Figurative Reasoning and Informatics: Metaphors in the Healthcare Room

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Abstract. This tutorial highlights opportunities for clinical informatics to introduce new perceptual-cognitive models involving figurative-metaphorical reasoning that will more faithfully reflect the flow of clinical practitioners' reasoning and actions. It is designed for professionals who focus on clinical informatics systems and their foundations in biomedical and health informatics and cognitive science. The level will be introductory. We raise critical questions arising from recent findings in cognitive science and neuroscience that present serious challenges to current paradigms of knowledge representation and understanding in Artificial Intelligence (AI) and statistical thinking, both relying on categorical and classification/generalization assumptions from traditional analytic philosophy, upon which they build. We describe challenging issues of clinical healthcare informatics which incorporate novel scientific approaches on language interpretation and its relationship with human perception, cognition and interaction. These are essential for developing new approaches to clinical and biomedical informatics problems incorporating the "bodies-as-mechanisms" metaphors used in almost all clinical reasoning with the practical heuristics of clinical care in populations. We describe how imaginative computational modeling, including natural language interpretation that introduces models for metaphors, together with figurative language, sketches, and images, are essential to convey concepts and actions in clinical practice. How we build "continents" of biomedical and health knowledge from "oceans" of data will benefit from advances in such figurative reasoning informatics.

Keywords. Figurative Reasoning, Metaphorical Language, Clinical Informatics, Biomedical Research Informatics

1. Figurative Reasoning in Clinical Practice and Biomedical Research Informatics

Physicians use embodied metaphorical thinking extensively in clinical practice, as recognized by an experienced practitioner in a book recently published [1]. Yet this central "visualizing driver" of clinical reasoning and practice is not found in current computer-based informatics nor in the modeling of expert clinical tasks and their IT because of both traditional biases in scientific thinking regarding cognition, and the focus on economics-theory-and-practice-driven thinking in conventional computer science, IT, as well as medicine and their underlying biosciences. Today's clinical systems can often be more hindrance than help in the actual treatment of patients, and biomedical research faces parallel impediments at the philosophical, scientific, mathematical and formal modeling levels, though different in terms of how goals, tasks, uncertainties, risks and responsibilities enter into scientific discovery. Clinical approaches to ontologies, or knowledge representations and algorithms in biomedical and health informatics, and the formal logical, mathematical and statistical models they rely on, assume practitioners and patients as agents adhering to computational bounded rationality [2]. Somewhat

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similarly, early Cognitive Science research often modeled the brain either implicitly or explicitly as an information processing device analogous to a computer [3], reinforcing a purely mechanistic and syntactic approach to explaining brain function and its processing of neural data. Under the pressure to produce "smart machines" and "smart software" that superficially appears to simulate logical, observable human behaviors, such approaches were understandable. Early AI medical consultation systems (including ours) showed that they could model clinical decision-making [4-7] for decision support.

2. Representation of Figurative Reasoning

There is converging evidence beyond cognitive linguistics that conceptual metaphor and other figurative language and thought is a cause of both human behavior and essential in thinking. There are now neuroimaging and related results from neuroscience showing that the "multimodal" areas of the brain responsible for sensory and motor integration are fundamental to semantic comprehension and language production [8,9]. Language comprehension and production in infants and children involves learning by imitation from their caregivers how to coordinate multimodal schemas that cross from one perceptual modality to another [10]. Multimodal areas of the brain also involve both physiological and socio-cultural constraints of embodiment that effect language, perception and cognition [11]. Central to understanding these phenomena are image schemas, which, like Gestalts, are dynamic perceptual wholes which prompt for 'normal' pattern completions based on recurrent experiences in interacting with the world. Theories of image schemas and of embodied cognition [12-15] bring a fresh perspective to intelligent systems involving vision, speech, natural language understanding, emotion understanding and gesture interpretation for clinical informatics.

3. Directions for Modeling Embodied Clinical Problem-Solving Processes and the Embodied Patient-Practitioner Experience

Research into how aids to clinical problem-solving can be re-conceptualized using the new scientific understanding of embodied, metaphorical and figurative reasoning can leverage the work of cognitive linguists such as those from the MetaNet Research group at the University of California at Berkeley, associated with the Center for Neural Mind and Society (CNNS.Berkeley.edu). The MetaNet system is a large, structured inventory of conceptual metaphors and associated conceptual frames. This linguistic resource is in a wiki format, which enables linguists to extend, and other public users to explore its contents and to make comments on the discussion pages [https://metanet.icsi.berkeley.edu/]. This resource has already been used to engineer natural language processing systems that discover metaphors and underlying constructs in text [15, 16]. The new embodied cognition approaches [14] promise to open up new approaches for relating computational and natural language models to human cognition and the design of computational aids to clinical interpretation and management going beyond today's purely information processing methods, not just from a methodological perspective, but from a deeper cognitive and perceptual viewpoint, re-focusing the attention of software designers on the primary goal of this process: to assist the experience of clinical history and present illness data-gathering, and its integration into

a clinical workflow that prioritizes treatment of patients' healthcare problems. This moves informatics research towards supporting the reasoning experiences in clinical problem-solving that are figurative in nature. Specific clinical examples will illustrate causal and metaphorical reasoning that changed physiological-level models affecting therapy choices (i.e. as happened with ulcer etiology when it became thought of as an infectious process rather than a mechanically induced process).

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