Peircean Proto-Signs

Janos J. Sarbo

Radboud University Nijmegen, The Netherlands

Abstract. Human knowledge is intentional, as opposed to 'knowledge' represented by the computer, which is syntactic. The premise of this paper is that nevertheless a process model of cognition can be defined which is isomorphic and analogous to Peirce's 9-adic classification of signs. An advantage of the relation with the Peircean concepts lies in the model's potential for the definition of a 'natural' representation of knowledge, a representation which can be more easily interpreted than the traditional formal ones.

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1. INTRODUCTION

The focus of my research in the past years has been on the development of a formal theory for a uniform representation of knowledge in the realm of perceptual judgments [8](2,142). Together with a colleague, we managed to prove that such a representation can be defined for various domains of knowledge like natural language, (naive) logic and reasoning [3], [9]. We paid little attention however to the consequences of the formal character of our approach, filling this gap is one of the goals of the current paper. The problem can be paraphrased as follows. If knowledge arises via cognition, representation is properly spelled as *re*-presentation, and formal is a synonym for computational (which is syntactic, hence *not* intentional), then 'formal knowledge representation' is a contradictio in terminis.

In my view, the problems of knowledge representation can be distinguished in two parts. The problems of the first part are due to the complex relationship of knowledge with cognition (how can physical stimuli be processed by the brain into meaning), and signification (how can we know about 'real' world phenomena by means of signs, and what types of signs are there). The problems of the first part have been the subject of our research in the past, the results of which I shall recapitulate later. The problems of the second part are related to the inherent properties of (formal) representation, which are exposed in their mature form by Searle's Chinese Room Argument (CRA) example and which I will use as a reference.

The goal of this paper is an attempt to show that, although the model introduced in [3] cannot solve Searle's 'intentionality problem' either, its representation can be more easily interpreted as knowledge, than the formal representations provided by traditional modeling.

The contents of this paper can be summarized as follows. The first part (section) is devoted to the problematic relation between meaning and computation. In the second part (section), the knowledge representation model is recapitulated. In the final, third part (section) the hypothetical concept of a proto-sign is introduced, linking formal computation with full meaning. Examples illustrating the uniform representation, which are omitted due to lack of space, can be found in [9], [11], amongst others. In this paper, the terms 'meaning' and 'knowledge' are used interchangeably.

2. KNOWLEDGE AND COMPUTATION

Searle's celebrated thought experiment invoked many discussions in the past, and though his problem is less prominently present in current literature, the questions of 'strong AI' have not yet been unanimously answered.

As Searle explains it [12], "the point of the Chinese room example [was to show that] instantiating a program could not be constitutive of intentionality, because it would be possible for the agent to instantiate the program and still not have the right kind of intentionality; [*intrinsic* intentionality]." Searle concludes [13] that the essence of the CRA can be captured in four premises: (1) brains cause minds; (2) syntax is not sufficient for semantics; (3) computer programs are entirely defined by their formal, or syntactical structure; (4) minds have mental contents; specifically they have semantic contents. To the question whether the digital computer was able to represent knowledge, after all, Searle answers [13]: "any digital computer is capable for knowledge representation, if by 'digital computer' we mean anything at all that has a level of description where it can be correctly described as the instantiation of a program".

The Chinese Room Argument invoked reactions from many areas of science like philosophy and AI, but also from cognitive theory. In Harnad's estimation [6], the CRA adequately shows "that symbol manipulation is not all there is to mental functions". Also Searle emphasizes that knowledge is "something made of qualia" [14]. In accordance with that view and the hypothesis, that cognition can be modeled by a recursive process, I will maintain that knowledge itself could be a quale.

2.1. The Source of Knowledge

I assume that knowledge arises from the observation of 'real' world phenomena. Seen from the semiotic point of view, phenomena are interactions appearing via the mediation of a change, as an event, which is meaning; as opposed to the cognitive point of view, according to which, a phenomenon is a quality which is a stimulus, triggering the senses (via a change) and generating a bio-electric signal (an event), which is a representation of qualia.

The combination of the two views yields the definition of meaning, as a quality which is a sign. Indeed, an interaction entails the existence of two, in principle independent dual entities, which are qualities; and, the processing of the input stimulus by the brain involves interpretation, implicating the existence of a sign. (In sensory perception, the independent entities which are qualities, are the input stimulus and the sense.)

According to categorical perception [5], the recognition of qualia is a distinguishing feature, besides the sensory level, also of the higher levels of cognitive processing. Seen from the computational point of view, qualia are information (which is only potential meaning), reducing cognition to information processing. How can meaning arise in such a scenario?

2.2. The Peircean View

According to Peirce, meaning presupposes signification. Peirce defines a *sign* as anything that stands for something else. That for which a sign stands, he calls the *object* of the sign. But that is only part of the story. Equally important is that a sign always stands for something else *in some respect*, which element Peirce calls the sign's *interpretant*.

To Peirce, the interpretant is an integral part of the sign in the sense that the interpretant *together with the sign and its object* constitutes what is properly called a Sign. Thus, we could make a distinction between a Sign and a sign. The term 'Sign' or *meaning* stands for the *triadic structure* of sign, object and interpretant, while the term 'sign' stands for whatever it is that stands in place of its object [2]. For instance, it is usually acknowledged that smoke may stand for fire in the sense that it indicates some danger. Thus, if we observe smoke, then the Sign is constituted by the smoke-signifying-fire-as-danger, while the sign is simply the smoke (having fire as its object and danger as its interpretant). Inasmuch a Sign itself may become a sign, recursively, in the rest of this paper the terms 'Sign' and 'sign' will be used interchangeably.

Though we may be able to 'derive' from the meaning of the Sign a relation between sign and object, and sign and interpretant; and the other way round the knowledge of such relations may enable us to 'imagine' the perception of a Sign, the important conclusion is that the meaning of such dyadic relations is always *less* than the triadic meaning of the Sign.

3. COGNITION AS A PROCESS

According to cognitive theory, physical stimuli are represented by the senses as qualia, which are processed by the brain in percepts. In a single operation, the brain compares the current percept with the previous one, and this enables it to distinguish between two sorts of input qualia (in short *input*): one, which was there and remained there, which is called a 'state'; and another, which, though it was not there, is there now, which is called an 'effect'. The 'goal' of cognition is to find an interpretation of the relation between such input state and effect.

The input triggers the memory which in turn generates a response, consisting in information about the properties of the input qualia. In a *nested process*, which is not specified due to lack of space, the input and the memory response

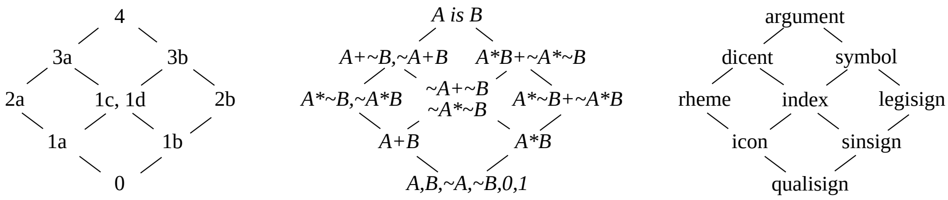

FIGURE 1. Computational, logical and semiotic interpretation of cognition, as a process.

are linked, yielding the signs of the input state and effect, completed with their properties. Such properties, which can be subject to learning, specify the possible co-occurrences of the qualia, as a *combinatory* potential. On the basis of the activation of the memory response, which is either below or above threshold, the completed signs can be classified as those (i) which are in the *focus*, and (ii) which are only *complementary*. This completes the initial operation (step 0) of cognitive processing.

In step 1 (cf. fig. 1), the input qualia which are in the focus are identified separately, as *constituents* (1a), and collectively, as a *co-occurrence* (1b). Also the complementary signs, representing the *context* of the observation, are represented analogously (1c, 1d).

Subsequently, in step 2, the signs of 1a and 1b are used for the representation of the meaning of the constituents, independent from the meaning of their co-occurrence (2a); and the other way round for the representation of their co-occurrence, independent from their meaning as constituents (2b). In both cases the underlying operation is relative difference, which is interpreted differently in 2a and 2b (for details see [3]).

The complementation of the abstract meaning of the constituents (2a) with the meaning of the context (1d), obtains the actual meaning of the constituents or the *subject* sign of the observation (3a). Analogous complementation of the abstract co-occurrence meaning of the input (2b) yields the characteristic property or the *predicate* sign of the input (3b). Finally, by combining the subject and predicate representations, cognitive processing 'generates' the meaning of the entire input, as a proposition which is a hypothesis (4).

3.1. Logical Interpretation

The different stages of cognitive processing can be interpreted as logical operations. The logical meaning of the input state and effect qualia (step 0), can be represented by independent logical variables, denoted by A and B. A variable stated positively and negatively, corresponds to qualia which are in the focus and which are complementary, respectively. Accordingly, the state and effect qualia of (i) can be denoted, respectively, by A and B, and those of (ii) by $\neg A$ and $\neg B$. Additionally, 1b can be interpreted as a logical 'and' operation on qualia, 2a as an 'inhibition', and 3b as an 'equivalence' (the logical definition of a property). The logical interpretation of the remaining computations of cognitive processing are displayed in fig. 1. Our analysis [3] has revealed that all 16 Boolean relations on two variables can be assigned to the relations of cognition, indicating the completeness of this process in the 'naive' logical sense (0 and 1 can be defined as the sign of a 'not-valid' and 'valid' input, respectively). The 'naive' character of the representation is due to the synonymous interpretation of some of the Boolean relations, for example, $A*\neg B$ and $\neg A*B$ (in 2a).

3.2. Aspects of Meaning

The problematic character of knowledge, as a process, is due to the inherent property of signification that signs must be embedded. According to Peirce, there are ten types of such embeddings, the properties of which can be distinguished in nine classes (cf. Peirce's decadic and nonadic classifications of signs). More specifically, a sign of the decadic classification can be characterized (analytically), as a compatible combination of nonadic types. Such types, interpreted as *parameters*, are what I call an *aspect* (of meaning).

Following this line of thinking I suggest in this paper that each stage of cognitive processing an aspect of meaning can be assigned to. For example, the aspect of an 'actual event' to 1b, the aspect of 'abstraction' to 2a, the one of a 'consensus' to 3b. We proved elsewhere [3] that an isomorphic relation between the 9 types of cognitive representations and the types of signs introduced by Peirce in his nonadic classification can be defined, and that each of the cognitive computations can be given a meaning, which is analogous to the meaning of the corresponding Peircean type.

This relatedness between the cognitive and semiotic concepts is the key to a *natural* definition of the combinatory properties of qualia, as *habits*. In addition to this, the dependency between the Peircean types themselves is the key to the interpretation of sign recognition as a process, generating increasingly better *approximations* of the final meaning of the observed phenomenon. This altogether may explain why the computational model of cognition can be seen as a *natural* model for knowledge representation.

4. KNOWLEDGE AND QUALIA

An inherent element of the theory of semiosis, as well as of cognitive processing is the assumption of an irreducible 'whole' (the concept of a Sign, and a quale, respectively), emerging from constituents that themselves are brought about the same process. According to Searle, "there are many examples in nature where a higher level feature of a system is caused by lower level elements of that system, even though the feature is a feature of the system made up of those elements. Think of the liquidity of water or the transparency of glass or the solidity of a table, for example. Of course, like all analogies these analogies are imperfect and inadequate in various ways. The important thing is this: there is no [...] obstacle to claiming that the relationship between brain and consciousness is one of causation and at the same time claiming that *meaning* [my emphasis] is just a feature of the brain" [14].

An example of a physiological phenomenon which is a process appearing as a quale, is the perception of apparent motion. When we watch film or TV, what we are really seeing is a series of still pictures (frames) that appear briefly with momentary darkness in between. The illusion of motion is due to the optical phenomenon known as persistence of vision. In a nutshell, the idea means that a single image lingers on the retina (or later, in the brain) for a fraction of a second, which the brain then connects with the next different image and interprets the difference as movement. Recent studies have shown that the real reason we see movies move is more complex but not essentially different [7].

What makes motion perception especially interesting for knowledge representation is that motion, as a quale, emerges from the observation of still pictures. Though all picture individually, i.e. viewed for several seconds, can have a *full* meaning, any one of the pictures can contribute to the perception of motion, in a *partial* sense only, as a 'sign' which is *not* finished (i.e. degenerate, semiotically). That the perception of pictures, as individual meanings or the illusion of motion must correspond to each other, follows from our ability to 'imagine' motion from the full recognition of individual pictures and, our potential to 'derive' an underlying series of (partially recognized) pictures from the experience of motion.

4.1. The Motion Perception Metaphor

Hypothetically, motion illusion can be explained as the difference between the first and last pictures of a series, interpreted by the process of comparisons of subsequent pictures of the same series. Assuming a single comparison can distinguish the qualia of subsequent pictures in two types: qualia which are present in both frames, hence marked by the relation of agreement, can be interpreted as a *state*, and those which are present in one of them only, hence marked by the relation of difference, as an *effect*, the meaning of a single picture, which is always with respect to the preceding picture of the series, can be defined as the interaction between such state and effect, and the meaning of a series of pictures, as the interaction between the initial state and the complex effect induced by the series as a whole. A representation of such an interaction is that I shall call the sign (or meaning, or quale) of motion.

The analogy of motion illusion with cognition, as introduced in sect. must be clear. Also cognitive processing makes use of two initial samples (previous and current percepts), which are compared with each other in the sense of agreement and difference. The two samples can be said to correspond to the first and last pictures of a series, and the intermediate results of cognitive processing, that are stored in the working memory (conceptually), to the subsequent pictures of the same series.

In this account of the representation of knowledge, the phenomenon of motion perception is used as a metaphor. This is not an entirely novel idea. In fact, many authors have proposed an analogical representation for cognitive processing, in the past [1], [4]. A common denominator of those theories is the assumption of the decidability of a correspondence relation on qualia of subsequent pictures, an assumption which is fundamental for the approach of this paper too.

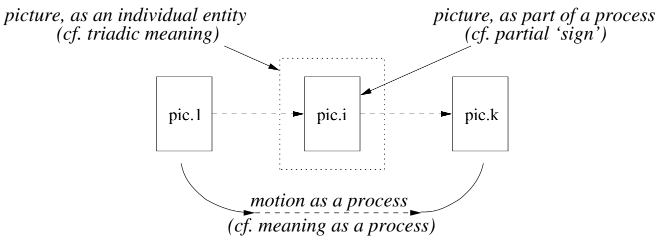

FIGURE 2. Motion perception as a metaphor

Remarkably, the number of pictures and re-presentations necessary, respectively, for the creation of motion illusion and the recognition of qualities, as knowledge, is in the same order of magnitude. Motion perception needs 10…24 pictures (per second), whereas sign recognition requires two initial percepts and an additional collection of $2*9$ partial 'signs' (there are two instances of the type of process introduced in sect. , the first is the nested process, linking the input with memory information, the second is the process of cognition, establishing the meaning of the relation between the input qualia). In the special case, the first process can be sufficient already, and the second process reduces to a re-presentation of the result of the first, as the final sign of input processing. This sets the minimum number of such 'signs' to 10. But there are also obvious differences between the two phenomena. In motion perception, the pictures are organized in a sequence, which is a chain, as opposed to sign recognition, in which the re-presentations induce a complex partial order. Attractive though the analogy between the two processes may be, it is left to the cognitive scientist to prove if sign recognition could be a higher-level analogue of motion perception.

4.2. Proto-Signs

An important feature of motion picture is its potential for a dual interpretation of a single picture, both as a full and a partial meaning (cf. fig. 2). I will use this duality as a metaphor, for improving the specification of the model of cognition of sect. . In this respect, I will assume that the types of partial 'signs' of cognitive processing are identical to the types of Peirce's nonadic classification, interpreted as *aspects*. Additionally I will assume that such aspects can be recognized as a triadic meaning, as a result of embedding. That the nine types of 'meanings' may arise in such a process indeed, can be justified by the logical analysis of our model (cf. fig. 1). However, the hypothesis that the process of such 'meanings' can be interpreted as a full meaning, can be 'proved' indirectly only, by making use of the phenomenon of motion perception, as a metaphor. Inasmuch the partial 'signs' of cognitive processing can be assigned to the 'meaning' of a sign which is not finished, such signs can be called, at the most, pre- or *proto-signs*.

Summarized, the assumption of this paper is that the dyadic relations generated by cognition, as a process, can be experienced by the human interpreter as a full meaning, through the perception of such relations, as aspects of meaning. There are nine types of such relations, which are organized in process. Each relation, which is an event, is at the same time a constituent of the next relation. Being governed by a 'goal' (characterizing all process [2]), which is the recognition of the entire input as a 'whole', such relations can be interpreted more easily than other relations, which are not organized in a process. This claim can be reinforced by the cognitive foundation of those relations, but also by the formal complexity of the representation as a whole. We formally proved in [10] that the model of cognition is linearly complex in the number of input symbols and operations on them. Linear complexity, which is also called real-time complexity, is commonly known as 'real-time' processing, characterising the generation of perceptual judgments.

4.3. The Completeness of Representation

The analogy of cognition with motion perception can be sharpened as follows. Insofar as the experience of apparent motion can be said 'to contain' the meaning of an underlying *complete* series of individual pictures, so can the full meaning of the input be said 'to include' the meaning of *all* types of aspects, as proto-signs, like the representation of the input qualia as independent entities, but also as a constituency, and a co-occurrence relation, etc. The other way round, as motion perception, as a quale, can be 'abstracted' from the (full) meaning of the pictures of a series, so can

TABLE 1. The used terminology

level	motion perception	knowledge
sign	*motion (as a quale), picture (as an entity)*	*triadic meaning/relation, nonadic/decadic type*
proto-sign	*picture (as part of a process)*	*dyadic relation (as part of a process), 9-adic type as an aspect*
computation	*picture (as a set of qualia)*	*dyadic relation (as a function on combinatory properties)*

we ‘create’ the full meaning of the input, from its relational representations, through their interpretation as proto signs. Such a process is cognition, the logical interpretation of which is depicted in fig. 1. The fact that *all* types of logical relations on two variables are generated by that process, indicates that the input is ‘considered’ by cognition from all possible angles. This *completeness*, as a governing ‘goal’, is the *key* to the potential of cognition, as a process, for generating the parameters of *all* types of triadic meaning.

Another argument for the analogical relation between knowledge representation and motion perception, is due to the partial order induced by sign recognition. In that process, the ordering of the re-presentations is such that each relation is obtained from other relations which it is a cover of. The fact that all representations are generated by means of a *simple* operation (relative difference), the process can be said to satisfy the requirement, analogously to motion perception, that subsequent representations (cf. frames) differ from each other slightly only.

The relations identified by the model of cognition can be interpreted as proto-signs, but also as a triadic meaning, ambiguously. This ambiguity of reference is witnessed also by [3], in which, knowledge is defined as a process of *sign* interactions. Although that view can be correct, the signs involved in that process are only proto-signs. The terminology used in this paper is recapitulated in table 1.

5. CONCLUSION

In the analytical tradition of representation, knowledge can be defined only as a formal mathematical relation, as opposed to the full fledged meaning of knowledge, which is intensional. The premise of this paper is that nevertheless the two views can be linked with each other, by means of introducing the concept of a proto-sign. Such signs refer to the unfinished meaning of intermediate results generated by cognition, as a process.

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