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LEXICOGRAPHIC AND LOGICAL DEFINITIONS FOR TERMS

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Abstract – Definitions are a central concept in terminology. The original idea of *definition* stems from logic. Logical definitions are based on a set of necessary and sufficient conditions which determine a precise borderline of a concept. However, natural meanings are prototype-based, so that they do not have natural borderlines. In dictionaries, we find definitions that characterize the prototype. Therefore, they are generally not adequate as logical definitions. In terminology, this creates a tension. Dictionaries cannot be seen as a description of the vocabulary of a language, but should be interpreted as a source of information about the use of words. Logical definitions only have a role when they are supported by an authority. In domains in which rules have to be enforced, terms that determine the interpretation of a rule should have a logical definition supported by the domain-specific authority. In domains relating to empirical science, terms that are used in the evaluation of theories and theoretical claims should also have logical definitions. To what extent a generally accepted logical definition is achievable in such domains depends on the existence of a body that is generally accepted as the authority in the relevant domain.

Keywords: terminology; definition; dictionary; authority; prototype semantics.

1. Definitions

In terminology, *definition* is a central concept. The original idea of definition stems from the earliest attempts at logical reasoning. Etymologically, *definition* has *finis* (‘boundary’) as its root. The concept was already known by Aristotle, but is probably much older. In Ancient Greece, logic was not a separate discipline. It was embedded in *φιλοσοφία* (‘philosophy’), a word which was formed from *φιλο* (‘love’) and *σοφία* (‘wisdom, knowledge’). The meaning can perhaps best be paraphrased as ‘the pursuit of knowledge’. For this pursuit, a precise delimitation of the concepts used to describe one’s findings is essential.

The classical definition consists of a *genus proximum et differentiam specificam*. The Latin formulation is due to Boethius († 524), whose translation of Aristotle was at the basis of the medieval scholastic tradition (cf. Hanks 2016, p. 99). The idea is that as a first step one selects a hyperonym and subsequently one identifies how instances of the concept to be defined differ

from other instances of the hyperonym. This can be illustrated by the definition of *ambulance* in COED (2011), given in (1).

(1) *ambulance*
a vehicle equipped for taking sick or injured people to and from hospital.

In (1), the hyperonym is *vehicle* and the *differentia* is the rest of the phrase, indicating the type of vehicle an ambulance is. The hyperonym and the *differentia* have different functions. The hyperonym determines a domain that is taken as a starting point for the definition. The *differentia* takes the form of a condition that excludes a part of this domain.

Not all definitions are so easily mapped onto this plan. Consider, for instance, the definition of *fire brigade* from the same dictionary in (2).

(2) *fire brigade*
an organized body of people trained and employed to extinguish fire.

In (2), it is easy enough to recognize the *differentia*, which is "trained and employed to extinguish fire". It is not so straightforward, however, to make "organized body of people" the hyperonym. Whereas in (1), we have a single word referring to a concept as the hyperonym, in (2) the corresponding expression is itself complex. The question is whether *organized* is not a condition itself. The same can be asked of *of people*. However, if we move these expressions from the hyperonym to the *differentia*, we end up with *body* as the hyperonym in (2). Apart from being very general, this word is used here in a transferred sense. OED (2000-2020) gives it as sense 13.

One way of resolving such problems is to take the hyperonym as a condition as well. The starting point for each definition is then the entire set of entities. In (1), being a vehicle is the first condition. In (2), being a body of people is a good candidate for the first condition, with the degree of organization as a second. The advantage of this approach is that whereas for a hyperonym we expect a single concept, for a condition there is no such expectation.

If we adopt this approach to definitions, a definition is a set of conditions. These conditions are organized sequentially and applied as a kind of algorithm. Together the conditions are necessary and sufficient. *Necessary* means that no exemption for any of the conditions can be granted. *Sufficient* means that a positive outcome of the algorithm cannot be overridden by other considerations.

It is not only the entire set of conditions, but also individual conditions that can be qualified as necessary or sufficient. Each condition takes as input a set of entities and divides this set into two parts. One part contains the instances of the original set that fulfil the condition, the other the instances that do not.

In the case of necessary conditions, the former set is the starting point for further reasoning. In (1), "(being) a vehicle" is a necessary condition, so we discard the non-vehicles and go to the next condition. In definitions such as (1) and (2), all individual conditions are necessary. An example for the use of sufficient conditions can be taken from (3).

(3) a. Admission: Adults £ 8, concessions £ 5, children under 12 free.
b. Concessions: Children under 18, senior citizens over 65, students under 26

In (3) we find a typical set of rules for calculating admission prices to, for instance, a museum in Britain. *Concessions* as used in (3a) is a term defined in (3b). The definition in (3b) lists three categories of people who are entitled to the lower admission price. Each of these three constitutes a sufficient condition. The unexpressed starting point is *people*. The first condition distinguishes between those over 18 and under 18. The latter class is included in *concessions*, but the former is taken as the set to which the next condition is applied. The second and third conditions are applied in the same way. Obviously there is no overlap between the sets identified by the first and the second conditions. There may be an overlap between the first and the third.

The reason why in definitions we generally have a set of necessary conditions rather than a set of sufficient conditions is obvious when we consider the differences among (1-3). In (1) and (2), with necessary conditions, we create a coherent concept. In (3b), however, the individual sufficient conditions do not result in a concept that has any further shared features than being entitled to a lower admission price.

Aiming for a definition as a set of necessary conditions that together are sufficient, we arrive at an algorithm for determining whether something is an instance of the concept defined. As long as we are dealing with logic, such definitions are fine, because the concept is conceived at the same time as it is defined. When we apply this procedure to real-world items, however, we can run into problems, because the real world is not as neatly ordered as the logical one we construct.

2. Prototypes

In the 1970s, the insight emerged that natural concepts do not have natural boundaries. Labov (1973) studied the concept of *cup*. A cup has a certain ratio of its height and its width. If we make a cup wider, it will eventually rather be a bowl. If we make it higher, it will become a vase. By showing people different objects and asking them whether they would qualify as a cup, Labov found that there is a gradual transition between *cup* and *bowl* and between *cup* and *vase*. The degree to which an object was deemed to be a cup was calculated by taking

the percentage of respondents accepting it as a cup. There is no obvious cut-off point. In fact, as Jackendoff (1983) notes, the situation gets more complex when we also consider the presence of a handle. According to OED (2000-2020: *cup*), a cup is a vessel "with or without a handle". This suggests that the handle does not influence whether something is judged to be a cup. This is not so. A vessel with a handle is more likely to be considered a cup than an otherwise similar one without. However, having a handle is neither a necessary, nor a sufficient condition. Not everything with a handle is a cup and not everything without a handle is not a cup. Jackendoff calls having a handle a *preference rule* for a cup.

Another example is the concept of *chair*. This concept was discussed by Rosch (1978). There are many different types of chair, but it is difficult to come up with necessary conditions. A good candidate for a necessary condition is that one can sit on it. However, this is not sufficient. We could imagine that we have an image of a typical chair as a basis and in judging whether an object is a chair or not, we determine how close the object is to the typical chair. This is the basis for prototype semantics. A complication is that each of us has their own image of a typical chair. Moreover, the prototype is underspecified in some respects. It is unlikely, for instance, that the colour has much of an impact on how typical a chair a particular object is. Nevertheless, any actual picture of a chair will necessarily assign it a colour. Prototypes are also easily adapted to a context. When we talk about an office, we have a different idea of a chair than when we talk about a garden or a restaurant.

An important question to ask here is for what purpose we would like to delimit *cup* or *chair*. As long as there is no particular need to determine whether something is *actually* a cup or not, the prototype nature of our concept is in fact a highly efficient way of using the concept accurately. This situation changes when we consider the distinction between *van* and *lorry*. They are both vehicles for transporting goods, but they have characteristic differences. Lorries are bigger and heavier. This will be reflected in the prototype. Again, the prototype is not a fully specified image, because colours are not part of it, although every van or lorry has a colour. Borderline cases between *van* and *lorry* can be imagined quite easily, because size and weight are continuous measures. Other properties that may have an influence are the shape of the part where the load is kept, the number of wheels, etc. The case of *van* and *lorry* differs from that of *cup* and *bowl*, because there are specific rules that refer to these concepts. In order to drive a lorry, one needs a special driver's licence. In many countries, lorries have a lower speed limit. On some roads, lorries may not overtake. If such rules apply to lorries but not to vans, we need to have a way of determining whether a vehicle is a lorry and subject to these rules or a van and exempt from them. In such a context, a definition is necessary to ensure that rules can be applied.

3. Lexicographic definitions

Definitions constitute a traditional information category of dictionaries. Thus, handbooks of lexicography typically include a chapter on definitions. In two recent handbooks, the chapters dealing with definitions illustrate two different approaches. Lew (2013) embeds the discussion of definitions in a discussion of sense distinctions, which is a typical lexicographic topic. By contrast, Hanks (2016) connects the lexicographic approach to definitions to the logical one, thus also highlighting the differences between them. In the context of terminology, the latter approach is more useful, because for terms the relation to logic is more relevant than the one to sense distinction.

In order to explore the differences between definitions in dictionaries and in terminology, I will discuss a number of definitions from OED (2000-2020) and indicate how their formulation is different from what we would expect in a logical definition. The choice of OED as a source of definitions should not be taken as an attempt to attack the value of this dictionary. Although I have shown elsewhere (ten Hacken 2012) that its claim to be "The definitive record of the English language", as its website states in the header, cannot be upheld, it is a generally recognized, unique lexicographic resource of a very high standard and value. I have chosen a number of definitions from this dictionary that illustrate typical differences between lexicographic definitions and logical definitions.

In my selection of definitions, I have only considered words that can be seen as terms. A first example is *comet*, which OED in its second edition (1989) defines as in (4).

(4) A celestial body moving about the sun in a greatly elongated elliptical, or a parabolic orbit, and consisting (when near the sun) of a bright star-like nucleus surrounded with a misty light, and having a train of light or 'tail', sometimes of enormous length, and usually directed away from the sun.

As a definition, (4) starts with a hyperonym ("celestial body"). When we evaluate the remaining part of (4) as a set of conditions, there are two types of problem. First, in the final part of (4), we find conditions modified by *sometimes* and *usually*. In this formulation, the condition cannot be applied as either necessary or sufficient. It acts as a preference rule in the same way as having a handle for *cup*.

Secondly, the description of the orbit, when elliptical, as "greatly elongated" gives only a vague impression of it. This is not necessarily a problem. Whether it is, depends on the distribution of the shapes of the orbits found in nature. In ten Hacken (2018, pp. 71-73), I discuss the case of *planet*. After the distinction between *planet* and *asteroid* had been made, for more than a century no precise boundary in size had been specified. Asteroids are smaller

than planets, but as long as the smallest known planet (Mercury, diameter 4879 km) was much larger than the largest known asteroid (Ceres, diameter 946 km), any further specification, e.g. a diameter of 1000 km or of 4000 km, would have been arbitrary. If the degree of ellipticality of the orbits referred to in (4) has a similar distribution, i.e. if there is a large gap in the actually attested shapes, the formulation is unproblematic.

Interestingly, in a 2017 revision, OED changed the definition of *comet* in the relevant sense to (5).

(5) A celestial object typically following a greatly elongated elliptical orbit around the sun and appearing, when in the inner solar system, as a slow-moving, starlike head surrounded by a diffuse luminous envelope or coma and with one or more long tails directed away from the sun.

From an astronomical perspective, the use of *appearing* in (5) is definitely an improvement. Of the conditions we identified as preference rules in (4), one has been removed, the other made into a necessary condition. The vagueness of *greatly elongated* has been maintained, but as noted, this is not necessarily a problem. Therefore, (5) is an improvement of (4) from a terminological perspective, even though *typically* makes the shape of the orbit a preference rule.

As a next example, let us consider *particle*. For the specialized sense as used in physics, OED gives the definition in (6).

(6) Any of numerous constituents of the physical world that are smaller than an atomic nucleus, such as protons, electrons, neutrinos, and quarks.

In (6), the hyperonym is *constituent of the physical world*. The indefinite plural "any of numerous" does not really add to the condition. The size indication is a necessary condition. What follows are four examples. Together with the use of *numerous*, the introduction of the examples with *such as* emphasizes that the list is not exhaustive. This excludes an interpretation of the list as a necessary condition. To the extent that they are conditions at all, they can only be sufficient conditions. As such, "protons" in (6) means "if the item is a proton, it is a particle". In a logical definition, the combination of necessary and sufficient conditions does not lead to a proper delimitation of the concept.

The third example to be discussed is *lion*. As a natural species, it is a particularly hard concept to define properly. OED gives the definition in (7).

(7) A large carnivorous quadruped, *Felis leo*, now found native only in Africa and southern Asia, of a tawny or yellowish brown colour, and having a tufted tail. The male is distinguished by a flowing shaggy mane. (The Maneless Lion of Gujerat is a recognized Asiatic variety with only a slight mane.) It is very

powerful, and has a noble and impressive appearance; whence it is sometimes called 'the king of beasts'.

The definition in (7) starts with a hyperonym, *quadruped*, but much of the other information it gives can hardly be interpreted as necessary conditions. Properties were selected that evoke the image of a lion, but most of these properties are not conditions at all. The adjective *carnivorous* is the only good candidate. Of the other properties, some are descriptions of the prototype, e.g. the colour and "very powerful", others only constitute encyclopedic information, e.g. its area of native distribution. The Latin name is a synonym. As a learned equivalent, it has the function to connect *lion* to an unequivocally determined place in the zoological taxonomy.

Whereas *lion* may be considered a difficult word to define, because it is such a common word, there are also uncommon words that raise problems of definition. An example is *phytocoenosis*, for which OED gives the definition in (8).

(8) A community of plants; all of the plant species found at a particular site, considered collectively.

The structure of (8) does not correspond to that of a logical definition. There is no obvious hyperonym and there are no clear conditions. One of the more remarkable properties of (8) is the parataxis. The two component parts of (8), separated by the semicolon, are not explicitly related to each other. Formally, it remains unclear whether they are alternative meanings or separate conditions. In a way roughly analogous to (7), one can interpret the intention of (8) as approaching the description of the concept twice independently.

As a final example, let us consider the OED definition of *zymin* in (9).

(9) A pancreatic extract used in medicine.

In (9) we again have the format of a logical definition in the sense that *pancreatic extract* serves as a hyperonym and is followed by a statement that can be interpreted as a necessary condition. However, even to a non-specialist, it should be clear that (9) is not sufficient as a definition. The condition of being "used in medicine" is rather circumstantial. Presumably, the substance existed before it was used in medicine and remains the same substance if it is no longer used in it. In a way not unlike (8), (9) tries to convey some general information about the word without delimiting the concept.

In (4-9), we have seen a number of lexicographic definitions. Their analysis has shown some divergences from logical definitions that are in fact typical of definitions as they appear in dictionaries. As we have seen in section 2, word meanings have a prototype structure. Whereas a logical

definition focuses on the boundary of a concept, a lexicographic definition concentrates on the prototype. A logical definition consists of a hyperonym and a sequence of further necessary conditions. All information in the definition is part of a condition that can be interpreted as necessary. Together it is sufficient. A lexicographic definition evokes a prototype. As such, it is much freer in its structure. For a common concept such as *lion* in (7), a lot of information is given that contributes to the prototype. For the more technical concepts of *comet* and *particle*, the use of preference rules in (4) and examples in (6) should also be seen in this vein. Such elements of the definition do not contribute to identifying boundaries, but they help the reader in building up a prototype for the concept. For even more technical concepts such as *phytocoenosis* and *zymin*, the approaches we have seen in (8) and (9) indicate that the dictionary is content with a rather vague impression of the prototype. The parataxis in (8) is logically problematic, but may be helpful in its evocative function. The partial, non-sufficient definition in (9) gives at least an approximation of the concept, indicating some basic properties, even if it does not identify the concept precisely.

4. Languages and dictionaries

For a full appreciation of the status of the definitions discussed in section 3, it is necessary to relate them to the nature of dictionaries and languages. Dictionaries are usually presented as a dictionary *of* a language, as in the dictionary titles in (10).

(10) a. Collins Dictionary of the English Language (Collins 1986)
b. van Dale Groot Woordenboek der Nederlandse Taal (van Dale 2015)
c. Dictionnaire alphabétique et analogique de la langue française (Robert 1986)
d. Il Dizionario della Lingua Italiana (Devoto, Oli 2000)

The dictionaries in (10) are selected standard dictionaries for English (10a), Dutch (10b), French (10c) and Italian (10d). In Dutch, *woordenboek* (‘dictionary’) and *taal* (‘language’) are not cognates. For all these and many other dictionaries, the title suggests that there is a privileged relationship between a dictionary and a language that need not be specified any further. As I showed, for instance, in ten Hacken (2009), the problem in describing this relationship starts when we try to determine the concept of *language* referred to in (10).

We tend to think of language as a natural entity. It is empirical in the sense that its existence and the way it presents itself are independent of any observer. In fact, when we observe two people speaking there are two senses

in which language exists as an empirical entity. Let us suppose we are at a coffee place and at the table next to us, Frances and Gillian are having coffee and talking to each other. On one hand, language is realized in the conversation we hear. This conversation exists also when we are not listening to it. Of course, Frances and Gillian shape the conversation, but their purpose is communication, not realizing language. On the other hand, language is realized as a knowledge component in Frances's and Gillian's minds. If they did not have this knowledge, they would not be able to have a conversation. What exactly constitutes this knowledge is not so easy to assess. The way our linguistic knowledge is stored in our brain is geared towards its use in communication, not towards its systematic description. It is obvious, however, that the knowledge exists whether or not it is observed. It is also obvious that Frances and Gillian do not have the same knowledge in the sense that they each have their own realization of language in their own mind. If Frances learns a new word, Gillian does not automatically know it, too.

The two senses of *language* discussed in the context of Frances and Gillian's conversation correspond to what Chomsky (1965, p. 4) calls *performance* and *competence*. As Chomsky notes, they are directly related to each other. Performance is only possible because of competence. The conversation between Frances and Gillian can only take place if their competence is similar enough for them to understand each other. Without their competence they would not be able to produce language and understand what the other says. There is also a connection in the opposite direction, because competence is the result of language acquisition. As a child, Frances has built up her competence on the basis of the performance of people in her environment.

The sense of *language* used in (10a) does not correspond to competence or performance. Modern dictionaries tend to claim that they are based on a corpus, i.e. a collection of performance data. However, "the English language" is not a corpus. When we taperecord the conversation between Frances and Gillian, it is likely to contain many false starts and unfinished sentences. In a written collection of performance data, we find typos and other errors. For "the English language", we would not like to include such phenomena. The only way we can exclude them is by moderating the data. This moderation consists in two types of decision. On one hand, we have to decide whether an expression is correct or not, on the other whether it is English or not. The former type is close to grammaticality judgements, the latter cannot be taken on a purely empirical basis.

The observation that decisions about what to include in a corpus depend on the use of competence may suggest that we take competence as the empirical entity corresponding to "the English language" in (10a). However, there are a number of problems with such an approach. First, if we suppose that

Frances and Gillian speak English, what do we do when they disagree on what is correct? Competence is individual and although we can assume that, if Frances and Gillian have a similar background, their competence will be very similar, it is not identical. A second type of problem is that people are often unsure whether an expression is correct or not. It is especially in such cases that differences between speakers are likely. Thirdly, at a more conceptual level, the question arises how we can decide whether someone's competence is actually English. As explained in more detail in ten Hacken (2020), the only way to determine this is to follow a two-step process. First, it must be determined which languages there are. Second, each speaker's competence is classified with respect to these languages. These decisions are not purely empirical. Questions such as whether Scots and English are one or two languages or how many Romance languages there are in Italy cannot be decided entirely empirically.

Therefore, *language* as referred to in (10a) is not an empirical entity. As a consequence, a dictionary cannot describe the vocabulary of a language. As I argued in ten Hacken (2009), a dictionary should be interpreted as a problem-solving tool. If Frances and Gillian disagree about the meaning of a word, they may take their smartphones and look up the word in a dictionary. This means that they assume that the dictionary they consult has an authority that they both recognize. What they find in the dictionary is information they have to interpret. Ultimately, the dictionary gives a sequence of letters. How this relates to their question is something they have to work out, using their competence. Other queries for which they may consult a dictionary concern, for instance, the spelling, the inflection, or the proper use of a word. Or it may be whether a particular word exists. In the latter case, whether it is recorded in the dictionary is taken to answer this question.

Most modern dictionaries are corpus-based. Definitions found in dictionaries are therefore the result of what a lexicographer formulated on the basis of data found in a corpus. The lexicographer interprets these data. The interpretation involves a selection of headwords, an evaluation of their usage and an organization of this usage into senses. None of these decisions can be delegated to the corpus or to automatic operations performed on corpus data. In taking these decisions, the lexicographer should think of the use of the dictionary they produce.

5. Definitions in terminology

In terminology, the traditional approach to definitions is more akin to their use in logic than in lexicography. In his classical introduction, Wüster (1979, p. 1) characterizes work in terminology as in (11).

(11) Jede Terminologiearbeit geht von den *Begriffen* aus. Sie zielt auf scharfe Abgrenzung zwischen den Begriffen.[1]

At the start of his introduction, Wüster distinguishes terminology quite explicitly from lexicography. In (11) he emphasizes the onomasiological starting point and the aim of precise delimitations as two crucial differences. In principle, these differences are independent of each other. An onomasiological approach results in an ontology, which serves as a basis for naming the concepts. The semasiological approach taken in lexicography takes the list of words as a starting point for definitions. In both approaches, one can use logical definitions or definitions of a lexicographic nature.

An important consideration in the choice of the type of definition is that, as argued above, natural concepts are prototype-based. This means that formulating a logical definition is not natural. It overrides the natural structure of the concept, replacing the gradual decline in prototypicality by a sharp borderline. As an example, let us consider the concept of *goalkeeper*. COED (2011) gives the definition in (12).

(12) a player in soccer or field hockey whose role is to stop the ball from entering the goal.

Obviously, (12) is a lexicographic definition. It follows the pattern of a hyperonym and special conditions. For most purposes, it is sufficient as an explanation of the meaning of the word. However, it does not delimit the concept very precisely. Arguably, all players of a team should prevent the ball from entering their goal.

A sharp delimitation of the meaning of *goalkeeper* depends on an authority. There is no single authority covering both soccer and field hockey, so we have to specify which concept we are dealing with. Let us assume that we are interested in *goalkeeper* as a term in football. The highest authority on the rules of football is the *International Football Association Board* (IFAB). IFAB was founded in 1886 by the four footbal associations representing the constituent parts of the United Kingdom. The *Fédération Internationale de Football Association* (FIFA) was founded later and was admitted as a fifth member in 1913. Since 1958, FIFA has had a 50% share of the votes at the Annual General Meeting which decides the rules of the game for the next season. I will use IFAB (2019) here.

Football, as any sport, is a special case in terminology. Here we have a completely artificial universe with rules that can be set and changed arbitrarily. Thus, there is no other reason that it is not allowed to play the ball with one's

[1] Each project in terminology starts from the *concepts*. It aims to arrive at a sharp delimitation between the concepts [my translation].

hands than that this is stipulated in the rules. Players enter this universe volontarily at the moment when they start playing football. This means that for the definition of *goalkeeper* in football, no other source than IFAB (2019) has any authority.

IFAB (2019, pp. 180-189) gives a list of football terms with definitions, but *goalkeeper* is not in this list. In the body of the rules, IFAB (2019, pp. 34-136) mentions *goalkeeper* 65 times. In none of these places, there is a proper definition. Therefore, a definition has to be constructed out of the information provided by the rules. The first introduction of the concept is in Law 3, "the players". It is given in (13).

(13) A match is played by two teams, each with a maximum of eleven players; one must be the goalkeeper. (IFAB 2019, p. 49)

The information that can be taken from (13) is that a goalkeeper is a player and that each team has exactly one. This can be used to determine the hyperonym in the definition. For the formulation of the further conditions, we have to evaluate the degree to which the other occurrences contribute to delimiting the concept of *goalkeeper*. Many of the occurrences are of the type of (14).

(14) The hands and arms of all players, including the goalkeepers, are not considered. (IFAB 2019, p. 99)

In (14), which occurs in the explanation of *offside position* in Law 11, the goalkeeper is mentioned as a player, but no specific properties for identifying them are given. As opposed to (14), we find conditions such as (15).

(15) a. The two teams must wear colours that distinguish them from each other and the match officials
b. Each goalkeeper must wear colours that are distinguishable from the other players and the match officials
c. If the two goalkeepers' shirts are the same colour and neither has another shirt, the referee allows the match to be played (IFAB 2019, p. 58)

In (15), we find the regulations for *Colours* in Law 4, "the players' equipment". (15b) gives a condition that has to be fulfilled by the goalkeeper. In (15c), *goalkeeper* occurs as well, but we only find a rule that guides the referee. By assessing the occurrences of *goalkeeper* in IFAB (2019), one can find two further conditions that single out the goalkeeper from among the other players. On this basis, we can formulate a definition as in (16).

(16) A goalkeeper is the designated player of a team who
- is recognizable by wearing a different colour to the other players,
- is allowed to handle the ball within their own penalty area, and
- is required to defend the goal in the case of a penalty kick.

In (16) we have a logical definition with a hyperonym and three further conditions. It is of course possible to formulate different logical definitions that are also in accordance with IFAB (2019). One may also take one or two of the three conditions as defining criteria and reinterpret the other(s) as rules that apply to the goalkeeper. Thus, one may say that (15b) is a rule for goalkeepers rather than an identifying property and eliminating the corresponding condition in (16). As it stands, however, the formulation in (16) in my view keeps an adequate balance between explanation and logical necessity. Balancing clarity and conciseness is something terminologists have to do whenever they formulate definitions.

When we compare (16) to the dictionary definition in (12), we can observe some characteristic differences. Whereas (12) starts with a specification of the domain, in (16) this specification is presupposed. Terms are inherently domain-specific and the domain is an information category separate from the definition. Whereas (12) focuses on the most prominent task, (16) highlights more specific properties that serve to uniquely identify the goalkeeper.

As a second example of a term, let us consider *lung*. COED (2011) gives the definition in (17).

(17) each of the pair of organs within the ribcage into which air is drawn in breathing, so that oxygen can pass into the blood and carbon dioxide be removed.

In (17), we recognize a typical lexicographic technique in the formulation "each of the pair". *Lungs* typically occur in pairs, but in a dictionary one wants to describe the singular noun. Another remarkable aspect is that (17), as opposed to (12), does not specify the domain. The reference to *ribcage* implies that only vertebrates can be meant. It may well be that many readers of (17) automatically assume that the domain is (human) anatomy. In principle, one could also see *lung* as a term in zoology, however, and consider claims and questions such as (18).

(18) a. Lungs occur only in vertebrates.
b. Are the spider's book lungs really lungs?

When a claim such as (18a) or a question such as (18b) should be discussed meaningfully, we need a different type of definition of *lung* than (17). We should consider, however, that zoology is a domain of a very different nature to football. Whereas football can be constructed as a universe of its own, zoology is only meaningful if it relates to the actual outside world. Zoology is an empirical science, which means that it aims to explain aspects of the outside

world by building up a model of it. Logical definitions can be part of this model and make aspects of it testable.

The claim in (18a) and the question in (18b) have a substantial overlap, because the so-called *book lungs* found in arachnids such as spiders and scorpions, the status of which is the subject of (18b), are the most prominent potential counterexample to (18a). The definition of *lung* should provide the basis for deciding this issue. However, there is no body corresponding to IFAB to take a decision on the definition. In an empirical science, the evaluation of a definition is based on the explanatory potential of the theory that uses it. There is no actual fact of the matter that determines whether (18b) should be answered in the affirmative or in the negative, in the same way that it does not make sense to ask whether planes "really" fly.

In the assessment of a claim such as (18a), a standard procedure in zoology is to consider the evolutionary origin of an organ. We find lungs in many vertebrates, but not in the most primitive ones. Therefore, it is likely that in the course of evolution, lungs only emerged after vertebrates had developed. This argues in favour of a confirmation of (18a) and a negative answer to (18b). Another way of looking at (18) is to consider the function as primary. Thus, *wing* is used for insects and for birds, but they emerged in entirely different ways. In birds, the wing has grown out of a limb, whereas in insects it is an extension of a body part that originally served the regulation of body temperature. If we take this perspective, (18a) should be rejected and (18b) answered in the positive.

The choice between the two perspectives is basically a matter of the status assigned to the term *lung*. If we adopt an evolutionary perspective, we can make different claims and build up a different type of theory about lungs than if we adopt a functional perspective. Ultimately, it depends on how convincing the theory using it is, which type of definition is to be preferred. If the function is central, we may well use (17) and take *lung* as an item of specialized vocabulary. For an evolutionary perspective, a logical definition will have to be devised so that (18a) can be evaluated and (18b) tested unequivocally.

As a final example, I would like to turn to *planet*. COED (2011) defines it as in (19).

(19) a celestial body moving in an elliptical orbit round a star.

Although (19) has the form of a logical definition with a hyperonym and a further condition, it is only approximative. While excluding moons, which orbit around a planet, it does not exclude various other types of celestial bodies recognized as different from planets in astronomy. In fact, the International

Astronomical Union (IAU) adopted a definition in 2006 which delimits *planet* as in (20).

(20) A planet is a celestial body
- orbiting a star or stellar remnant,
- massive enough to be rounded by its own gravity,
- not massive enough to cause thermonuclear fusion, and
- which has cleared its neighbouring region of planetesimals.

Compared to (19), (20) uses the same hyperonym, but it has four conditions. The first condition is more or less the same as the one in (19), but the other three add further detail. They distinguish planets from (most) asteroids, which are too small to be rounded, from stars in a double-star system and from bodies such as Pluto, which do not have a monopoly to their orbit but appear as a member of a cloud.

When we consider the status of (20), it may be surprising that in astronomy, which is an empirical science like zoology, we have a definition adopted by a body, IAU, which seems to have a status similar to IFAB in football. IAU was founded in 1919 and organizes academic meetings of various types, including every three years a general meeting. The authority of IAU in the field of astronomy makes it possible to adopt authoritative definitions such as (20). In constructed domains such as football, the existence of such an authority is necessary. In empirical domains such as zoology and astronomy, it depends on various factors, some rather accidental in nature, whether a body with such an authority emerges or not.

6. Conclusion

Definitions constitute a central concept in the study of terminology. They are also used in logic and in lexicography. Logical definitions consist of a hyperonym and further conditions. Each condition is necessary and together the conditions of the definition are sufficient. Logical definitions are the model of definitions in terminology. In dictionaries, definitions characterize the meaning of a word.

Lexicographic definitions often use devices that cannot be accepted in logical definitions. For two reasons, this does not disqualify them as proper definitions for a dictionary. First, natural word meaning has a prototype structure. The meaning has one or more prototypical cases and a gradual decline in prototypicality as instances are further removed from the prototype. Crucially, there is no natural borderline around the concept. A second reason is that dictionaries cannot be interpreted as descriptions of an empirical entity. Each speaker has their own prototype for a concept, which may be more or less

specified. On the basis of a corpus, lexicographers aim to give information about a word that is likely to solve problems that prompt users to look this word up.

Whether a term behaves like a logical item or like a natural word depends on how we use it. This correlates quite strongly with the nature of the domain. In domains where rules have to be enforced, logical definitions are necessary. In a domain such as football, where there is no empirical reality before it is defined, rules have to be explicit enough for logical definitions of crucial terms to be extractable from them. In domains of empirical science, the necessity of a logical definition depends on the role of the term in the evaluation of theories. In all domains, the existence of a generally accepted authority supports the formulation and acceptance of logical definitions. In ten Hacken (2015), I make a distinction between *terms in the narrow sense* (TiNS) and *specialized vocabulary*. For TiNS, logical definitions are necessary. For terms belonging to specialized vocabulary, a lexicographic definition based on the characterization of the prototype is sufficient.

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