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KNOWLEDGE AND BELIEF AS LOGICAL  
LEVELS OF REPRESENTATION

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We propose a representation system consisting of two interacting subsystems, named K-theory and K-model, which play the respective roles of conceptual and episodic knowledge. We define belief a model M used by thought processes not directly, but through a meta-structure which predicates a relation of M to other models. We claim that from an intrasystemic point of view the difference between knowledge and belief is determined neither by the structure and content of a model nor by its relation to objective truth, but by the logical level of its representation.

## 1. THEORETICAL FRAMEWORK

A number of different approaches to the distinction between knowledge and belief have been proposed in philosophical, AI and psychological literature. A first classification of such proposals is based on the distinction between:

- the aim of globally classifying a representation system as either a knowledge system or a belief system (Abelson, 1980);
- the aim of attributing the status of knowledge or belief to individual representational items within a system (Hintikka, 1962; Miller and Johnson-Laird, 1976).

A second classification, independent of the previous one, relies on the criteria used to assign the status of knowledge or belief to a system or to a single item. The main existing approaches are:

- (i) an observer judges a representation system with respect to the objective reality; all representations are a priori considered as beliefs, and whenever a belief happens to be true it is considered as knowledge (Hintikka, 1962). For an AI application of such an approach see Cohen and Perrault (1979), and Perrault and Allen (1980);
- (ii) an observer judges a representation system with respect to another representation system; see for example the "nontransparent" criteria by Abelson (1980): nonconsensuality and different in existence assumptions;
- (iii) an observer judges a representation system on the basis of its structure; see for example the "transparent" criteria by Abelson (1980): presence of alternative worlds, of evaluative and affective components, of a substantial amount of episodic material, unboundedness, varying degrees of certitude;
- (iv) an observer judges a representation system S with respect to his own representations, assumed as knowledge. Whenever the representations of S agree with those of the observer, they are considered as knowledge; otherwise, they are regarded as beliefs. See for example the "deictic" definitions of KNOW and BELIEVE in Miller and Johnson-Laird (1976);
- (v) a system judges his own representations.

Abelson (1980) accounts for his case by emphasizing the possibility of "awareness of nonconsensuality". Instead, Miller and Johnson-Laird (1976) discuss the relation between KNOW and BELIEVE and the degree of dubiety of a representation.

Finally, note that the approach implicit in most AI representation systems is not to deal with the problem of beliefs, therefore considering all representations straightforwardly as knowledge.

From a psychological point of view, a human system can have access to external facts only through their internal representations. Therefore, the question becomes the ability of humans to subjectively assign to their own representations the status of knowledge or belief (Airenti, Bara, Colombetti, 1982). In Section 3 we shall argue that this distinction relies on the logical levels of representations.

## 2. THE REPRESENTATION OF KNOWLEDGE

We propose a knowledge representation system consisting of two interacting subsystems, named K-theory and K-model, playing the respective roles of conceptual and episodic knowledge (Airenti, Bara, Colombetti, 1980, 1981).

K-theory is a theory of the world, and can be conceived as a network of conceptual entities describing classes of objects, relations, processes, actions, etc. (for example: the concept of a book; of x being on y; of x falling from y; of an agent z opening y; etc.).

The cognitive system does not deal directly with the world, but with partial representations of it, which constitute what we call K-model. In fact, there is no way for K-theory to reference entities in an external world: in the cognitive system, representations only can be mentioned and used. K-model contains all episodic knowledge of the cognitive system, i.e. knowledge about particular objects, facts, episodes, etc. (for example: the book B Maria is now reading; the fact that B is presently on desk D; the fall of B from D; Maria's opening of B; etc.). These can only be expressed by means of the conceptual machinery provided by K-theory.

We assume that the essential feature of K-theory is the ability to generate models for insertion and subsequent manipulation in K-model. For example, the concept of a "book" is a structure in K-theory allowing the cognitive system to construct models of books whenever needed by a thought process. K-model contains the representation of the perceived world, which is continuously changing through time and space. As K-model is intended to capture the cognitive system's subjective experience, it does not only represent the perceived world, but also any possible imagined world. This corresponds to saying that any imagination process must produce data which belong to K-model, and thus satisfy K-theory. So K-theory determines the set of worlds

which are possible for the cognitive system, i.e. the spectrum of all its possible subjective experience. This leads to conceiving K-model as a set of models of K-theory, each representing parts of a possible external world - presently perceived or remembered or imagined.

The partition of knowledge into K-theory and K-model is logical rather than functional. This is reflected by the fact that K-model, as noted above, collects data used by different thought processes. Actually, all data involved by perception, imagination, illusions, dreams, plan formation and execution, language comprehension, etc., are introduced through different thought processes, but share the same logical structure. We emphasize that models are used by such thought processes as data; in these cases the system is not concerned with problems of existence of entities or truth of facts represented in a model.

### 3. THE LOGICAL STRUCTURE OF BELIEFS

On the basis of our previous definitions of K-theory and K-model, we assume a constructional standpoint. That is, the sole reality for the cognitive system is what is constructed by its thought processes using K-theory. It follows that the position which, according to Hintikka's approach, defines as knowledge a belief satisfied by the real world, cannot be applied. In a constructional approach, in fact, K-model necessarily satisfies the part of K-theory used to build it. For instance, if Margaret assumes in her K-theory that seawater is sweet (i.e. unsalty), in all models produced by her the sea will be sweet, regardless of the objective truth of this fact. From a subjective point of view it is appropriate to say that Margaret knows that the sea is sweet.

Now suppose that Margaret happens to taste seawater. Let us assume that Margaret is able to distinguish between sweet and salty water, and that her K-theory represents the two tastes as mutually exclusive when attributed to the same object. We suggest that the relevant possibilities in this case are:

- (i) since the construction of the model of salty seawater would be conflicting with the previous models, either the new model is not constructed at all, or the new model is constructed but the discrepancy is not appreciated (in this case Margaret maintains her theory about the sweetness of seawater);
- (ii) the model is reinterpreted (Margaret may think that her perception of a salty taste depends on a particular kind of salty rocks);
- (iii) the discrepancy between the two inconsistent models is appreciated and faced by assigning to the discrepant models that status of beliefs (Margaret acknowledges the existence of two contradictory models).

Our hypothesis on case (iii) is that the coexistence in K-model of two contradictory models makes the thought processes unable to use them straightforwardly. To face this situation the system introduces in K-model a structure, which refers to the two models and represents the conflict between them (see Fig. 1). As such a structure predicates a relation between the two models, it can be considered at a meta-level with respect to them. It is by using this meta-structure that thought processes handle the conflict. The possible outcomes of such processes are: the old model is privileged and the new one is discarded; the reversed situation, i.e.

the new model is privileged and the old one is discarded; a situation of uncertainty, where both models are maintained.

We define belief a model M used by thought processes not directly, but through a meta-structure which predicates a relation of M with other models. Such meta-structures are necessarily used by the system whenever two models cannot be interpreted simultaneously, i.e. cannot be predicated at the same time of the same thing.

This definition of the term "belief" seems to be the most appropriate within a subjective, constructional approach to the human mind. The difference between knowledge and belief is reduced to the different use that thought processes make of a representation, assumed either as absolute or as relative to other representations. Whenever the system does not directly manipulate a model M of the world, but reasons on it through a second level representation, M assumes the role of belief. Note that both structure and content of M remain the same when used as knowledge or as belief.

### 4. DISCUSSION

Referring to the first classification introduced in Section 1, we have discussed the problem of attributing the status of knowledge or belief to an individual representational item within a cognitive system. Many researchers who deal with this problem commit themselves on the assumption that the difference between knowledge and belief can be defined in terms of the objective truth of a fact. That human beings cannot have access to an ultimate, absolute truth is a trivial statement. As Miller and Johnson-Laird (1976) point out, it is not acceptable, either from a psychological or a linguistic point of view, to assume that "...knowledge is simply justified true belief and that one cannot be said to know something that is false".

From our psychological standpoint, we have therefore assumed a different position and focussed on the internal structure of knowledge and belief. We have shown that our definition of belief is significant in the case a system has to deal with conflicting models of the world. The idea of a second level structure seems not to be restricted to such a case, but it can be applied whenever the system evaluates properties of a model. Among these are the degree of certainty of facts and the existence in the world of the entities represented in a model. In fact, both existence and degree of certainty are not part of a model, but are predicated on it.

Our treatment of beliefs opens a problem about the thought processes manipulating K-model. The two possibilities are:

- thought processes treat in a uniform way both the models of the world and the meta-structures mentioning them; an analogous approach is taken by Wilensky (1981) in his work on planning and meta-planning;
- there exist a type of thought processes specialized in manipulating meta-structures; in this case the two levels of representation would reflect into two corresponding levels of thought.

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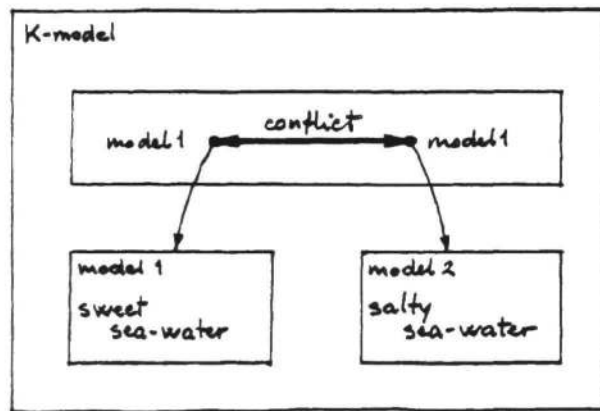


Figure 1. The meta-structure representing a conflict between two models.

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