A Cognitive Model of Conceptual Knowledge

In the previous chapter we mainly dealt with grammatical individuation as reflected in the grammatical properties of nouns. Conceptual individuation was discussed only in as far as it was necessary to distinguish it from grammatical individuation. In this and the next two chapters a model of meaning will be discussed which will form the basis for describing the conceptual individuation of nouns in Chapter 5 and which will form the background for explaining the semantic relations and information found in dictionaries in Part II.

Whereas grammatical individuation can be characterized as the linguistic way in which we quantify entities in expressions, conceptual individuation can be described as what we quantify from a conceptual point of view. In other words: what is the conceptual status of the entities or entity making up the grammatical ensemble (set or mass) associated with a term? This question is traditionally addressed in two ways:

- a semasiological approach which starts from the words in the language, defining meaning individually for each word irrespective of our general conception of the world.
- an onomasiological approach which starts with a concept given independently of the words of a language and defines all words that somehow incorporate this concept.

In the semasiological approach (which is also followed in FG) words are typically defined in terms of semantic relations with other words (the relational approach, see Chapter 4). Because meaning is defined in a language-internal way, the semasiological or fully relational approach does not make clear how meaning is matched with an independently given notion of denotation. However, as we saw in Chapter 1, the matching of meaning or denotation with our 'normal' perception of the world may be crucial to determine the individuation effect of terms:
Only because we know what denotation is normally associated with the noun "car" can we make sense of the deliberate mismatch with the perceived instance of the concept bike.

The onomasiological approach, on the other hand, does claim to define the different naming relations of words with an independently given concept. However, the problem for this approach is that it does not provide the criteria with which to access these concepts irrespective of language, nor can it explain how to comprehensively select all the words that can possibly incorporate this concept. Either concepts are still named by words (in capital letters, e.g. CAR instead of "car") or the approach is applied to small well-defined expert domains where the denotation can explicitly be defined (e.g. a fixed set of chemicals). Unless denotation is formally pre-defined we need a model of conceptual knowledge to be able to link the meaning of words to the obvious way in which we cut up the world: the denotation.

In this chapter I will therefore start by describing the basic principles and structures underlying conceptual knowledge from a general cognitive point of view. In Chapter 4 these insights will be used to anchor the semantic relational system of meaning as defined in FG to our general conception of the world, making it possible to follow a cognitively based onomasiological approach. In Chapter 5 different models of conceptual individuation for different semantic classes of nouns will be proposed on the basis of their different naming relations with such an independent notion of denotation.

From a cognitive point of view knowledge is needed to process information and the most basic constraints on what we know come from the hardware restrictions on information processing (section 3.1). As such the question addressed in cognitive psychology is not so much what we know but why we know and how we get to know. In this chapter we will discuss different types of knowledge, their representation, purpose and structure (sections 3.2, 3.3 and 3.4). In section 3.5 I will describe how the different types of knowledge can be utilized and how they interact. Finally, in section 3.6 I will give an overview of the distinctions made. I will only describe those aspects which are relevant for our discussion of individuation.

### 3.1 Memory as a component in information processing

Knowledge is stored in memory and cognitive psychologists have made various claims about it based on experimental evidence showing limitations in our processing capacity (responses to stimuli), various kinds of brain damage, language learning, or other clearly measurable external behaviour. Within most of these experimental studies memory is discussed in relation to information processing in general. Three main activities are distinguished in information processing: the processing of incoming data, the storage of these data, and the retrieval of data. Each of these steps can be subdivided into smaller ones and associated with different characteristics of the mind.

Lindsay and Norman (1977) describe such a model of memory in which three storage components are distinguished on the basis of different limitations:

- a very short storage of sensory information coming in (sensory information storage or SIS),
- a somewhat longer storage of interpreted information in so-called short term memory (STM),
- a permanent storage at a deeper level of interpretation in long-term-memory (LTM).

The processing of information via these stages is controlled by a fourth and separate component (a controller or supervisor) in which two conflicting strategies are coordinated:

- collecting as much information as possible from the input and the context in which it occurs: the bottom-up or input-driven approach,
- predicting as much information as possible from given knowledge or building up expectations about possible input: the top-down or given-knowledge approach.

The bottom-up procedure uses a pattern-matching device to match incoming data against available knowledge, whereas the top-down approach uses available data to build up expectations for incoming data and to focus attention on particular aspects of the input. The controller
probably continuously combines information from both strategies (Lindsay & Norman 1977, Kahneman & Treisman 1984):

### Figure 12: Three stages of information storage.

<table>
<thead>
<tr>
<th>CONTROL MECHANISM</th>
<th>SIS</th>
<th>STM</th>
<th>LTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>top-down strategy: focusing attention, building up expectations</td>
<td>sensory data</td>
<td>pattern-matching</td>
<td>integration expectations</td>
</tr>
<tr>
<td>bottom-up strategy: controlling pattern matching</td>
<td>attention</td>
<td>permanent but problems with retrieval of details</td>
<td>unlimited items at level integrated in other knowledge</td>
</tr>
</tbody>
</table>

| duration | up to ca. 60 sec. maintained by rehearsal only. | 0.5 sec. cannot be repeated. |
| quantity | single sharp perceptual image. | ca. 7 items at some interpretation level. |
| "sound" | "words" | "meaning" |

The distinction into different stages is based on a functional division of memory supported by various experiments showing different limitations in either storage capacity (number of items and duration) or retrieval capacity. STM is limited to a duration of about 60 seconds, can hold ca. 7 items and is restricted to more superficial data, whereas LTM seems to be permanent, and unlimited in terms of items, but what is retrieved are not superficial properties but deeper interpretations. In STM the form of the information is temporarily retained, whereas in LTM the form seems to be lost and only the interpretation stored. People cannot remember for example the actual words or the active or passive form of sentences that have been used but they know whether some content was expressed. Forgetting with regard to information stored in LTM is not explained in terms of deleting information but as having difficulty in accessing or retrieving information. In this view no information gets lost; rather it cannot be recalled, found, or accessed any more. Conscious retrieval of information from LTM seems to depend strongly on two factors: reconstruction of the context and the degree of integration of the knowledge in other knowledge. The greater the organization and coherence achieved, the easier it will be to retrieve information in LTM.

This strong separation of memory into separate components has come under attack (Sanford 1985). First of all, it fails to explain that people with particular types of brain damage, whose STM is limited to one item instead of seven, still can recall nine out of ten paired-associates after three trials and a six-hour delay (Shalice and Warrington 1970). Apparently the limitation of STM has not resulted in a corresponding loss of functionality. It also turned out that semantic information is also stored in STM and more superficial 'articulatory' information in LTM. As an alternative to the separate 'box-model' of memory Craik and Lockhoret (1972) propose a depth-of-processing model. Memory should be viewed as an integral part of the whole information-processing system. Different tasks either demand or facilitate the treatment of stimulus materials in different ways by the entire system, and what is remembered depends upon how these are treated. Differences in performance are due to processing for different tasks and not to different architecture within the brain. Memory is then a trace of processing activities carried out with respect to a given task. The experimental evidence suggests that traces of shallow processing are less durable, or less accessible than traces of deeper processing. Another criterion, although one closely related to depth of processing, is the diversity of resources deployed in processing. The more processing is spread over various resources and levels, the better the memorization.

An alternative explanation of the limitation in STM which does not commit itself to distinguishing two separate components of memory is the notion of Working Memory (Baddeley and Hitch 1974). Working memory (WM) is a kind of buffer in which data are temporarily held, during which time a person has the option of processing it in various ways. In contrast to STM the coding of information is thus not restricted to a superficial level. However, what is shared with STM is the restriction that only a small amount of data (ca. 7 items) can be held for a short period. This explains why the number of items that can be held in the buffer depends on how they are grouped:

(1) a down men small street the two walked  
(1)b two men walked down the small street

In (1)a 7 separate words are listed in alphabetical order, but in (1)b the same words form a single sentence at a higher level. The content of this sentence is a single item, and the individual words making it up can be remembered more easily. The grouping of items in larger units fundamentally depends on the level at which information is processed. WM can thus be seen as a limited working space in memory, in which information has to be stored and processed at the same time. The limitation can be explained as the result of competition between these processes: data storage and data manipulation.

What we have called specific situational knowledge in Chapter 1 thus corresponds with WM or STM in the above model, whereas general conceptual knowledge is part of the LTM.
3.2 Types of permanently stored knowledge

What is finally stored in LTM can be divided into knowledge of each experienced event and all entities involved in those events (episodic memory) and knowledge we have about events and entities in general, regardless of the specific instances that have been encountered (conceptual memory). It is believed that conceptual knowledge develops out of episodic experience. Rosch (1977a) mentions two reasons for this:

- reality as we perceive it is not randomly structured, but things tend to co-occur. Reality, regardless of its ontological status, is not amorphous but has structure.
- the mind is restricted in its capacity to process information. By interpreting incoming information in terms of more general concepts the mind can neglect redundant information and attend to relevant details, leading to more efficient information processing.

The generality of conceptual knowledge is thus partially explained by repetition in reality and partially by the functional advantage of overcoming processing limitations.

Besides this difference in generality, episodic and conceptual knowledge also differ in the following respects:

- conceptual knowledge is easily accessible at any moment, while episodic information gets more and more difficult to retrieve as time passes. Concepts in conceptual memory are readily accessible, without apparent search or effort. You just have to think of dinners in general and there is a stream of information, both perceptual and more abstract. Remembering information from episodic memory, such as what you had for dinner on the first Monday of April last year, is rather difficult, and asks for complicated strategies. The difference corresponds with the above notion of depth of analysis. It is obvious that general information is more integrated than specific information about instances of events and entities. Since dinner on the first Monday of April last year probably was not a major activity or interest it has not been integrated in the view and knowledge of the world on which general behaviour is based. The more detailed, unanalysed, specific, unique information is, the less accessible it is, and the more general, common and integrated knowledge is, the more easily we can recall this information.
- conceptual knowledge can take various formats, whereas episodic knowledge cannot be isolated from the form in which it has been encountered unless we interpret it in terms of more general conceptual knowledge. We forget the actual form of sentences we have heard, or the actual colours, the precise number of objects and the configuration of events, but we do remember the essence or the general concept behind it. This concept can be encapsulated in various forms and we can consciously visualize or verbalize stories or events, respectively.

Since the lexicon only contains general conceptual knowledge we will not discuss episodic knowledge any further. Let us now consider conceptual knowledge in terms of its representation (section 3.3), its structure (section 3.4) and its utilization (section 3.5).

3.3 The form of conceptual knowledge

In general three different forms of conceptual knowledge are distinguished:

- motor-movements to perform specific actions.
- mental imagery: the perception of States of Affairs or entities is re-experienced in the mind.
- symbolic form: information is stored or manipulated (e.g. by thinking) using some inner language symbolizing concepts.

Skills, such as walking and playing the piano, are typically remembered in the form of general patterns of motor-movements. We cannot really tell what we know since conscious reflection disturbs the performance. In a similar way, people can also imagine all kinds of sensory experiences not only by recalling specific previous experiences from episodic memory but also by calling up general images or new images never experienced before. Rosch (1977a) reports on experiments indicating that it is possible to make an average outline of objects at a relatively abstract general level which allow specific objects to be recognized as instances.

The classical view of these images is that they are a kind of general picture 'seen through the mind's eye'. There is however strong neurological evidence that these perceptual images, in contrast to motor-movements, are broken down into different components interrelated in a complex way. Zeki (1992) describes separate regions of the brain which fulfil different specialized tasks, such as the different areas of the visual cortex that register shape, movement and colour in processing visual stimuli. Awareness and thus recognition of a complete image is based on a complex interaction of these components via a diverse system of
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reentrant neurons. The direct input is assigned to the specialized areas by another separate area but from each of the specialized regions feedback is given through the reentrant neurons to any other area (Zeki 1992). Perceptual images in this sense cannot be interpreted in terms of the classical model whereby incoming stimuli are mapped against an internal holistic image or picture. Instead some kind of complex processing of data (coming in directly and via reentrant connections) in terms of distinct properties takes place and awareness of an object is the result of the complex convergence of signals from these different specialized sections. Damasio and Damasio (1992) describe a view of neurological representation in which the brain keeps records of neural activity that takes place in the sensory and motor cortices during interaction with a given object. These records are then stored as patterns of synaptic connections that can re-create the separate sets of activities that define an object or event in separate functional regions. However, at some point these patterns have to be bound together to create awareness of perceptions or perceptual images. According to Damasio and Damasio this happens in so-called convergence regions, in which signals from many anatomically separate and widely distributed neuron ensembles come together. In these convergence zones holistic images may be assembled. Reactivation within these convergence zones stimulates feedback projections to these ensembles.

Images can thus be used to represent specific experiences and instances, but also more general categories. There is even physical evidence that neurological processing of these images is broken down into analytically distinct dimensions (colour, shape, and movement).

Nevertheless, it is also clear that there is knowledge which is not directly represented by perceptual images or motor-movements. First of all, language itself is a phenomenon in which information is captured in non-perceptual form. In fact, when we hear or read a story about some entity, e.g. my cat, the described events will be stored in episodic memory in the verbal form in which it was codified. After that the following operations can take place to process the information:

- direct integration of the verbally expressed knowledge with all the other knowledge you have about my cat and about cats in general in symbolic form.
- visualization of the events via the available perceptual experiences (images of my cat you have, images of cats in general, images of the events described, etc.) followed by integration of the information into already available knowledge.

Regardless of the format in which the information about my cat is finally stored (symbolic or visualized), the fact that it was processed in verbal form at some stage means there has to be an interpretation at the verbal level first. Visualization can only take place afterwards, especially in the case of the usage of words to construe new unknown referents (see Chapter 1).

But even if all this verbally stored episodic information is visualized, or converted into mental images, we still intuitively feel that we can reason and think, or conceive thoughts without necessarily re-experiencing images. Furthermore, many general concepts are abstract or relational (e.g. truth, justice, negation, kinship, condition, rules, principles, formulas). Although a concept such as democracy may evoke various perceptual images and experiences, we will nevertheless associate it with some abstract condition as well. When asked to make this condition explicit we will typically use language and not draw a picture, or point to something in reality.

There is also experimental evidence that concepts to some extent exist independently of language. Damasio and Damasio (1992) describe three different types of patients with damage to different areas of the brain:

i. those who recognize an entity and can access the concept but cannot form the words or names appropriately: "loliphant" for "elephant".
ii. those who recognize the entity and can access the concept but cannot come up with the word at all. When they encounter a picture of a "raccoon" they will recognize it and can describe many properties but fail to produce its name.
iii. those who cannot access the concepts of everyday, ordinary entities. When they are shown a picture of a "raccoon" the animal is completely strange to them, and they will not be able to recall knowledge about size, habitat or behaviour.

They explain these different impairments by proposing three separate systems corresponding with the damaged areas: one for the representation of concepts, one for the formation of words and one system for connecting these two. Damasio and Damasio therefore suggest that there is a distinct area for conceptual representation independent of language. Although specific perceptual input is processed in terms of distinct properties the identification of these properties as an instance of a concept in the convergence regions does not depend on knowing the words or expressions naming these concepts. Awareness does not necessarily depend on symbolic naming of the concepts (although communication does). In the case of motor-movements awareness seems to be limited.

In the following we will mainly be looking at perceptual and verbal or symbolic knowledge. Therefore, from now on I will not really distinguish between perceptual images and motor-movements. When talking about perceptual images (and identification procedures) I will also imply motor-movements. Furthermore, in the following sections I
will be using words to name concepts or relations between concepts but I will not be making any claims about their representation. Words are simply easier to communicate with than pictures and motor-movements. Whenever claims are made that particular types of knowledge are stored in particular forms this will be stated explicitly. For the rest, conceptual knowledge can in principle have any form.

3.4 The structure of conceptual knowledge

A traditional claim about conceptual knowledge is that it has hierarchical structure to predict redundant properties. Not only do we generalize over specific stimuli by recognizing them as instances of general concepts, but the concepts themselves are also described as specific subtypes of general ones, leading to hierarchical levels of concepts. If for example the general concept for bird is defined by the properties having feathers and wings, being able to fly, lay eggs, recognizing stimuli as an instance of this concept makes these properties redundant. However, because the general concept bird is also hierarchically related to the general concept animal as a subtype, even more properties can be predicted: animate, concrete, can move, has body and body parts. Since these subtype relations are transparent the properties of animal apply not only to birds but also to subtypes of birds such as robins:

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Class</th>
<th>Specific Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>animal</td>
<td>&lt;&gt;</td>
<td>living, can move, has body with body parts</td>
</tr>
<tr>
<td>bird</td>
<td>animal</td>
<td>has wings, can fly, lays eggs, sings</td>
</tr>
<tr>
<td>robin</td>
<td>bird</td>
<td></td>
</tr>
</tbody>
</table>

Conceptual knowledge is thus claimed to be organized in the form of a network of hierarchical relations capturing redundant properties between concepts (Collins and Quillian 1969, 1972). This model of conceptual knowledge (which also prevailed in other related disciplines such as lexical semantics and artificial intelligence) has been dubbed the classical view of concepts. Evidence for this hierarchical dependency of concepts is based on different response times of subjects to properties asserted for robins derived from bird or from animal. The hypothesis was substantiated that since deriving properties from animal for robin involves an extra step this should lead to a longer response time in verification than for properties derived from bird.

When we encounter something new we typically begin by dividing it into known parts. In addition to hierarchical structure, another useful principle for organizing concepts is therefore based on part-whole relations (Miller and Johnson-Laird 1976, Chaffin et al. 1988). The prototypical example concerns body parts: a person's body can be described as the amalgamation or configuration of specific parts: head, trunk, arms, legs, and each of these, in turn, can also be broken into smaller parts: a head consists of ears, mouth, nose, eyes, forehead, skull, etc. These relations are transparent in that parts of a nose are also part of the body as a whole because a nose is part of an head and an head is part of the body: if Part(x,y) and Part(y,z) then Part(x,z).

Although part-whole and class-subtype relations are both transparent, only limited inferences can be made on the basis of former. Part-whole relations do not support inheritance of properties in the way the hierarchies do. Whereas we can infer from the fact that a concept is a subtype of a class that the properties of the class also apply to the subtype, we cannot automatically say that the properties of the parts apply to the wholes they make up (or the other way around). The colour of an apple is not the result of the colour of its flesh but only of the colour of its skin; bending one's fingers does not imply bending one's body whereas bending one's waist does (or the other way around). Rather than for strict implicational inferencing part-whole relations are used for so-called naïve inductive reasoning (Tversky 1986). Our experience and knowledge has taught us that parts form organized, integrated wholes and that some functions and properties of the whole can be predicted on the basis of these parts. However, these predictions depend on the organization of the whole and role of the parts within these wholes and do not follow from the part-whole relation as such.

Another restriction on part-whole relations is that not all components or parts of wholes are also exclusively parts of these wholes. A car can be said to consist of, among other parts, wheels and an engine but these things are not necessarily parts of cars. They can be parts of other types of objects or even occur as independent wholes. Again this restricts the predictive power of these part-whole relations.

3.4.1 Levels of abstraction in conceptual knowledge

Hierarchically structured conceptual categories are needed to reduce the cognitive load of information processing by reducing the infinite differences between stimuli to behaviourally and cognitively usable proportions. As such categories function as mini-theories generalizing over instances and more specific categories; these mini-theories serve to make predictions, to focus on other aspects than the redundant properties, and to overcome gaps, disturbances and mutilations of incoming information. According to Rosch there are two opposing principles that determine the value of categories in this respect:

- the more properties can be predicted on the basis of category membership the better. This principle would lead to a large number of categories applying to a restricted number of instances.
the fewer categories are needed the better. This leads to a small number of categories applying to as many instances as possible.

Furthermore, Rosch assumes that there is a basic level of categorization at which these principles are in balance:

We believe that the basic level of classification, the primary level at which 'cuts' are made in the environment, is a compromise between these two levels; it is the most general and inclusive level at which categories are still able to delineate real-world correlational structures. (Rosch 1977a: 213)

She reports extensive experimental evidence in which subjects had to list all the attributes for categories belonging to different levels of abstraction, e.g.:

<table>
<thead>
<tr>
<th>Superordinate Level</th>
<th>Basic Level</th>
<th>Subordinate Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>musical instrument</td>
<td>guitar</td>
<td>folk guitar, classical guitar</td>
</tr>
<tr>
<td>furniture</td>
<td>piano</td>
<td>grand piano, upright piano</td>
</tr>
<tr>
<td></td>
<td>table</td>
<td>kitchen table, dining room table</td>
</tr>
<tr>
<td></td>
<td>lamp</td>
<td>floor lamp, desk lamp</td>
</tr>
</tbody>
</table>

It turned out that at one specific level (guitar, piano, table, lamp) a significantly greater number of attributes was listed, whereas at the more general level only a few common attributes were given. More specific levels did not receive significantly more attributes. Similar results are reported for subjects' descriptions of motor-movements in using or interacting with these objects.

The work of Rosch has been extended by Tversky and Hemenway (Tversky 1986) who show that a further distinction can be made in terms of the kind of properties that play a role at different levels of abstraction. It turned out that attributes referring to parts of objects are particularly prevalent at the basic levels described by Rosch. The following table illustrates the percentage of attributes referring to parts for all attributes listed for objects at the different levels:

<table>
<thead>
<tr>
<th>level</th>
<th>object categories</th>
<th>organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>superordinate level</td>
<td>38% parts</td>
<td>25% parts</td>
</tr>
<tr>
<td>basic level</td>
<td>66% parts</td>
<td>70% parts</td>
</tr>
<tr>
<td>subordinate level</td>
<td>58% parts</td>
<td>46% parts</td>
</tr>
</tbody>
</table>

Furthermore, it turned out that what makes things different at the basic level are their parts, whereas more specific and more general concepts are distinguished more often in other properties than their parts. For example, a musical instrument is a superordinate that groups concepts on the basis of their function and not on the basis of similar parts. Part information is then typically added at the basic level, but these parts are also hardly shared by concepts at the basic level: guitars, pianos and drums differ extremely in their parts. On the other hand specific guitars, such as classical guitars, electric guitars, bass guitars, country & western guitars, share many or most parts but differ in other aspects. They all have a neck, strings, tuning pegs, a bridge, etc.

According to Tversky the importance of parts as attributes is due to the fact that it is the configuration of parts that determines shape. Shape but also other perceptual properties are the most important properties for recognizing instances of concrete basic level objects. Children tend to group basic level objects either on the basis of similarity of shape and colour (Melkman, Tversky & Baratz 1981) or on the basis of very salient thematic relations, such as spider - web from the triplet spider - web - lady bug (Tversky and Hemenway 1984). However, they do not group these objects on the basis of higher superordinate classifications (Rosch and Mervis 1975).

The classical view of concepts suggests that properties are as much as possible derived from more general concepts or more specific parts. Strictly speaking this means that the more levels of abstraction and the more levels of subwholes of parts we have at which we can locate a shared property the more properties can be predicted from these levels as being redundant. Take for example the conceptual dependencies in the next figure 13. In the top left hierarchy of Figure 13 the level of child and adult captures the property age which is implied for boy, girl and man, woman respectively. This property needs to be stated only once for each subconcept (twice in total) and can be inherited to the four leaf concepts. The hierarchy on the right lacks such an intermediate level and the same property therefore has to be stated four times. Similarly, in the bottom hierarchies the location of the parts mouth, nose, ears, eyes can be established relative to head in the left part-whole dependency. The head is then located relative to other major parts such as arms, chest etc. In the right part-whole dependency, however, each subpart has to be located relative to all other parts right away. In addition to the fact that it is a part of the head the location of the head with respect to the other major parts has to be expressed for each of them.
However, from the findings of Rosch, Tversky and Hemenway we can conclude that both the hierarchies and the part-whole relations underlying the structure of conceptual knowledge (at least for concrete objects) are limited and structured in a specific way. Inheritance of properties and assemblage of parts and configurations (together with all properties that depend on those parts) seem to be concentrated around the basic level, limiting the structures proposed in the classical view of concepts. Apparently our mind does not strive for the most classical system with a maximum of categories and levels but seeks for a balance. Interesting questions are then: what is the use of the other levels of categorization if they do not predict much information, and what are the distributions of concepts over those levels?

3.4.2 The internal structure of categories

In its strongest form the classical view of categories underlying conceptual knowledge claims that all subtypes of a concept share common properties that are necessary and sufficient conditions for defining the concept. Since the conditions are shared by all the members, the properties are common and they are sufficient conditions. According to the classical view, properties are shared by members of categories and the necessary and sufficient conditions define membership in a category. The classical view, however, has been extensively attacked by various researchers from different disciplines.

Wittgenstein (1984) points out that in many cases no defining properties can be given to determine membership. The classical example given by Wittgenstein is the concept game: the intersection of all properties shared by all games is empty. The reason for naming something "a game" cannot be described in terms of necessary and sufficient conditions, but in terms of a much looser notion of family resemblance: one game A may be similar to another game B which is again similar to C, but A and C may have no properties in common at all.

A similar claim is made by Fillmore (1975) that there is no such thing as a 'checklist of meaning' that determines what properties should be met for a concept to apply. The important implication is that in the case of family resemblance there is nothing to inherit at all from more general concepts, undermining the motivation for hierarchical structuring.

It also turned out that the response time differences on which the classical conceptual networks of Collins and Quillian (1969, 1972) were based did not always occur, and a host of other experimental evidence suggested that membership decisions exhibit various typicality effects, summarized by Medin and Smith (1984) as follows:

- since membership of some subtypes (e.g. robin) of categories (birds) are judged faster and more accurately than others (e.g. ostrich), some members are more typical than others. More typical subtypes are also learned first by children, and when trying to retrieve all members of a category (e.g. all bird names) people tend to name the typical members first.
- category boundaries are not clear-cut, and people's responses are not consistent on different occasions. There is uncertainty about membership, some concepts appearing to fit into more than one category (multimembership).
- non-necessary properties are used for categorization: i.e. properties which are not shared by all members.
- nested concepts: nesting results in accumulation or inheritance of
common shared properties going from general to specific levels. Yet, specific members are sometimes rated as being more similar to higher superordinates than to direct superordinates.

To explain these phenomena Rosch et al. (Rosch 1977a. Rosch and Mervis 1975) proposed a prototype organization of categories based on the notion of family resemblance introduced by Wittgenstein. Each category is internally represented by a prototype (e.g. by the clearest cases or the best example) with graded non-prototype members. Two aspects determine the grading of membership: the number of features shared with other members and the commonness of these features among the members. The latter factor is based on experimental findings that each feature can be weighed on the basis of the number of members which share that feature and that subjects' typicality ratings correlate with these weights. If for example the properties listed for birds are having feathers, having wings, laying eggs, flying, singing, swimming, running the most prototypical bird not only shares most features with the other birds, it typically has those features which are most common. If swimming and running are exceptional it is unlikely that the most typical bird will have these features. The most prototypical bird will thus not only predict most features of the other birds but also those features that apply most often: i.e. is most representative for all other birds.

The universal principles behind category formation lead to the phenomenon that even where reality is a continuum, as in the case of colours, we do not produce categories which blend or overlap, but these categories are maintained as discrete by prototypes of the most characteristic members of the category. Berlin and Kay (1969) have demonstrated that speakers from various languages are extremely consistent in recognizing or naming prototypical colour names, whereas individuals are very uncertain in naming non-prototypical colours, and even inconsistent on different occasions. Rosch (1977b) extended this line of research to show the universality of prototypical colour concepts, forms and facial expressions. Speakers of the New Guinea language Dani who had only two basic colour terms "mili" (black) and "mola" (white) to cover the whole colour spectrum were divided into two groups. One group had to learn arbitrary colour names for eight focal, prototypical colours, whereas another group had to learn arbitrary names for eight non-focal, a-typical colour names. The first group succeeded in learning these names much faster than the latter group.

What determines the correlational structure of prototypes partially depends on the correlational structure of the world as we perceive it, and partially on our culture and interest.

Unfortunately this experimental evidence is restricted to these non-object classes only, which are perhaps less representative for concepts typically

Thus, in different cultures, not only available real-world structures may differ, but interest in attributes and their correlation for specific domains may differ thereby, contributing to differences in the content of categories. (Rosch 1977a: 222)

In this respect Lakoff (1986) discusses many types of culturally dependent prototypa, such as social stereotypes. In cultural categorization it is interest that weighs properties and not so much perception (Domain of Interest Principle, Lakoff 1986: 20). It is not surprising that Lakoff claims that the principles behind culturally determined categorization cannot be predicted. Predicting what will be of interest in a culture comes close to predicting the future. Therefore, he suggests that categorizations can only be explained on the basis of this knowledge and not predicted. But because of this possibility of explanation, and because of the general principles discovered by Rosch et al. categories are most certainly not to be seen as arbitrary.

3.4.3 A combined view of conceptual knowledge

The motivation behind the notion of hierarchical structure was to be able to predict redundant information and to store information efficiently. Prototype theory in a sense undermines all this. As we have seen, the depth of hierarchies is limited and organized around a rich basic level, and the notion of family resemblance is a further weakening of the redundancy principle underlying the classical view, in that properties are not necessarily true for all instances. What is the use of such an imperfect system, in which some information is predicted and in other cases it is not? Why should we group things together for unclear reasons, resulting in uncertainty on membership of instances? Why do we need a flexible, elastic and broad notion of categories?

A way of accounting for both structures is to assign different functions to each. A possible use of non-ideal, graded, fuzzy categories could be for pattern-matching in perception (or patterns of movements). In order to recognize infinitely varying instances (such as e.g. the continuum of colours) in terms of separate constant categories we need the very flexible system that prototypes provide. The classical and analytical view, by contrast, may serve to consciously deduce properties in reasoning or to integrate incoming information into the knowledge and beliefs people have in general. Such a division of tasks has been proposed by Miller and Johnson-Laird (1976), who distinguish between a so-called core and an identification procedure for concepts. In the case of concepts for concrete physical objects the identification procedure consists of a series of perceptual tests to categorize real-world objects, while the core of the concept contains properties that reveal relations with other concepts. In the case of a concept such as grandmother, the core
could be the mother of a mother or father, whereas the identification process would be based on perceptual properties determining age. The identification procedure for age would then have a graded and fuzzy prototype structure used for pattern-matching, and the core of the concept may conform to the classical view used to integrate knowledge into the general knowledge and beliefs people have. Integration also involves deducing one belief from another (Armstrong et al. 1983), or verifying categorizations (Smith and Medin 1981).

There is some experimental evidence that different types of knowledge exist simultaneously and are utilized differently. Armstrong et al. (1983) investigated concepts that have typical analytic aspects, such as even and odd numbers or plane geometry figures. They demonstrated that subjects rated instances of these concepts as varying in typicality and categorized typical instances of these concepts faster than atypical ones: thus prototypes can co-exist even with such typically classical cores. Schreuder et al. (1985) describe experiments which show that perceptual and core properties have independent effects. Perceptual properties, used for naming objects, are activated relatively early (or have initially stronger activation), whereas core properties, used for making analytic decisions, have a delayed activation which overrules the former. Naming takes less time than deciding on the effect of core properties which are not yet activated in the naming phase. Landau (1982) did some experiments in which people first had to categorize pictures as an instance of the concept grandmother and next had to justify their decisions. In the picture the age of a woman was varied, and her environment with respect to the presence of young children. The results showed that age was most crucial for categorization, while presence of young children was crucial for justification but not for categorization.

As a further motivation for distinguishing the types of conceptual knowledge Medin and Smith (1984) suggest that deductions such as "any grandmother is also a mother" can only be made when systems are somehow separate:

Suppose it were otherwise: then we might not be able to infer that a grandmother is a mother because such an inference could require that all the properties of mother be included in those of grandmother, yet the identification procedure for mother would include the property of being young-to-middle aged while that for grandmother would not. (Medin & Smith, 1984: 122)

They further state that people's intuitions are that object concepts do have defining properties, even though these intuitions will frequently yield counter examples. This suggests that people tend to approach the world as if it conformed to the classical view even if it does not. According to Miller (Miller 1977, Miller and Johnson-Laird 1976) analytic models are the result of a conscious effort to structure and model the world around, us and the core meanings of concepts can only be explained when embedded in these models. Yet another argument from Miller in favour of complementing the identification procedure (and motor-movements) with an analytic part is that different identification procedures can be set up that are equally successful in bringing about the right naming of perceived objects. The classical characterization of human beings as featherless bipeds is a perfect identification procedure which does not make sense in the way we conceive the world around us. Identification procedures alone cannot fully explain the way we structure our conceptual knowledge and approach the world. Making sense of the world around us by identifying instances in terms of general concepts to reduce the load of cognitive processing will not yield causal relations and will not result in much hierarchical structure in conceptual knowledge.

The classical view can therefore be seen as the layperson's metaphysics of concepts or conceptual knowledge. However, these mini-theories are extremely incomplete and average people will in many cases not be able to verify or falsify their claims, beliefs and categorizations. That people can still maintain these views despite the lack of defining properties (or even an exhaustive identification procedure) is due to what Putnam (1975) has called the division of linguistic labour. According to Putnam ordinary people do not know the exact procedure to determine the true extension of concepts such as "gold", "platinum" and "uranium". They still distinguish these concepts because they can rely on the fact that experts, such as chemists, have a means to keep them apart, which motivates their existence. People can thus use words (representing concepts) in a variety of contexts without being able to determine their true extension (Kripke 1977, Putnam 1975, Wierzbicka 1980) but, according to Miller (Miller 1977, Miller and Johnson-Laird 1976), this means at most that for some words they acquire superficial intensions (in Miller's terminology "intension" means a way of determining the appropriateness of a term to refer to some stimuli) which will support their use in social communication. In any case people will always need some minimal way of determining the appropriateness of a word to name some stimuli.

In principle there are three ways in which identification procedures and analytic models can mismatch:

i. people have concepts that fit an analytic model but have no ways of recognizing instances
ii. people can recognize instances of concepts but have no analytic classification for them.
iii. people have both a classification in terms of an analytic model and a classification for recognizing instances but these classifications do not match.

In the case of i, there is a gap in the identification procedure and all we know about the concept is based on its location within our general world
knowledge by the virtue of its core meaning. Describing the concepts "gold", "platinum" and "uranium" as "metal" gives them a superficial meaning, locating them in a body of knowledge we have. This core meaning can be extended with superficial perceptual procedures which may help us in many contexts, at least enabling us to use the words appropriately. These procedures can even be acquired without our ever having been aware of perceiving these metals by analogous reference to known procedures for other concepts:

(4) gold = material like metal, heavy but soft, with the colour of butter.

By analogous reference to perceptual experiences of "metals" and "butter" which we do have, we can get some superficial idea of what gold is and what is more or less the appropriate usage of the word.

In the extreme case ii., we may have clear identification procedures for phenomena which have not been described in our more general world model (which has not been integrated in this model) but which are based on (clear, repeated) events registered in episodic memory and resulting in a pure perceptual conceptualization. In that case nothing is built on top of these identification procedures. This could be the case for relatively unconscious patterns and correlations we know but do not yet happen to do much with, such as motor-movements, ideas which are in the air, déjà vu experiences, itches, etc. Miller (Miller 1977, Miller and Johnson-Laird 1976) even argues that hierarchical relations can to a large extent be implicit and are based solely on the fact that the perceptual procedures determining the appropriateness of these concepts overlap. This intensional overlap implicitly creates hyponymy relations, but these relations are not necessarily explicitly known. Miller in this respect discusses the hypothetical case that a child might be able to use the words "bed", "chair", "table" and also "furniture" correctly without explicitly knowing the analytic relation between these concepts and the relation to other knowledge he has. He only knows what things are known as such. The relation3 between "furniture" as a category and "bed", "table" and "chair" as subtypes is then completely implicit in this 'intensional' meaning and is not consciously used to deduce or inherit redundant properties. The child has no metatheory which explains the concept "furniture" with respect to "chair", "bed", "table".

In other cases (iii.) both identification procedures and analytic models are present but they do not match very well. Scientifically based classifications that are intuitively exceptional are in this respect illustrative. Everybody with an average education knows that the statement "a whale is a fish" is not true. However, most of the perceptual

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3 Actually in this case there is no ordinary hyponymy relation because "furniture" represents a diverse collection of "pieces of furniture". As such it is a collective of diverse objects.
but are not necessarily interconnected, and people are often unaware of these connections. Furthermore, incompleteness and perhaps even inconsistency hardly seem to be a problem for people in their daily behaviour.

A special type of concepts in this respect, one in which various models can be seen at work, is formed by what Lakoff calls experiential clusters. These are concepts that comprise a number of different categorizations simultaneously. The example discussed by Lakoff (1986: 37) is the concept of mother, which, he claims, comprises 5 different models:

- the birth model: the person who gives birth
- the genetic model: the female who contributed the genetic material
- the nurturance model: the female adult who nurtures and raises a child
- the marital model: the wife of the father
- the genealogical model: the female of the first ascending generation

In general the concept mother does not exclude any of these. They can all be implied, but none of these are necessary properties for applying the concept. There is thus not a single analytic model based on some expert notion of motherhood which determines the core meaning, but various different dimensions. The complex cluster as a whole is more basic than any of the individual submodels, as is illustrated by the fact that more 'specific' compound expressions such as stepmother, surrogate mother, adoptive mother, biological mother each more or less explicitly denote a single dimension. According to Lakoff the same effect can also be observed for metonymic extensions of meanings, e.g. the girlfriend mothering her boyfriend in which only the nurturant model is involved. The subtypes thus do not add features to mother but select a certain submodel, whereas in case of the general mother we have to infer from the context which cocktail of submodels is implied. For example the sentence 'She is a good mother' can only apply to the nurturant model of mother because the other models do not involve evaluative aspects. However, 'She is a good adoptive mother' can only make sense to the extent that we associate particular nurturance qualities with adoptive mothers in general. It can never apply to the fact that the child is adopted, which is the explicitly stated property of 'adoptive mother'.

A separation between expert and lay knowledge within one cognitive system can only mean that we are aware of what part is shared and what part is specialized. The distinction should thus not be taken too strictly in the sense of non-scientific and scientific. This knowledge can follow any model within any domain of interest (scientific, religious, mythical, social). It will contain social stereotypes we have about for example 'construction workers' as well as factual knowledge about the profession, kind of work, wages, holidays, number of people employed as such, education needed, etc. A similar view is held by Haiman (1980), who states that many cultures do not make a distinction between hard facts (scientific knowledge) and ethnosience. Furthermore he claims that all scientific knowledge is also rooted in experience. There is no truth, theories only explain more:

The difference between scientific experience and everyday experience is a difference in degree of precision and generality; because of the arcane nature of scientific experiments, it is a social difference as well: but it is not a difference in kind. (Haiman 1980: 339)

The difference in degree between highly sophisticated expert knowledge and less sophisticated knowledge could be that the former is highly conscious and can only be achieved by explicit training, whereas the latter is located at a more subconscious level.

3.5 The utilization of conceptual knowledge

Hitherto we have described two different types of conceptual knowledge on the basis of their function: prototypical identification procedures and analytic models for reasoning and classifying, and different systems for representing knowledge. To what extent are the functions and forms of conceptual knowledge separate?

If the perceptual images and verbalization of these concepts are, at least to some extent, separately accessible (although not independent of each other), then it seems appropriate also to restrict the representation systems to each type of knowledge separately:

- prototypical perceptual images are used to identify stimuli as instances of concepts.
- motor-movements are used to manipulate and use these instances.
- verbally represented propositions capture necessary and sufficient properties of concepts relative to some epistemic model.

Nevertheless there is evidence that mental images can still be manipulated in the mind and used for reasoning. Koslyn (1975) has shown that these images are constructed within a restricted space with relative proportions. The smaller the size of the image the longer it takes to verify properties. Size was varied by imagining them next to the image of an elephant or a fly. Shepard and Metzler (1977) had people perform mental rotation tasks for three-dimensional objects in two-dimensional representation. It appeared that matching rotated pictures took longer the more they had to be visually rotated. More important, however, is that in making inferences people do not restrict themselves to inheriting
properties directly from their analytic knowledge but combine analytic and prototypical information by means of **naive inductive reasoning** (Lakoff 1980, Lakoff 1986, Tversky 1986).

Suppose we have a conceptual knowledge base in which the concept of a "knife" has the following two representations:

- **analytic models:**
  - constituency: instrument consisting of a blade and a handle
  - function: instrument to cut or stab something/someone
- **prototypical identification**
  - procedure: a general perceptual image of a knife, motor-movements for using a knife.

So far four mechanisms have been described by which properties can be derived from these concepts:

i. (default) inheritance of properties from general concepts to more specific concepts.
ii. location of properties of wholes in parts.
iii. analogue reference from unfamiliar concepts to more familiar concepts.
iv. generalization of prototype properties to the category as a whole.

Strictly speaking, analytic models that define a concept only provide the **customary and conventionalized** ways of making inferences, basically exploiting i and ii., whereas the perceptual image would only be used to recognize an instance of "knife". Once an instance has been encountered the conventional analytic route of reasoning could be that first the directly specified analytic properties are derived and second the properties that can be inherited from the more general concepts, such as the fact that it is a concrete object, has weight and size, is an artifact, etc. Along the same lines functionalities may be inferred from the parts. From the knowledge about **blades** and **handles** we can infer that the **handle** should be **held** and that the blade **cuts** or **stabs**.

However, when the context requires us to classify something in an unexpected or new way other mechanisms operating on prototypical images can be used to derive further properties. The mental image can either be manipulated directly in a form of mental reasoning or we can compare it to other images that are in some respect similar and expect analogue properties. We can for example re-experience perceptions of instances and derive from that how many of these **knives** go into a box or how many of them we can carry. Alternatively, we might use the fact that **knives** consists of particular parts about which we have other knowledge or experience. Since **blades** are made of metal, and metal can get very hot a **knife** can also get hot. Similarly it could become magnetic, melt, get rusty, or break. Because its shape is similar to that of a **screwdriver** we may light on the idea to use it as such.

Not only do we have different ways of getting at different properties, we can probably also derive the same property via different sources and mechanisms. It is thus possible that properties which can be derived via **conventionalized** analytic models, such as the fact that a **knife** is a concrete object, are often not derived in such a way. **Concreteness** can also directly or locally be derived from a prototypical perceptual image used as the **identification procedure**, instead of going through the analytic steps material --> substance --> concrete. The above-mentioned claims from Schreuder et al. (1985) that perceptual properties are more easily activated suggest that a perceptual scenario may sometimes be preferable. As we have seen, information stored at the basic level in the form of prototypes is most informative in that a maximum number of features is distributed to a maximum number of subtypes. It would be a waste not to use this information to infer properties when needed. Therefore, we may expect that, in practice, people will probably continuously use particular mixtures of these strategies.

### 3.6 An overview of the structure of conceptual knowledge

We have distinguished two main types of LT Knowledge: episodic and conceptual knowledge. The latter have been subdivided on the basis of their main function into analytic knowledge and identification procedures. Analytic models are typically used for customized forms of reasoning and making inferences, whereas identification procedures are used for recognizing stimuli as instances of concepts. Combining these types gives the general model for permanently stored or LT knowledge as in Figure 15. In this overview expert and lay knowledge are built on top of the identification procedures and motor-movements, and all conceptual knowledge is ultimately embedded in episodic knowledge (Quine 1960). We cannot know unless we perceive, although what we perceive as episodic information is determined by what we know in general (see above: the process model of memory). Nevertheless we have seen that this hierarchical layering of knowledge does not mean that **all** lay&expert knowledge is built on identification procedures or that there is lay&expert knowledge on top of all identification procedures. In some cases the two types can even diverge (e.g. "whales" and "dolphins").

Because of their divergent functions analytic knowledge and identification procedures are also structured differently. The former tend to be organized in distinct categories with defining properties which form hierarchical structures and can be described or stored in verbal form, whereas the latter are limited in hierarchical level and are organized around prototypical perceptual images.
Analytic models are built around the following conceptual dependencies between concepts: subtype-class, part-whole and analogy. We have seen that there may also be multiple relations between concepts. Several subtypes may belong to a single class, and a subtype may belong to several (possibly unrelated) classes (e.g., *knife* as *cutlery* and as a *weapon*, or the different *mother* models). Similarly, a whole may consist of several parts and a part may belong to various wholes.

The following operations can be performed on these dependencies to derive properties applying to concepts:

- inheritance of properties from more general concepts to more specific concepts.
- generalization of properties of parts to wholes.
- sharing of properties that are related by analogy.

Prototypical perceptual images use a mechanism of family resemblance rather than deduction. Despite their non-analytic function these images can be used in reasoning as well. We have seen that images are processed in the brain in terms of distinct properties and can be manipulated at a relatively abstract level.

We have also concluded that conceptual knowledge is not built on these relations without limitations but that there is a strong tendency to concentrate properties and knowledge at a basic level. At this level the two constrastive principles (to maintain as few concepts and to capture as many properties) are in balance. Furthermore, at the basic level of specificity parts typically amalgamate into wholes. Finally, this level is also the most general level at which we may store a (relatively abstract) picture or image of the outline of objects which can still be used to recognize instances.

In the previous sections I have not described all aspects of conceptual knowledge but only summarized the major principles and claims needed to describe the phenomenon of individuation. In the following chapters I am not going to describe a knowledge base for conceptual knowledge that fully incorporates the above findings either. The difference in status between prototypical basic-level concepts and dependent concepts is used only to the extent that it explains the different conceptual individuation effects of words. Basic-level wholes can be seen as the most natural and obvious way of classifying the entities around us. The entities in a situation are most naturally divided into instances of these concepts. In this respect the basic concepts can be seen as the most natural level at which we could define the denotation of words. Words that simply name these basic concepts can then be seen as 'obvious names' for how we tend to divide reality into entities.