

## Chapter 2

# A Functional View Toward Mental Representations

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### 2.1 Representation in General

Representation is a notion used in many different areas; this may be a reason why its meaning is quite ambiguous. Regarding the philosophical tradition, we can refer at least to four essential meanings of “representation” (Cp. Ritter, Gründer, & Gabriel, 2007, vol. 8, p. 1384).

1. Any mental state with cognitive content (“imagination” in a wide sense)
2. Mental states which refer to earlier mental states like memory (“imagination” in a narrow sense)
3. Any structure-preserving presentation like pictures, symbols, or signs
4. A substitution of something

To use the notion of representation for experimental studies in learning sciences or in any other empirical science, it would be desirable to have a more clearly defined notion. This chapter offers a preliminary definition which can be adapted to special domains. Ideally, this definition will facilitate the process of operationalization and the search for the right indicators to measure mental representations.

An object used as a representation can be described as an object standing for or referring to something. This object might be a material thing, a sign, a process, or a state. A representation has the role of substituting for something else. Usually, representations are not detailed copies of the object they represent. They rather picture something as something for somebody; only the important information is presented and interpreted depending on the situation. (For a critical discussion, Cp. Goodman, 1969.) An important distinction is to be drawn between two types of representations: the mental (internal) and the external ones.

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The notion of a mental representation is introduced as a theoretical construct to explain ongoing information processing. Mental representations and their relations are used to explain how humans are able to respond in a flexible way to one and the same input instead of being obliged to react in a rigid manner. Depending on this inner state, humans are able to show different reactions to the same input. Any other cognitive process like believing, anticipating, expecting, and memorizing is explained by mental representations as we will discuss in Section 2.1. Although the notion of a mental representation is a theoretical notion to explain what is going on in the “black box”, in some future it might be possible to describe neurological states and processes in the brain which realize the role of mental representations. Questions concerning the possible neurological realization of mental states will not be discussed in this chapter. To describe the essential relations of a representation, there are several theoretical positions, e.g., the causal theory of representation, the functional theory, the theory of similarities, and the so-called theory of structural similarity (Cp. Dretske, 1981, Fodor, 1987, Millikan, 1984). We will return to those theories later on.

External representations are different and cannot be described within the same theory. Any object in the world can be used as a representation for another object or even for a mental representation. For example, a picture of somebody can represent this person, or a traffic sign can represent information, or an architectural model may represent a building. External representations presuppose mental representations; they cannot refer to something without somebody understanding this reference. Only if there is an interpreter of a sign can it be regarded as a representation; otherwise it is just a simple trace or an arbitrary copy of something. The necessary conditions under which something can be considered a representation are not to be found in the object itself but in the relations between the representation, the represented object, and the subject. Those representations will not be discussed in detail. But we should keep in mind that they are dependent on mental representations and interrelated with communication.

As we are dealing especially with the topic of learning and instruction, we will focus on mental representations. The structure of this chapter will be the following: To begin with we will discuss mental representations, clarifying the used terminology as there are the notions of a vehicle, a representandum, a subject, and a triple-digit relation. In the second part we will examine related notions of mental representations. And last but not least, we will have a short look at questions on operating on representations and what it means that some representations are reportable.

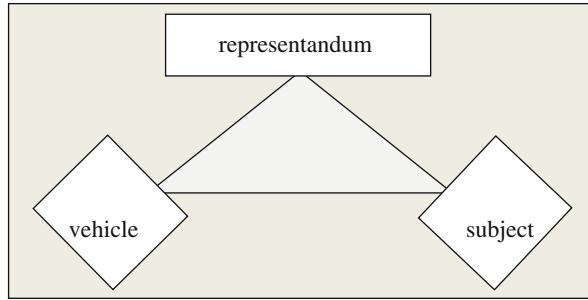
### ***2.1.1 Mental Representations***

Having a mental representation could be described as entertaining a mental image or an imagination. The word “image” might be misleading because it is suggesting a picture, whereas a representation can be any structural item that stands for the represented object. You may compare it to the binary code of a computer. This statement

does not claim anything about how something is represented. Typical examples would be conceptual representations like thoughts, beliefs, or wishes as well as sensory, non-conceptual representations like visual or auditory representations and any other sensation (pain, hunger, etc.). This distinction is analog to the following distinction in psychological literature: language-like representation and picture-like representation (images/imagery). The essential feature of a representation is its relation to something in the world or to another mental state – there is always a reference.

To be precise, following terminology will be introduced: Talking about mental representation you can distinguish between the vehicle (the medium, the representation itself), the representandum (the content, the represented object in the world or in the head), the subject, and the relation between those components. This relation can be described as a triple-digit relation: the representation has a meaning to the subject and refers by this meaning to the representandum (Fig. 2.1.). To quote Peirce (1931): “To stand for, that is, to be in such a relation to another that for certain purposes it is treated by some mind as if it were that other”.

**Fig. 2.1** The triple-digit relation:  $R<s, v, r>$



### 2.1.2 The Vehicle

Concerning the vehicle of a mental representation, it is useful to consider the function of theoretical constructs and their possible neurological realizations. First, a theoretical construct does not imply any ontological claim, but the further development of neuroscience might show that there are corresponding states and processes. At this point, we do not need to worry about whether neuroscience will successfully determine certain states or processes as indicators of mental representations or not. We may just assume that there is “something” that is realizing the vehicle of a representation and ask ourselves what functional features go along with it.

### 2.1.3 The Representandum

The representation is referring to the representandum which may be an object, a fact, or another mental state. To specify the representandum, we can use the notion of

content. The content of a representation can be true, accurate, appropriate, adequate, or consistent; that means it has semantic properties. But this is only true if there is an interpreter, in the case of mental representations the subject employing the representation. The content of a mental representation could, for example, consist in knowing something about facts in the world. Language-dependent representations have a content which can only be understood if you take the language community into account as well.

### ***2.1.4 The Subject***

The relation between the representation and the representandum must be created by a person, the language-community, and the circumstances. Being a representation is not a property of something itself; being a representation is dependent on the fact that somebody is using it as a representation. Otherwise it would just be something like a natural sign (spoor or trace) and not a representation. If something is used as a representation, it has a function to the user. Besides that, the attitude of the subject toward the representandum plays an important role; you can wish, believe, or hope something.

### ***2.1.5 The Triple-Digit Relation***

As we have stated before, a representation is not just a copy of the referred-to object. Its relation to the representandum differs, depending on what kind of representation you consider. As we mentioned above, there are different theories of representations but each theory on its own seems not to be able to cover all kinds of representations. This has not been really successful because the description of the adequate relation of a representation depends on the type of representation you refer to. In this chapter we will just deal with two types of mental representations: the sensory (non-conceptual) and the conceptual ones.

Concerning the general case of sensory, non-conceptual representations (comparable to imagery/pictorial representations), there is something like a causal link to the representandum: A stimulus evokes a reaction/response of the sensory systems (organs) and together with some sort of information processing a representation evolves. Concerning visual stimuli, you can observe information processing before anything like a representation is accessible for the human being. A causal theory of representation seems to be adequate to describe the triple-digit relation to the representandum concerning sensory representations. An exception would be a hallucination, which is a representation of a non-existent object and therefore without a direct causal link to the representandum. A possible objection is the fact that hallucinations also presuppose a memory of sensory sensations. Taking this into account, you might talk about an indirect relation to a representandum. But it should be called a misrepresentation (see below) as well.

On the other hand, conceptual representations (comparable to non-pictorial, language-like representations) have structure-preserving relations like isomorphic as well as partial isomorphic relations. Concerning the former, we postulate that some essential structures are chosen and represented, but to distinguish a simple trace from a representation we have to claim a relation to the subject employing the mental representation as mentioned above. Concerning conceptual representation, a theory of structural similarity would be one way to describe the relation of the vehicle to the representandum. But taking into account that content can only have a meaning if it is playing a functional role for an interpreter, a functional theory might be a way to describe the relation of the subject to the representandum.

An interesting approach to describe representations has been developed by Gottfried Vosgerau (2008): Going back to the idea of the automata theory, the behavior of an automaton is described by a function, defining the mapping of a state of the automaton plus the input and the consequent internal state plus the output.

This approach is related to the symbol-system hypothesis saying reasoning is symbol manipulation and the so-called Church–Turing thesis claiming that any symbol manipulation can be carried out on a Turing machine. The consequence of these hypotheses implying that any symbol manipulation can be carried out on a large enough deterministic computer will not be discussed here.

To describe the behavior of human beings, we can refer to inputs (sensory sensations, internal states, mental representations), outputs (behavior), and following states. The claim of an inner state can explain why humans are able to react in a flexible way to one and the same input instead of being obliged to react in a rigid manner. A human being can react differently depending on his internal state. Just like a soda machine reacts differently depending on whether money has been inserted or not which is equivalent to two distinct states. The fact of money having been inserted or not is represented through the inner state of the machine, and this state plays a functional role for the further behavior of the machine. In the same way, internal states have a functional role for human behavior. How this function is best described will be a question for individual sciences to answer. The main idea here is to see that internal states can represent facts or substitute facts in a way so that they play a functional role to further processing.

### ***2.1.6 Types of Mental Representation***

To come to an even clearer notion of mental representation, we will have a look at further distinctions. There seem to be many kinds of representations which differ in certain ways. The terminology differs not only regarding the different disciplines. Looking, for example, into the field of imagery (Cp. Kosslyn, 1980) – a topic mainly treated by psychologists – you will find the distinction of pictorial and non-pictorial representation. The non-pictorial representations are seen as discrete or digital. The

pictorial ones are described as continuous and analog. Of course, you can also think of a hybrid form having pictorial and discrete elements.

In cognitive science, you will find several terminological notions for different formats of mental representations, just mentioning mental models (Johnson-Laird, 1983), retinal arrays, primal sketches and 2½-D sketches (Marr, 1982), frames (Minsky, 1974), sub-symbolic structures (Smolensky, 1989), quasi-pictures (Kosslyn, 1980), and interpreted symbol-filled arrays (Tye, 1991).

In the philosophical discussion as introduced above, you will find the distinction of two or three types of mental representations. The first one is called non-conceptual representation and its characteristic properties are phenomenal features. The notion of phenomenal feature involves, roughly, sensory representations, experiences, and image-like representations. The second group is called conceptual representation which is normally seen as non-phenomenal but rather abstract. The conceptual representations might be described as being in a language-like medium. But this is not accurate, because there are positions claiming that there are conceptual representations which do not depend on language. For example, very young children are able to distinguish between living and nonliving things. They have no linguistic abilities but they have an idea, a concept of living things. The third one is again a hybrid type, a representation with phenomenal features and conceptual elements.

Looking at the relation to the subject, the content of a representation can be conscious or unconscious. Unconscious representations will play no role in this chapter because our focus is on conscious representations. This is owed to the fact that diagnosis of knowledge is related conscious knowledge. There are several possible attitudes a subject can have concerning the content (representandum) of a representation, like believing, regretting, hoping, fearing. This differentiation will not be analyzed in detail because it does not play an important role in studies in the field of learning sciences.

Figure 2.2 shows you what types of representations we have already referred to:

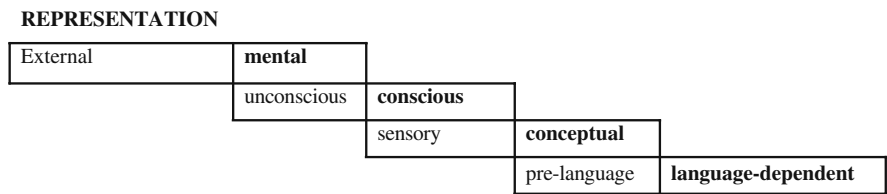


Fig. 2.2 Kinds of representations

So far we can state that the mental representations referred to in this book seem to be mainly mental, conscious, conceptual, and language-dependent representations. These are the very representations we will focus on from now on. After this general introduction, we will first examine what is not falling under this concept to describe the demarcation of the notion of representation to other nearby notions. The aim is to come near to a clear-cut discrimination.

## 2.2 Related Notions

Seeing mental representations as a component of information processing with semantic properties and being described by a triple-digit relation, you have to describe the relationship to other nearby notions of mental representations. The aim of this section is to prevent that those notions are mistaken with the notion of a representation. First, we will give some examples where psychological processes are explained by representations, then we will refer to notions explaining how representations can be structured, and last but not least we will discuss what a misrepresentation is meant to be.

### 2.2.1 “*Explained by . . .*”

In many descriptions of mental processes, representations play a role; they are used as cognitive building blocks. Memory, imagination, thinking, anticipation, expectation, and substitution are explained by the function of representations. Having a memory means to have a representation that is a reconstruction of an earlier mental representation. You can classify them via their content: There can be – just to mention some – perceptual, conceptual, and episodic contents, and there are more categorical representations using abstract schemata and several forms of hypothetical representations. The theoretical construct of a representation is used to describe processes in the so-called black box in order to explain cognitive abilities. Analog other cognitive abilities are explained by using representations.

### 2.2.2 “*Structured by . . .*”

In the following section, some structuring notions are shortly introduced to describe their relation to representations. Notions like schema, scripts, and mental models have in common that they describe how representations can be organized. Focusing on the meaning of the notion of a schema concerning cognitive science, you can state a schema is meant to be a hierarchically ordered structure of knowledge, evoked by recurring experience, for example, by repeated episodes of actions. Components of schemata have the role of variables which assures the flexible use of those structures (Cp. Ritter et al., 2007). A schema is a structure that can be used to organize representations. A nearby notion is the notion of scripts; they seem to be a little bit more language dependent but this impression is not backed up by any definition; it is just the casual usage of this notion. Schemata and scripts are seldom used in philosophical discussions, a similar structuring function is here fulfilled by so-called mental models (Cp. Johnson-Laird, 1983); they are understood as a conceptual framework of representations of knowledge. This knowledge can be related to the person itself (self-model), to parts of the world (world-model), or to abstract correlations. It is worth pointing out that the above description differs from the meaning of “model” in learning sciences where a model is an ad hoc construction with no duration. In philosophy, however, a model has a lasting structure. Those different meanings

should be discussed to avoid misunderstandings before any interdisciplinary work can start. Many other notions have been introduced to describe structuring features of representations. Just by looking at the papers collected in this anthology, you will find notions like semantic maps, concept maps, or an individual's knowledge structure described as a data association array.

Reflecting these structuring notions, you can state that representations which should represent complex knowledge have to be structured and connected to other representations. To be able to have a conceptual representation, you must be able to develop the ability to structure information. And this might even be a necessary condition for the possibility to "externalize" representations as we will discuss later on. The accurateness of a conceptual representation seems to depend on the right structuring framework.

### ***2.2.3 Misrepresentation***

To have a clear notion of representation, we should have an idea about what constitutes a misrepresentation. To define what is meant by a misrepresentation, we go back to our first general explanation: a representation is understood as a triple-digit relation. A misrepresentation is a representation that fails to refer to a representandum. This is the case if the representandum doesn't exist or if the represented properties do not belong to the related representandum (Drestke, 1994). A relation can go wrong if it is not adequate; this means we have to define what an adequate relation is. First, we state that any mental representation has an intentional character; the vehicle is used by somebody to refer to something. Second, we have to analyze which criteria have to be fulfilled so that this "referring" can be judged as successful. As we mentioned above, there are different positions about the nature of this relation. Keeping in mind that there are several kinds of representations, it might be reasonable to assume that this relation differs depending on what kind of representation is involved. There may be no unifying theory of representation defining the criteria of an adequate relation for every type of representation. Consequently, it is reasonable to look for a theory about particular types of representation as a first step toward an overall theory (Cp. Vosgerau, 2008.). For example, the so-called sensory representations can be described with a causal theory; stimuli evoke those representations. A misrepresentation would be a representation of a stimulus without the existence of the stimulus, for example, a hallucination. (Possible objections were discussed above.) This is still a representation; there is a relation to a representandum but this relation is not adequate concerning a causal link. In this case, it is a misrepresentation because there is no causal link to a stimulus. Concerning conceptual representations, it seems reasonable to refer to structure preserving similarities to judge whether a representation is adequate or not.

## **2.3 How to Operate on Representations**

The detailed description of how one operates on representations depends on the special type of a representation. In this chapter, we focused on internal, conceptual,



and language-dependent representations. Just being able to represent something mentally is not enough for gaining knowledge. You have to be able to operate on representations as well. You need a form, for example, a schemata, a script, or a mental model to provide a structure which is able to picture relations between different representations. Given such a structure, you can simulate or anticipate possible changes; those structures make it possible to enrich the knowledge base.

The description of what it means to have a concept of something will lead us to a deeper understanding of the operations necessary to the ascription of a conceptual representation to a system. A concept requires abilities of differentiation, classification, abstraction, and generalization. For example, to have a concept of the color red, you should be able to ascribe this property to different objects, and you will need an idea of something being colorful.

Having a concept of something can be understood as analogue to the expression of having a mental (conceptual) representation of it. Of course, there are different theories about concepts, like concepts as abilities or as abstract objects (Cp. Margolis & Laurence, 2008). In this chapter, we will restrict ourselves to the understanding of concepts as a specific kind or form of conceptual representations. This idea goes back to Fodor (1987) and his representational theory of the mind (RTM). Concepts are deemed to psychological entities. As we described above, the relation between a subject and a mental representation is presented as taking a belief or any other propositional attitude.

A classic contemporary view (Fodor, 2003) postulates that representations have a language-like syntax and a compositional semantic. Besides this view, some claim that representation involves more pictorial structures. But if you remember the different types of representations, it is easy to imagine that pictorial structures are more suited to sensory representations than conceptual ones. Here we are concerned with the conceptual, language-dependent representations, and for those the above language-like description will be appropriate. Having a language-like syntax means that you will find a subject/predicate form including logical devices like variables or quantifiers. This mental representation view of concepts can be found in the work of Pinker (1994), Carruthers (2000), Fodor (2003), and Laurence and Margolis (1999). It seems to be a widespread position.

### ***2.3.1 How Do You Know that Someone Is Able to Generate and Use Conceptual Representations?***

From a philosophical point of view, you will ask yourself under which criteria you will be inclined to ascribe an internal conceptual, language-dependent representation to a person. This could lead to a discussion about dispositions and abilities which seem to be a consequence of representations. Given that a certain conceptual representation is explained by the knowledge about a certain fact, for example, the simple fact that if it is raining then the person with this representation has the knowledge, and under normal circumstances this person is able to express this knowledge with the sentence: It is raining. The person knows what it means for the statement

to be true and is able to judge whether incoming information about the outer world fulfills the truth conditions of this statement.

In interdisciplinary fields, this question of sufficient and necessary conditions should not only be understood as a pure conceptual question; the findings of the empirical sciences are to be included in determining the conditions for conceptual representation. There are indicators which tell us that somebody has the ability to generate and use conceptual representations. In learning sciences, the diagnosis of knowledge is done by means of several methods; on the one hand you can try to test what somebody does not know and on the other hand you can try to find out what somebody knows. To examine complex knowledge structures, concept mapping is a widespread method. Concerning the topic of text understanding, test persons are asked to give a written summary of a given text and then they are asked to develop a concept map with the main notions in boxes and pointers with annotations. Conceptual representations are not described here; all you can claim is that those tests indicate that somebody has some knowledge and this knowledge is represented somehow. An external representation like a concept map refers to mental representations in two ways. First, the external representation bears relations to the individual conceptual representations, for example, relations among items on the map are assumed to be isomorphic to relations among concepts. Second, there must be a relation to mental representations of other members of the language community, otherwise we could not talk of a successful expression of knowledge. The important point is that external representations have to be interpretable by other persons as well.

The process of transforming a mental representation into an external one is often described as externalization but this may not be the accurate way to describe this. In my opinion, a mental representation cannot be externalized but an external representation can refer to a mental representation. Given that someone has a conceptual representation about some facts in the world and he has several possibilities to express himself like talking, writing, or drawing, then he can be asked to show that he has this knowledge and that he is able to express it in an adequate way. Language is in the normal case the best means to create external representations referring to the content of an internal, conceptual, language-dependent representation.

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