aspects of mental function that are not best captured by local computation. One candidate might be attention, which seems to involve a global, cross-modality apportioning of resources (and which F never, to my knowledge, has discussed). I can also understand F's feelings of gloom and doom; I have my own with respect to large swaths of linguistics (see Jackendoff 2002). But F's dialectic here is so sloppy, so empty of actual examples, and so loaded with polemic that on balance it's hard to consider this book a useful contribution to ongoing discourse.

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Where mathematics comes from: How the embodied mind brings mathematics into being. By GEORGE LAKOFF and RAFAEL E. NÚÑEZ. New York: Basic Books, 2000. Pp. xvii, 492.

Reviewed by D. TERENCE LANGENDOEN, *University of Arizona*

This is an extremely ambitious book. Its goal is to launch the discipline of 'mathematical idea analysis', a branch of cognitive science devoted to the understanding of the concepts of mathematics, considered as human creations, not as disembodied notions awaiting discovery by intelligent creatures. Lakoff and Núñez refer to the latter view as the 'romance of mathematics' (xv). More specifically, L&N maintain that '[t]here is no way to know whether theorems proved by human mathematicians have any objective truth, external to human beings or any other beings' (2); they choose instead to focus on a question that they think they can begin to answer, namely '[W]hat mechanisms of the human brain and mind allow human beings to formulate mathematical ideas and reason mathematically?' (1) Here's how they try to do it.[1]

First, in Ch. 1, L&N summarize research that shows that humans have certain innate mathematical abilities including simple arithmetic and 'subitizing', the ability to determine the size of small collections of objects without counting them. Second, in Ch. 2, they claim that humans are also endowed with conceptual primitives they call 'image schemas', for building systems of spatial relations that are expressed in human language. These can be combined in various ways to form what they call conceptual schemas, some of which, such as the 'In schema', are said to be fundamental to mathematical thought. Third, also in Ch. 2, they invoke 'metaphor . . . the basic means by which abstract thought is made possible' (39). The rest of the book is primarily taken up with the metaphors that L&N identify as providing the meaning of central mathematical ideas, ranging from the concepts of arithmetic (Chs. 3–4); algebra, logic, and set theory (Chs. 5–7); infinity (Chs. 8–11); and calculus (Chs. 12–14). Chs. 15–16 deal with the theory and philosophy of what they call 'embodied mathematics', and two other sections discuss the resolution of a particular paradox of infinity (325–33) and the meaning of Euler's equation $e^{\pi i} + 1 = 0$ (383–451).

There is little discussion of linguistics in this book, but what there is is crucial to L&N's arguments. First, as I have already observed, L&N ground certain basic mathematical ideas on semantic primitives of natural languages and some notion of compositionality. Second, L&N argue that a specific linguistic notion is at the source of our understanding of infinity: 'To begin to see the embodied source of the idea of infinity, we must look to . . . what linguists call the *aspectual system*' (155). Specifically, L&N maintain that the device of iteration with imperfective verbs (as in *flew and flew* and *flew on and on*) denotes continuous processes by means of a metaphor that equates continuous processes with iterative ones (157). To arrive at the notion of 'actual infinity—infinity conceptualized as a thing, not merely as an unending process' (xii), one must go one step further, by creating 'a metaphorical *result* of a process without end' (158). This is what L&N call 'the basic metaphor of infinity' (159).

However, the result of an unending process can be understood without the use of metaphor. Understanding of ordinary universal quantification is sufficient. One who understands a simple English sentence such as *every number is interesting*, and also understands that there is no end to the number sequence 1, 2, . . . , thereby understands the concept of actual (denumerable) infinity without the use of metaphor.[2] So the use of metaphor is not necessary for the understanding of such mathematical concepts as absolute infinity.

It is also not sufficient for the understanding of mathematical concepts, despite L&N's airy

[1] The lure of objective truth, however, is too strong for even L&N to overcome: 'In this book, unlike most other books about mathematics, we are concerned not just with *what* is true but with what mathematical ideas *mean*, how they can be understood, and *why* they are true' (8).

[2] L&N concede that understanding an unending sequence does not require metaphor. Thus the only room for metaphor in this account of absolute denumerable infinity is in the meaning of the expression of universal quantification. But its meaning is the same in *every number is interesting* as it is in *every chair is broken*, which is understandable in situations in which subitizing is possible, as when you see three broken chairs. Consequently understanding the meaning of universal quantification also does not depend on metaphor.

However, understanding universal quantification over unbounded domains is not sufficient to provide an understanding of higher orders of infinity. For example, understanding the sentence *every proposition is either true or false* does not in itself lead to an understanding of the size of the infinite (and possibly nondenumerable) class of propositions. The latter can only be determined from the size of the class of atomic propositions and the type of recursion needed to form complex ones. For this, one needs to do real mathematics, and metaphor is of no help whatsoever.

claim that '[o]ne of the principal results in cognitive science is that abstract concepts are typically understood, via metaphor, in terms of more concrete concepts' (39). L&N tell us very little about what metaphor is, beyond the not very useful observation that the last two decades of research on metaphor in cognitive science have shown that 'metaphorical mappings are systematic and not arbitrary' (40). L&N's most precise characterization of metaphor is that it is a mapping from one domain to another that 'preserve[s] inference structure' (53). But this definition of metaphor makes use of some of the very mathematical ideas (mapping and inference) that metaphor is supposed to account for.

The conclusion we must draw is that metaphor explains nothing about mathematical ideas. Either it is an imprecise notion that cannot be used for serious analytical purposes such as mathematical idea analysis, or it is a name for a precise mathematical idea (such as inference-preserving mapping) and therefore something that must be explained by mathematical idea analysis, not something that can be used to explain mathematical ideas in the first place.[3]

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Fixed expressions and idioms in English: A corpus-based approach. By ROSAMUND MOON. (Oxford studies in lexicography and lexicology.) Oxford: Clarendon Press, 1998. Pp. xiv, 338.

Reviewed by THOMAS E. NUNNALLY, *Auburn University*

Rosamund Moon, noted Cobuild lexicographer (e.g. Moon 1995, Sinclair et al. 1987), continues her contribution to the field of phraseology with this book based on her 1994 doctoral thesis (University of Birmingham). It provides a compendium of scholarship, an attempt to use, critique, and expand computational research, and a meticulous analysis of a full data set of phrases. As M is careful to point out, it is preliminary, calling for additional research.

M sets out to describe in detail a corpus of 6776 FEIs (fixed expressions and idioms) appearing mainly in the eighteen-million-word Oxford Hector Pilot Corpus (OHPC), and supplementarily in sources such as the Bank of English (323 million-word corpus at M's press time). No claim of comprehensiveness for English FEIs is made. M's approach is descriptive, to ascertain the character, use, and behavior of FEIs. Using the cover term FEIs is an important decision based on the vexing nature of earlier attempts to define idioms and fixed expressions. The opaqueness of the acronym relieves readers of facing the conundrum that, as she shows, fixed expressions are often not totally fixed.

Chs. 1–3 concern background, theory, problems, and the field in general. Chs. 4–10 present specific analyses of her data. Ch. 11 is a brief conclusion. Ch. 1 (1–25), 'Introduction and background', reviews important earlier works, brings consensus to a messy set of concepts, and establishes the direction of the study. Bibliographically, M presents an impressively deep review of scholarship subdivided into various approaches, including largely unavailable Russian re-

[3] Some of L&N's metaphors do not even measure up to the modest formal requirements they set for them. In particular, the BMI does not preserve the inference structure of finite sets: Not all inferences that are valid for finite sets are valid for infinite ones. For example, from the fact that Q is a proper subset of P it follows that Q is smaller than P (has a smaller cardinality than P) if P is finite, but not if P is infinite.