

predication is that the former can systematically lead to explicit negation. When performing explicit negation, one has to contrast the perceived object with some prototype and to exclude the former from the latter. You may say *this is not a flea, because it is too big*, or *this is not a star, because it is too big*. R-predication alone, because it is holistic, cannot offer such explicit negation. It can only refuse class membership by measuring a holistic distance and comparing it to some threshold. Yet, every human being has the ability to perform explicit negation on any domain without any specific training. This endowment, which underlies the argumentative use of language, is a consequence of our ability to contrast perceptions and form C-predicates. We suggested elsewhere why this ability can be considered as one of the main cognitive differences that distinguishes *homo sapiens* (Dessalles 2000). It offered a new adaptation, namely, the possibility to detect lies. By contrasting one's own perception with the liar's report, one may not only disbelieve the report, but also offer an explicit reason why the report should be rejected. Similarly, because they can be systematically negated, the predicates used in logical accounts of human thinking are C-predicates, not R-predicates. The fact that C-predicates can be used to make membership explicit (*this is a galaxy, because it is big*) may explain why they are mistakenly supposed to be necessary for any categorisation, and hence imprudently granted to animals.

The scope of Hurford's argument is thus more limited than anticipated, because it cannot be extended to "genuine" predication, what we called C-predication. The author's insight and the comprehensive line of argument that he draws from it could yet be extended in some way to C-predication. Our ability to "locate" an object on the axis provided by the contrast operator may be an evolutionary derivative of the fundamental ability to handle location and property separately. To say that this apple is big or that it is bigger than that apple, we must assign positions to objects, not in physical space but on the contrast axis, which may be, in some cases, quite abstract.

Representational limitations of the one-place predicate

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Abstract: In the context of Hurford's claim that "some feature of language structure maps onto a feature of primitive mental representations," I will argue that Hurford's focus on 1-place predicates as the basis of the "mental representations of situations in the world" is problematic, particularly with respect to spatiotemporal events. A solution is proposed.

Hurford's claim that "some feature of language structure maps onto a feature of primitive mental representations" (target article, sect. 1) is clearly on the right track. However, I will argue that Hurford's focus on 1-place predicates as the basis of the "mental representations of situations in the world" is problematic. Specifically, I will propose that a more appropriate representation is based on the structure of perceptual events that are functionally and behaviorally relevant to the nonlinguistic individual. Such events would include physical contact, transfer of possession of objects, and the like, that inherently consist of multiple-argument predicates. In developing this argument I will exploit Hurford's requirement that the characterization of an appropriate representation should include: (1) "a plausible bridge between such representation and the structure of language" (sect. 1), (2) a characterization of "primitive mental representation" independent of language itself, and finally (3) a plausible story for the neural basis of the representation.

Mapping to language. With respect to the bridge between the representation and the structure of language, Hurford argues that

"very little of the rich structure of modern languages directly mirrors any mental structure in pre-existing language" (sect. 1.1). He further states that in contrast to the morphosyntactic complexity of language, the syntax of logical form is very simple. These comments reveal the shortcoming of $P(x)$ as the representation – it is too simple. Indeed, it seems that by focusing on a representation that is appropriate for logic, Hurford steers off the course of a behaviorally useful representational schema. Nonhuman primates likely have quite rich representations of events, their temporal structure, the individuals involved, and so forth. Constructing such representations in a neural first order predicate logic would be difficult. Indeed, the difficulty of the mapping is revealed by the quantity of effort expended in developing a theoretical basis for mapping logic to language and the meanings that can be expressed in language (e.g., Kamp & Reyle 1993; Montague 1970; 1973; Parsons 1990).

I suggest that although 1-place predicates are certainly useful for representing object properties, they are inappropriate for (and do not extend in a straightforward manner to) event representations. Imagine instead that the prelinguistic representation was based on the perceptual structure of events, with ordered predicates yielding a structure something like "event(agent, object, recipient)." In this case the mapping from the mental representation to language becomes more interesting and more iconic. The distinct ordered predicates in the event representation take on specific thematic roles that are iconically reflected in regularities in word ordering and/or morphosyntactic and closed class structure in a cross-linguistic manner. In the example, "A man bites a dog," the representation: bite(e), man(x), dog(y), agent(x), patient(y) appears arbitrary, unordered, and less informative than bite(man, dog), in which the relations between the event and the constituent thematic roles (agent and patient) are encoded in the representation. I would thus propose that the capability to represent 1-place predicates does not extend in a useful manner to ($n > 1$)-place predicates for representing meaning.

Characterization of the primitive mental representation. Having made this claim, one is obliged to demonstrate the psychological validity of ($n > 1$)-place predicates independent of language. I will approach this from the perspective of (1) observations from developmental psychology and (2) studies of automatic perceptual analysis.

From the developmental perspective, one of the most salient perceptual primitives (after motion) is contact or collision between two objects (Kotovsky & Baillargeon 1998). Prelingual infants appear to represent collisions in terms of the properties of the "collider" and their influence on the "collidee." This supports (but does not prove) the hypothesis that contact is represented by a 2(or greater)-place predicate in prelingual infants.

But is the n -place predicate computationally tractable? That is, is it reasonable to assume that nonlinguistic beings can construct such representations? I have recently explored this question by developing an automated system that extracts meaning from online video sequences of events performed by a human experimenter in a simple setup involving manipulation of toy blocks. The objects are recognized and tracked in the video image, and physical contact between two objects is easily detected in terms of a minimum distance threshold. The agent of the contact is then determined as the one of the two participants that has a greater relative velocity toward the other in the contact. In this context, the event types of touch, push, give, and take can be defined as variants or types of contact events (Dominey 2002; 2003). This demonstrates that sensitivity to a simple class of perceptual event (contact) can provide the basis for a multiple ordered predicate representation of event structure. A more general demonstration of how the perception of support, contact, and attachment can be used to learn the lexical semantics of verbs is provided by Siskind (2001). The objective of developing this perceptual scene analysis system was to demonstrate the feasibility of generating meaning in an event(agent, object, recipient) format, based on the perception of physical contact. This was motivated by simulation studies

of language acquisition based on the learning of mappings between grammatical structure and predicate-argument structures (Dominey 2000), that in turn was based on combined modeling and neurophysiological testing of the underlying functions (Dominey et al. 2003).

These and subsequent studies revealed that the complexity of grammatical forms (e.g., relative phrases) corresponds to an analogous complexity in the predicate-argument representational structure. For example, in mapping the grammatical construct, “The block that pushed the triangle touched the circle,” onto the representation push(block, triangle), touch(block, circle), we can observe an iconic relation between the relativized structure of the sentence and the meaning representation in which the two events share a common agent: block (Dominey 2003).

With respect to the neural basis of multiple argument predicates for representing events, one possibility can be found in the F5 neuron populations described by Rizzolatti and Arbib (1998), which, when observed together, allow distinct representations for grasp(me, raisin) versus grasp(someone-else, raisin). Thus, access to two distinct populations of these neurons allows a event representation with distinct agent and object coding.

In summary, I want to insist that Hurford’s undertaking is quite valid and interesting with respect to the stated goal of investigating the neural basis of predicate-argument structure. Where it fails is in the thesis, “The structures of modern natural languages can be mapped onto these primitive representations.” I hope to have argued that the required representations for events (and their description) are more complex than those described by Hurford – and that they cannot be represented by the primitive structure he describes.

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Cognitive structure, logic, and language

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Abstract: Philosophical accounts of thought crucially involve an array of abilities to identify general properties or features of the world (corresponding to concepts) and objects that instantiate those general properties. Abilities of both types can be grounded in a naturalistic account of the usefulness of cognitive structures in adaptive behaviour. Language enhances these abilities by multiplying the experience bases giving rise to them and helping to overcome subjective biases.

Hurford’s paper signals a potentially important resonance between Fregean truth conditional semantics and neural structure of the type that philosophers like Evans (1982) and Campbell (1995) have begun to explore.

Underpinning this post-Fregean stream of philosophical naturalism is the idea that thought works with a world-picture comprising objects and their properties, and that such a cognitive map of the world is an adaptive achievement for any higher animal. According to this view, the crucial adaptation is a move away from feature-driven stimulus-response patterns, to tracking abilities based on more complex response sets related to object characterisation and recognition. It is a further move for any creature to share information from multiple subject-object encounters so that a rich dossier of information can be used to inform its behaviour in relation to the world in which it lives. A theory of thought and its content of this kind is indicated by the naturalistic tendency of Wittgenstein’s later (post-*Tractatus*) writings and allows truly innovative thinking in theoretical cognitive neuroscience.

We can begin with truth conditional semantics according to which the semantic content of a thought or sentence is given by

the conditions in which a competent thinker would hold it to be true. For a creature in a world like ours, such conditions would, stereotypically and ideally, concern an object and a predicate: “the cat is moving”; “the poison berry is red”; and so on. Notice that even if the noun phrase in the sentence concerned is complex (e.g., “the poison berry”), it concerns an object that is salient for the creature thinking the thought. The simplest question that any creature could ask the world would be “what is that?” where an object catches the creature’s attention, and it must assign properties to the object so as to potentiate a range of appropriate responses. And the information available to the creature is greatly enhanced if objects can be identified and reidentified (under conditions which yield slightly different perceptual features from the first encounter), so that a dossier for objects of the relevant type can be compiled.

It would be a further step to identify numerical individuals (Blackie) rather than categorical types (big monkey) and the computational resources for such a task would be useful wherever the identification and reidentification of individuals had an adaptive pay-off (e.g., where appropriate responses differed among individuals of the same type as in a dominance hierarchy). Human beings could be expected to have an individual identification system good enough to meet the needs of the environment in which their language developed because exactly this condition holds. These thoughts suggest a three-level scheme of the type mooted in Hurford’s article but divorced from the implicit Cartesianism of Frege and many empiricists.

Stage 1: Egocentric space and stimulus response pairings based in individual dispositions – a feature-response scheme.

Stage 2: Egocentric space and activity directed by information about objects as loci of salient general properties – the simple PREDICATE(x) scheme.

Stage 3: Activity (cognitive or overt) in a shared world directed on mutually accessible identified objects and open to information from others – PREDICATE(x’).

Human beings have language and interpersonal behaviour as a primary mode of adaptation (Trevarthen 2001), so stages 2 and 3 of Hurford’s scheme are modified by signs and conventional referring devices for both general features of the world and particular objects in the world. These facilitate and elaborate the response repertoire of any individual so as to give them access to shared dossiers of information about objects and their affordances. If language is used to expand the informational power of an organism, we need to supplement the three-stage scheme by noting the effect of semantic markers (Gillett & McMillan 2000). True concepts and mature conceptions of objects are tied to truth conditions by the normative uses of natural language, so there is a concurrence of semantic content between colinguisic speakers. Thus, early in language learning I might think that a dog is a big black furry thing that bounds around the neighbourhood, but later I discover that dogs include chihuahuas and poodles. Such convergence in categorisation with other competent language users occurs by conversational correction within a colinguisic human group. By noticing this fact, we can, without denying the continuity between human thought and that of higher animals, bring out a point of difference which increases the power of human epistemic activity and in which language plays a central role.

Attention, a prominent theme in Luria’s work (cf. Luria 1973), is important in the formation of concepts and conceptions of objects. In both cases the subject must ground the thought concerned on selected aspects of the environment (Gillett 1992). For example, in the PREDICATE(x) type thought “that frog is bright orange,” “that frog” focuses on and tracks an object, and “bright orange” links a feature of the frog to other stimulus arrays instantiating that colour. Kant (1789/1929) said that thinking was “cognition through concepts”(B94), whereby information from an object was linked in two distinct ways to form discursive or semantic content: (1) to general concepts (square, red, dog, baroque), and (2) to other presentations of the same object. The second link could, in the animal case, be mediated by biological abilities to