be seen as resulting from erosion**. They yield, on the contrary, additional cost in encoding and decoding.
- **The form of symbols is usually expected to be standardized to a certain degree**. The form of logical symbols (like $\cap$, $\cup$, $\rightarrow$), and the form and order of phonemes forming a word have to be invariant to a certain degree in order to be identifiable as this same symbol, whereas the "arrows" in maps, diagrams, and charts can take on different forms (straight, circular, spiral, etc.) in order to answer their context-specific function.
  In other contexts the arrow seems to be quite resistant against erosion processes and deformations. In the heart pierced by Amor's arrow the arrow is straight and still has its swept-back wing. This sign is an iconic symbol in which the arrow has not the function of pointing somewhere but has to look like an arrow.

It is hard to decide whether the "arrows" in our diagrams are in fact descendants of arrows or not. Maybe they are descendants of pointing hands, as the "hands" (sic!) of our watches possibly are. Some road signs make us think of real arrows (Krampen 1986: 40), some others of a ("mummified") gesture of a pointing hand — a "fingerpost" saying "left hand!" or "right hand!" (Krampen 1988: 26). But irrespective of the origin — gestures, arrows, gestures with arrows — of these road signs and of our "arrows" in the diagram, I would state that all of them were used as **a symbol from the very beginning**, but just as a simulation-aided symbol, or as a simulation, which was expected to work as an "indexing symbol". Meanwhile, this symbolic function is so familiar to us, that the "shaft" or the "arm" can take on different forms and additional functions without the risk of misinterpretation. The arrow in the tourist map running around corners points somewhere **and** simulates the way from the railway-station to the exhibition, and the arrows in Figure 2 point somewhere **and** allude to the metaphor of the insect's "life cycle". From this point of view, we may indeed see some parallels between linguistic symbols and the diagrammatic symbol(s) we call "arrow" — parallels to onomatopoetic words, and parallels to **economic** phenomena. Signs, and especially already familiar words, get shorter by fusional processes and are candidates for becoming part of new compounds and for representing different, more or less literal meanings in different contexts. And maybe we should view the arrow in the tourist map, running around corners in order to show the way to the exhibition, as a result of an economic "erosion" or fusion of a series of single straight arrows pointing straightforward, to the right, forward, to the left, etc. Needless to say, our long and bent "arrow" communicates the best way to the exhibition in a much more economic way than such a series or a verbal description.

On superficial inspection, our (unstraight) arrows' semiotic status may appear like that of the contour lines in the map. But the arrows are symbols: they basically represent a concept or proposition ("this way"), regardless of possible additional functions like simulating (e.g. following the road to the museum on the tourist map) or alluding to a metaphor, and regardless of whether or not they need additional symbolic labels telling us which town or museum we can reach "this way" or which dimension (time, weight, etc.) we have to think "this way". The contour lines, however, do not represent concepts or propositions. They do not represent the concept "contour line" but **are** contour lines. Their only function is to simulate the "outlines" of a concrete landscape at different sea-levels. They are a simulative element of the map and depend on abstract — though sometimes iconic — symbols ("1500–2000 metres"; or a certain colour representing this range by virtue of "1500–2000 metres" in the key of the map) to specify the respective region and sea-levels.

The "arrows" in diagrams are known as a thorny classification problem in semiotics. Even more knotty is the question about the semiotic status of automatic recordings: are the recordings of barographs, electrocardiographs, seismographs, etc. iconic?

If we accept our more restrictive Version II for defining *iconicity*, the answer is clear. According to this version only symbols can be iconic. The recordings mentioned are no symbols, because they do not represent concepts or propositions. And despite the fact that the method of drawing contour lines and the method of recording the electrophysiological activity of the heart or the brain is of course standardized, the patterns produced by these recordings are no symbols and therefore not *iconic* in the sense of Version II.

Problems arise if we use the weaker Version I, because this version allows a considerable spectrum of more or less restrictive positions. Within this version the answer to our question — are the recordings *iconic*? — depends on our decision of whether we can view these recordings as *simulations* or not.

– The most restrictive and least problematic position within Version I is to view the recordings of barographs, electrocardiographs, etc. as cases of "indexical similarity", i.e., of similarity established by direct physical connection between the recordings and the recorded. If so, these recordings are not iconic, since we have excluded "natural indices" from sign functions. The situation is, according to this view, like the situation in a photograph, which is, in principle, nothing but a stored mirror image. Similarity is not established by the simulating actions of a mediating person. The **isomorphic relation** between "reality" and photo is exclusively a matter of physics, achieved without any mediating "intelligent" action. The mediating activities and the creativity and intelligence of the photographer — intelligence in the sense of *interlegere* ("to select") — may make something stand out and may reduce similarity in a well calculated way, but **not establish** similarity. According to this position, our recordings are not even in the weaker Version I instances of *iconic signs*.
  Let us take a temperature curve as an example in order to determine the relevant borderline between the iconic and the non-iconic. There are, as we know, isomorphic relations between (changes of) body temperature (a), length of mercury column (b) and values in the visual display (c). Isomorphism between (a) and (b) is non-simulative and therefore non-iconic. Isomorphism between (b) and (c) is simulative and iconic if and only if (b) is transformed into the chart by an actually mediating subject instead of an automatic plotter.

- Defining *simulation* in a less restrictive way leads into severe problems. Should we talk about "simulation" despite the fact that — in the case of the registration of brain potentials, for instance — we cannot know in advance what will be recorded, i.e., what will be the "object" of our "simulation"? Where is the actually mediating and simulating subject when we send automatic cameras and sonographs, attached to the head of a whale, through the ocean, and what are the "objects" to be "simulated"? In such cases one could, nevertheless, claim that there was a person having specific interests and hypotheses regarding a more or less specified "domain". But what about the case of a camera which falls from someone's hands and is triggered thereby? "Is the very same photo an icon when produced intentionally, and non-iconic, when produced inadvertently? Or do we have to go back as far as the intentions of those who have invented, constructed, produced" (Fenk 1997: 221–222) the camera? Or should we say that in some automatic recordings (like a seismograph or an electrocardiograph) the situation is different from that in the photo, because here the selected aspect of "reality" — the temporal pattern of "waves" — is recorded according to a conventional corset we know from the Cartesian diagram with its two orthogonal dimensions (latency on the x-axis, amplitude on the y-axis). And if a registration or recording is the output of such an extremely selective and extremely conventionalized, isomorphic transformation, this might be regarded as sufficient for *simulative representation*. But to be "more or less selective and conventionalized" is a matter of degree.

Similarity is a matter of degree and of discretion, too. Cartesian diagrams allow a wide spectrum of representations ranging from rather rare cases of direct perceptual similarity with the represented (see the first example below) to representations where the category of "similarity with the represented" is inappropriate. Why that? The framework of diagrams — the orthogonal arrangement of two axes (x, y) representing two "dimensions" — is, in principle, the same construction as a two-dimensional matrix and is in no way isomorphic or "iconic". The shape of a curve generated within this matrix is determined by this construction, by the kind of (conceptual or empirical) "dimensions" combined and, in the case of empirical dimensions, by the data set to be represented:

- Ballistic curves (with a take-off angle of 30°, 45° and 60°) illustrated in a diagram (with the horizontal distances on the x-axis and the vertical distances on the y-axis) will be similar to what I can see if I watch the trajectory of a javelin. (In particular, if I hold the encyclopedia where I found the diagram, upward).
- Maybe some of us will "see" some similarity between the acceleration of a rocket or a sprinter and the shape of what we (metaphorically) call the "accelerated curve" in a diagram with the time passed since starting on the x-axis and the speed gained on the y-axis. But do we "see" such similarities if the diagram represents the time (y-axis) a sprinter needs for achieving his maximum speed as a function of the time (x-axis) invested in a special training program? And if it represents the development of the mean life expectancy during the last decades, or the calculated trend predicting, according to specified assumptions, the increase of the mean life expectancy during the following decades?
- Facing a line graph visualizing the information of events in bits (y-axis) as a mathematical function of the probability of events (x-axis) corresponding to the formula "information (in bits) = 1/probability", the question about perceptual similarity with the represented becomes absolutely invalid.

In all of these examples the axes (with or without arrowhead) are symbols: they do not represent arrows. The very same line represents — depending on the label attached — time, or income, or probability. The orthogonal arrangement is a very useful (with respect to automatic recordings, too), but in other respects it is an "arbitrary" construction. Where, if not in the diagrams and recordings, can we "see" an orthogonal relation between age (x-axis) and weight (y-axis) of a baby?

Nevertheless, Cartesian diagrams like line graphs are "self-explanatory" to a certain degree. The way we construct and interpret them seems to be inspired by common (and metaphorical?) expressions like *high* informational content, *high* cognitive load, *high* frequency, *high* tones, *high* pitch-levels.

Our languages are infested with such topological expressions applied to non-spatial "objects". Historically, it must have been an immense economic advantage to be able to go back to an already highly differentiated repertoire of topological description when communication turned to more abstract "topics" (a word which again derives from the Greek *topos*, "place"). These figurative applications are internalized by the members of a linguistic community during language acquisition. One may regard them as spatial metaphors, or doubt their metaphorical character (Miller 1985: 154). Anyway, they form the way we construct and interpret musical notation — "higher" tones on upper lines and therefore higher on the music stand — or diagrams (as in Langacker 1997: 22, 23) visualizing "higher" stress or "higher" pitch-level along the "vertical" y-axis.

In the two-dimensional space of our Cartesian diagrams, other than in our gestures and in (American) Sign Language, the time-line can not directly be encoded as a back/front dimension going through the subject's body. Such an encoding would correspond to the spatial metaphor of the "time behind" or "before us", and this is a very "convincing" metaphor with respect to what Cooper and Ross (1975) call the "prototypical speaker", who conceives himself as the starting point of any relevant perspective: the subject moving forward in space reaches the more distant (less close) later (Fenk-Oczlon 1989: 535), i.e., in the more "distant" future. The y-axis, which would offer itself easiest for encoding this time-line going through the body of the subject who draws and/or views the diagram, seems to be reserved for encoding "higher/lower" quantities, amounts, degrees, intensities, etc. of what in many cases can be specified as the "dependent variable". And the direction of the remaining x-axis usually is — probably influenced by the direction of within-line writing and reading (Tversky et al. 1991) — from left to right in our diagrams.

2.3. *Logical pictures: figural symbols interacting with linguistic symbols*

Logical pictures like the famous Ogden and Richards triangle and like our Figures 1 and 5 (A, B) are often described as "non-representational" or "arbitrary". But if so, where do they get their form from? The Venn-diagram we have used in order to illustrate our two versions of *iconicity* is not iconic, because it is not — and it cannot be — similar to what it represents. It is not "non-representational", because it represents conceptual relations. The graphical configuration is symbolic by virtue of the symbolic labels or keys giving the graphical elements (areas of circular or quadratic or any other arbitrary form) their relevant and specific meaning. It is arbitrary in the sense that different forms can represent the very same meaning and that the very same form can represent different meanings. But diagrams like Figures 1 and

5A are not completely "arbitrary"; they refer to the spatial metaphors of "overlapping" concepts and "inclusion". The elliptic or rectangular areas do not represent elliptic or rectangular areas, but **are** elliptic or rectangular areas used in order to make conceptual relations transparent by superimposing graphic figures on our figures of speech (Fenk 1992a). Figure 5B and the numerous semiotic triangles (cf. Ogden and Richards 1923/1985: 11, Habermeier 1988: 271) also accomplish the function of making conceptual structures transparent. But Figure 5B refers to the spatial metaphor of "conceptual hierarchies" and to the corresponding "subsumption metaphor", and the semiotic triangles or Bühler's (1965: 28) Organon Model to the so called "path metaphor".

From the point of view of Kress and Leeuwen (1996: 7) "the process of sign-making is the process of the constitution of metaphor", and "signs are never arbitrary". Our description of logical pictures might well fit into such a general framework. But *non-arbitrary* has a broader meaning than *iconic*, and logical pictures are not iconic, regardless of whether we accept Version I or Version II for defining *iconicity*. According to our classification system logical pictures, as well as the metaphors from which they derive, are of a symbolic nature. Iconic symbols, i.e., "icons" in the sense of Version II, as well as logical pictures, allude to well-known things in order to help the recipient to grasp or remember what is meant by the representation and, moreover, to facilitate the ("lexical") accessibility for the active user of that symbol. But while in iconic representations the allusion is brought about by simulation of "objects" of our perceptual world, the allusion in logical pictures is to the figural allusions of linguistic symbols.

3. Experiments with logical pictures in con-text

3.1. *Hypothesis*

Rost and Strauß (1993: 73) found an advantage of the graphical feedback over propositional representation "only if it is presented in a format which corresponds to the mental model of the problem solver", and Gattis and Holyoak (1996: 231) propose, as a general interpretation of their experimental findings, "that graphs provide external instantiation of intermediate mental representations, enabling people to move from visuospatial representations to abstraction through the use of natural mappings between perceptual and conceptual relations".

Our general assumption is that such mapping processes are mediated by spatial metaphors. These metaphors seem to play the role of a cognitive tool which we can use to create new tools like "logical pictures" which in turn materialize the metaphor's virtual space in a really spatial, two-dimensional analogue. This two-dimensional representation provides "a form or a matrix permitting direct visual control of the admissibility of mental drafts, models, and operations" (Fenk 1994: 58).

A more specific hypothesis regards logical pictures in instructional and scientific texts and the effects of an esthetic principle of text-picture composition on the intelligibility of the texts: **The more precise the mapping between the spatial metaphor (linguistic format) and the logical picture (graphical format), the higher the efficiency of the picture in reducing the cognitive costs of text processing.** This more specific hypothesis was subject to the evaluations described below.

3.2. *Method*

Measurement: A method for measuring text-picture coherence, i.e., the "transinformation" between text and picture (Fenk 1993: 155) was developed along the following lines. The informational content of a text combined with different pictures is determined using the guessing-game technique, whose principle derives ultimately from Shannon (1951) and whose advantage as a measure for comprehensibility is for instance discussed in Groeben (1982). The picture that makes the greatest contribution to reducing the informational content of the text is the one that "fits" the text best (largest transinformation) and also makes the greatest contribution to rendering the text comprehensible. The extent of this "information contribution" can be determined quantitatively (in bits). Instead of Shannon's original guessing game technique, and instead of an even more precise but also more time-consuming technique proposed by Fenk and Vanoucek (1992), Weltner's (1973) guessing test for single letters was applied. In this procedure, the guessing subject has only one guess per "sign" (letters, "end of word"). After his guess (e.g. "T") the subject gets the feedback: either "Yes!", or, if wrong, the correct sign (e.g. "N!"). The punctuation was added by the experimenter.

According to Weltner's formula, the mean subjective information (H) of a text can be calculated from the relative frequency of false guesses n(f): $H = 0{,}27 + 4{,}93 \cdot C$, with $C = n(f) / n$.

Design: Designing relevant experiments is difficult because the text-picture combinations to be compared have to be equivalent in their "meaning". One needs at least two different text-picture compositions representing the very same meaning. One way is to create a situation where the hypothesized tendency (e.g. preference for an upward ordering of chronology in "phylogenetic trees") should come into conflict with — and maybe overcome — approved tendencies of diagram construction and reception (e.g. the left-to-right ordering of chronology in "normal" flowcharts and time series). A second solution is to find two different spatial metaphors which can be used for depicting the very same conceptual structure.

Both design ideas were realized. First of all in the previous rating-tests reported in Section 3.3 below, where the output is the preferences of the subjects for different text-picture compositions. However, in the guessing game it is the performance scores of subjects that are used as the measure for the appropriateness of text-picture composition (see Section 3.4).

Materials: One text had to be constructed for the first design, and two different texts for the second design.[3] The pictures used in the second design (Figures 5A and B) are logical pictures in a narrow sense of the word, i.e., in the sense of graphics used to depict those ("logical") relations between concepts which are prerequisites for or part of definitions and syllogisms. They illustrate the very same conceptual relation but are based on different spatial metaphors. The pictures used in the first design (compare Figure 4) are, in some way, connected with empirical data (measured and estimated values) and realize, in some way, a Cartesian diagram: in the upward position, the invisible y-axis represents chronological order, and the invisible x-axis represents the degree of relationship (obviously in the sense of "distances" to the reference point "homo"). This diagram seems to be motivated by spatial metaphors in at least two respects: The transformation of "age" and "relationship" into spatial dimensions seems to be inspired by figural expressions like "temporal distances" and like "near kin" versus "remove relationship". And, secondly, it is a "**dendro**gram" alluding to the metaphor of "ramification" or "embranchment", and, in upward position, to the metaphor of the "**phylo**genetic **tree**".

3.3. *Pilot studies*

In a pilot study of the first type (Fenk 1992b) a text on the evolution of hominides was presented. Expressions related to the "phylogenetic tree" metaphor prevailed in the text. In a rating-test, the diagram of the "tree" (see Figure 4) was offered in four different orientations: upward, downward, to the right, to the left. Subjects were asked to decide which one of the four diagrams they would combine with the text. Our central hypothesis was that the upward orientation of the "phylogenetic tree" should be the most successful version. Originally it was expected (Fenk 1991: 14) to be followed by the downward version which corresponds to our reading direction from line to line and to the "normal" ordering of chronology in the genealogical tables in our history books, and the orientation to the right. The right to left ordering was expected to be the loser in the contest. For the results see the first line of Table 1: 50% of the subjects chose the upward-version as the best fitting one, and 69% chose one of the two vertical orientations. Right to left ordering received only 7% of the choices. But, contrary to our hypothesis, the left to right ordering — corresponding to our direction of within-line reading and to the "normal" ordering of chronology in line graphs (time is the independent variable which usually is represented by the x-axis) — proved to be slightly "better" (20 choices) than the downward ordering (16 choices). For the guessing tests, our hypothesis was modified according to this result.

In a pilot study of the second type (Fenk 1996) the "inclusion metaphor" (predominant in text a) and the "subsumption metaphor" (predominant in text b) and corresponding diagrams — see pictures A and B in Figure 5 — were used in order to explain the relations between taxonomical concepts. A rating-test was applied: 43 students were given one of the two text-versions (a or b) and both diagrams, and were asked which of the diagrams they would combine with the given text. 67% of the subjects decided, in line with our hypothesis, in favour of the combinations A a and B b.

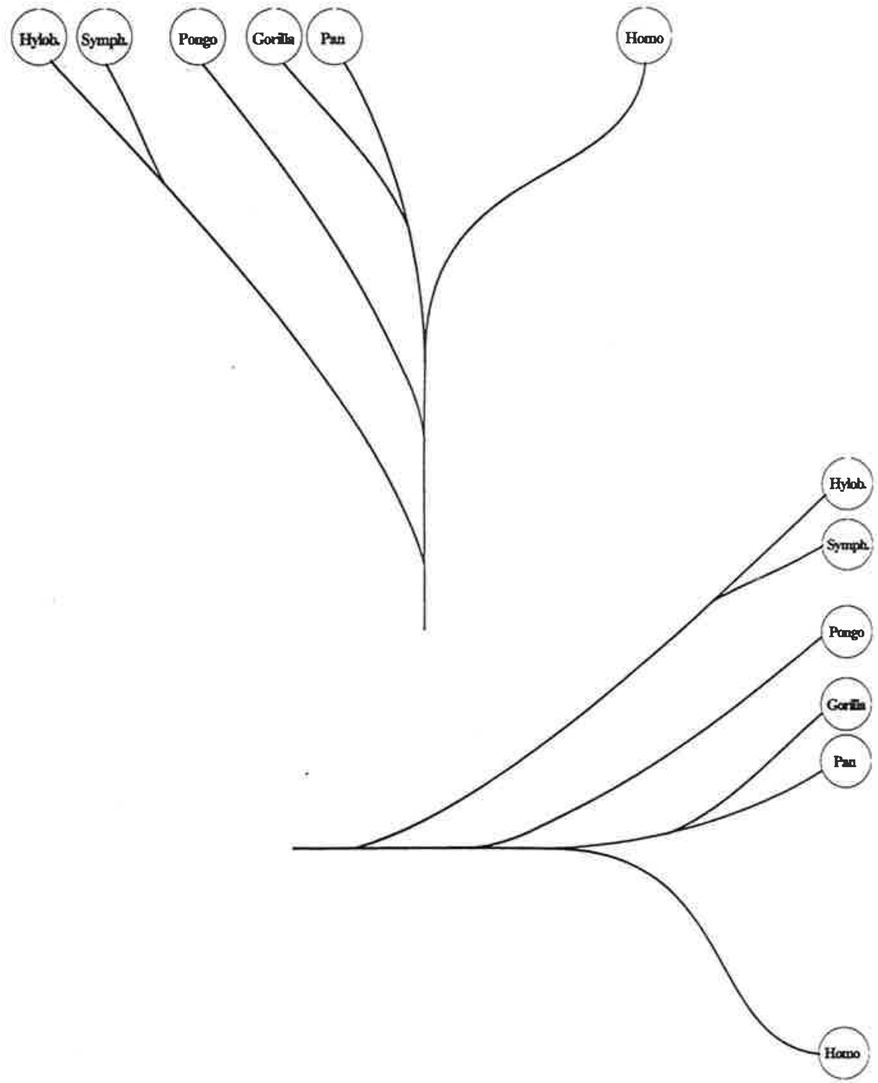

Figure 4. *The dendrogram in the two most successful orientations (see text). The two remaining orientations used in the experiment where 90°-rotations of these dendrograms, and not their mirror inverted counterparts.*

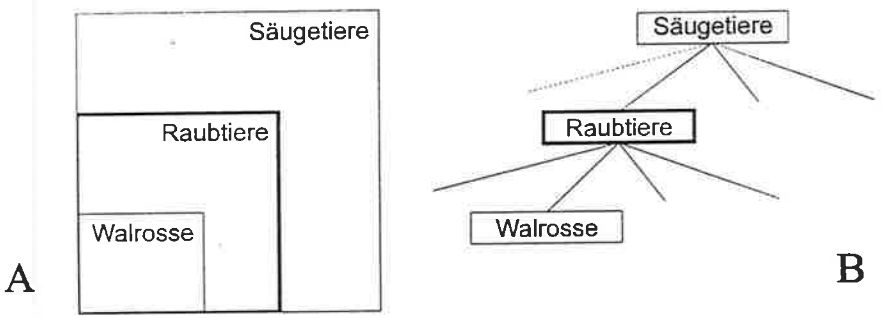

Figure 5. *Picture A alludes to the inclusion metaphor, picture B to the subsumption metaphor.*

3.4. *Two experiments using the guessing game technique*

Hypotheses: Hypotheses concern the **reduction of the text's informational content achieved by different drafts of diagrams.** As to the "phylogenetic tree", the following rank order was expected: upward > to the right > downward > to the left. For the second experiment, involving the Venn-diagram (Figure 5A) and the graphical hierarchy (Figure 5B), it was expected that Figure A would be more successful than Figure B in text a, alluding to the "inclusion metaphor", whereas in text b, alluding to the subsumption metaphor, Figure B was expected to be more successful.

Procedure: The principle of the guessing game technique used was already outlined above. Some further clarifications:

- During the guessing game, each subject had all the following before his or her eyes: the picture, the first sentences of the "textbook" text, and the incremental part of this text which had to be completed letter by letter.
- The "experimenters" carrying out the guessing tests were — as already in the pilot-study (Fenk 1992b) — university students and participants in a course in "Media Communication". Each of them was instructed to carry out the guessing test with four different subjects. Each one of these subjects was confronted with one out of the four orientations of the "phylogenetic tree" or, in the second design, with one of the four possible text-picture-combinations: aA, aB, bA, bB. This provision — all four conditions of a design carried out by each one of the experimenters — should diminish possible effects of different habits of the experimenters, such as quick versus slow feedback.

Subjects: The "experimenters" were asked to conduct the guessing game only with persons having completed high-school in order to guarantee a minimum age of eighteen and a certain educational level. Unfortunately in some of the experimental records delivered the data regarding age and gender were missing. In the first design, of 26 persons per condition, data regarding gender were available in 18 cases and data regarding age in 19 cases:

Orientation of dendrogram:

upward	10 male, 8 female	mean age: 25
to the right	9 male, 9 female	mean age: 27
downward	8 male, 10 female	mean age: 26
to the left	10 male, 8 female	mean age: 28

In the second design one of the 10 experimenters did not report gender and age data:

text/picture

a / A	4 male, 5 female	mean age: 25
a / B	6 male, 3 female	mean age: 23
b / A	2 male, 7 female	mean age: 28
b / B	4 male, 5 female	mean age: 32

Results: Results of the dendrogram-experiments are presented in Table 1. They show the following:

- There is a clear correspondence between the relative frequency of choices for the single dendrogram orientations and the reduction of text information yielded by these orientations: the more choices, the lower the informational content of the text.
- The upward-orientation, which was expected to be the winner, was the best-fitting one according to all criteria: most choices, highest predictability of the text (lowest number of false guesses and therefore lowest informational content), highest speed in guessing. The orientation "to the left", which was expected to be the loser of the guessing game, was the worst version according to all of these criteria.

- The results of the comparison between "to the right" and "downward" are not as clear. The orientation to the right was slightly more successful in the rating test (number of choices). In the guessing game it yielded much more accuracy (lower number of false guesses), but speed of guessing was much lower. Bearing in mind the well known speed-accuracy tradeoff it is difficult to decide if the orientation "to the right" actually was more successful in the guessing game.

Table 1. *Results of a previous rating test (Fenk 1992b) with a total of 84 subjects (upper line in the table) and the results (mean values) of a guessing game with a total of 104 subjects.*

orientation of dendrogram:	↑	→	↓	←
n of subjects and choices: 84	42	20	16	6
n of subjects: 104	26	26	26	26
n of false responses n(f)	118.4	121.6	127.6	128.8
subj. information (per sign) in bits	1.433	1.464	1.523	1.535
time needed in minutes	37.0	39.2	37.7	39.7

The results of the "contest" between the Venn-diagram and the graphical hierarchy are set out in Table 2:

- In the overall contest, text b (subsumption metaphor) turned out to be much more predictable than text a (inclusion metaphor). And picture B (graphical hierarchy) turned out to be more successful than picture A (Venn-diagram) — though one might have expected a better fit between picture A and text b than between picture B and text a with respect to the fact that the arrangement of the taxonomical terms in A is the same as in the graphical hierarchy B. Correspondingly, the text-picture composition b B was the most successful combination.
- Despite this unintended overall superiority of text b (and, less pronounced, of picture B), the results conform to our hypothesis. In combination with text a, picture A was more successful than picture B in the number of choices and in the predictability of the text yielded by the pictures, while in combination with text b picture B was better than picture A in these criteria. Only the criterion "speed of guessing" in text a does not conform with our expectations.

Table 2. *Results of a rating test with a total of 43 subjects ("n of choices ..." in the table) and the results (mean values) of a guessing game with a total of 40 subjects.*

		picture A	picture B
	n of choices for above picture:	14	9
text a (484 signs to be guessed)	n of subjects	10	10
	n of false guesses n(f)	136.9	138.7
	subj. information (per sign) in bits	1.664	1.683
	time needed in minutes	32.5	24.6
	n of choices for above picture:	5	15
text b (473 signs to be guessed)	n of subjects	10	10
	n of false guesses n(f)	131.3	124.0
	subj. information (per sign) in bits	1.639	1.562
	time needed in minutes	30.0	21.0

Practical consequences for text-picture composition. Conscious visualization of spatial metaphors will enhance the intelligibility of specified texts! And the coincidences found in both experimental designs between subjective preferences (number of choices) of certain text-picture combinations and a higher predictability of the texts within these combinations indicate that — in cases of conflicting design-principles — a simple rating of a sample of addresses can give a clue as to the most appropriate design for these addresses.

4. Conclusions

The conceptual framework presented distinguishes two functional types of representation: simulating (i.e., establishing similarity by simulating or imitating the represented) and symbolizing (i.e., denoting concepts or propositions). And if, based on the fundamental distinction between these functions, the classification is of "sign-bodies" (i.e., objects realizing these functions), this results in non-disjoint classes of representations. We called the objects these classes have in common "iconic symbols". *Icons* can either be identified with any (result of) simulation, or, in a more restrictive definition, with "iconic symbols".

The attempt to apply this framework for defining the semiotic status of different (diagrammatic) representations revealed different types of interaction between different sign-properties and different sign-elements:

(1) **In *iconic symbols* symbolizing falls together with simulating.** Examples are onomatopoetic words, pictograms, or the blue colours in the geographical map representing different depths of the ocean.

(2) **Other representations realize simulating and symbolizing by separate elements:** the contour lines in the map as well as the curves in Cartesian diagrams are not symbolic, but can be viewed as simulations interacting with (iconic) symbols like the "arrows" representing the two orthogonal dimensions of the Cartesian diagram, and like the linguistic labels or numbers attached.

(3) **In logical pictures, (para)linguistic symbols interact with figural symbols.** These figural elements (of Venn-diagrams, of graphical hierarchies, etc.) are closely connected with the language system. They get their specific meaning through linguistic labels and keys. They are "arbitrary" in some respect — the very same figural elements may represent different sets, concepts, relations, and the very same sets, concepts or relations may be represented by different figural elements — but are "motivated" by spatial metaphors. They can not be similar to what they directly represent. Whether one accepts version I or II for defining *iconicity,* they are not iconic but of symbolic character.

Human reasoning, as we know, is accompanied and enhanced by "mental models" (Johnson-Laird 1983) or "mental images", and "graphical images" are sometimes assumed to "catch characteristic features of mental images" (Wildgen 1994: 18). Spatial metaphors are a linguistic equivalent of such mental representations. Metaphors in general (Klix 1992) and spatial metaphors in particular (e.g. Macdonald-Ross 1979) seem to play an important role in creative thinking and in the process of sign-production — for instance in the production of those signs we have viewed as two-dimensional analogues of spatial metaphors. These metaphors are the collective property of a linguistic community and hence guarantee that a picture language based on them (e.g. Venn language, Cartesian language) is, within this linguistic

community, self-explanatory to a certain degree. Such diagrams serve, moreover, as an "external memory" appropriate for a visual examination of the appropriateness of a certain mental operation. The visualization of spatial metaphors seems to encourage the "internal " mapping between propositional thinking and mental modeling.

Two experiments were conducted in order to test the following hypothesis. The more precise the mapping between spatial metaphor (linguistic format) and logical picture (graphical format), the higher the efficiency of the picture in reducing the cognitive costs of text processing. In the first experiment the very same text on the evolution of hominides, using expressions belonging to the "phylogenetic tree " metaphor, was combined with four different orientations of a dendrogram: upward, to the right, downward, to the left. The upward ordering of chronology was expected to overcome approved tendencies of diagram construction such as the left-to-right ordering in "normal" time series or the downward ordering known from the genealogical tables in history books. In the second experiment two different spatial metaphors — the "inclusion metaphor" (text a) and the "subsumption metaphor" (text b) — were used in order to depict the very same taxonomical structure. It was assumed that a Venn-diagram would better match with text a and a graphical hierarchy with text b.

In both experiments two measures were used for determining the fit between text and picture: a simple rating test (number of choices) and a more time-consuming guessing game technique (relative frequency of false guesses by subjects who try to guess a text corresponding to a figure). Our experimental results — subjective rankings as well as performance data — confirm the hypothesis that a precise mapping between spatial metaphor and diagram is apt to enhance the interaction between propositional and visuospatial reasoning in text comprehension.

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Notes

1. The terminological framework presented is developed from Peirce's theory of signs but meets, in this respect, a second and younger tradition using the terms "symbol" and "icon" as well. Authors like Mac Cormack (1985), Jorna (1988 and 1990), or Fischer (1997), do not refer to Peirce but either to Goodman (1968) or to influential works in

cognitive science, like Kosslyn (1980), Newell (1980) or Pylyshyn (1984). A characteristic of this tradition is a very broad meaning of "symbol" — almost as broad as the meaning of *sign* in Peirce — and a preference for the term "symbol theory" instead of "semiotics". Jorna (1988: 175) for instance proposes to call "the elements of presentation" "symbols", whether the presentation is linguistic or pictorial.

2. "The same Perceptible may, however, function doubly as a Sign. That footprint that Robinson Crusoe found in the sand, and which has been stamped in the granite of fame, was an Index to him that some creature was on his island, and at the same time, as a Symbol, called up the idea of a man" (Peirce 1906: 496).

3. Three "textbook" texts had to be completed in the guessing games. Text b (473 signs to be guessed) is given here as an example, with the part to be guessed in capitals.
Das Walroß frißt hauptsächlich Muscheln und Krebse. Würden Sie es als "Raubtier" bezeichnen?
In der Alltagssprache wird der Begriff "Raubtier" recht uneinheitlich gebraucht: MANCHMAL FALLEN NUR LANDRAUBTIERE DARUNTER, WIE KATZEN, HUNDE, BÄREN UND MARDER, EIN ANDERES MAL WIEDER VERWENDET MAN IHN ALS OBERBEGRIFF FÜR ALLE MÖGLICHEN RÄUBERISCH LEBENDEN TIERE, ETWA RAUBVÖGEL ODER RAUBFISCHE. EINDEUTIGER GEREGELT IST DIE VERWENDUNG DES WORTES IN DER ZOOLOGISCHEN SYSTEMATIK: HIER FÄLLT "RAUBTIER" UNTER DEN OBERBEGRIFF "SÄUGETIER" UND IST SEINERSEITS OBERBEGRIFF FÜR DIE LANDRAUBTIERE SOWIE DEREN FLOSSENBEWEHRTE VERWANDTE, DIE SEEHUNDE, OHRENROBBEN UND WALROSSE.

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