Words, grammar, and number concepts: Evidence from development and aphasia

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Abstract: Bloom's book underscores the importance of specifying the role of words and grammar in cognition. We propose that the cognitive power of language lies in the lexicon rather than grammar. We suggest ways in which studies involving children and patients with aphasia can provide insights into the basis of abstract cognition in the domain of number and mathematics.

Writing in the tradition of Brown (1973) and Macnamara (1982), Bloom provides a thorough review of research on how children learn the meanings of words. The rich texture of his book testifies to the diversity and depth of research in this area, and its implications for our understanding of how the mind of the young child works. Bloom claims that there is no mechanism that is uniquely dedicated to children's word acquisition, but that it is built on abilities that exist for other purposes such as theory of mind. He proceeds to address the impact of words and concepts in domains such as numerical reasoning, and draws upon the evidence from a range of conditions such as aphasia and deafness to examine the interplay between language and cognition. In this commentary, we examine the issues of words, grammar, and concepts and how they might reconfigure the human mind.

In the cognitive sciences, there are increasingly frequent claims that certain forms of reasoning can only be performed though access to the resources of the language faculty. In the recent research of Spelke and her colleagues, a link between language and cognition (e.g., in the form of numerical and spatial reasoning) has been demonstrated. For example, the ability to combine sources of visuo-spatial information has been reported to depend on language (Hermer-Vasquez et al. 1999). Moreover, exact arithmetic addition calculations have been shown to be associated with a language representational format, whereas estimations of magnitude are language independent (Dehaene et al. 1999).

However, there remains a critical need to establish the relative contributions of the components of language – the grammar and the lexicon – to cognitive operations. Some take the view that grammar is crucial in many sophisticated cognitive capacities such as theory of mind reasoning (e.g., Carruthers 1996; de Villiers & de Villiers 2000), whereas others maintain it is the lexicon – the pairing of concepts with linguistic forms – that configures some aspects of human cognition. Bloom describes two competing claims in the domain of numerical cognition: that of Chomsky (1988), who maintains that grammar provides a rule-based blueprint for the potentially recursive combination of individual units with potentially infinite outputs, and the alternative claim that number words create the potential to develop a mathematical faculty that extends beyond the numerical capacity apparent in preverbal infants and some non-human species (Sulkowski & Hauser 2001; Wynn 1998).

Evidence from aphasia provides important insights on the role of language in cognition, although the evidence is limited to the role of language in a mature cognitive system rather than in the initial configuring of the system. The relation of grammar to cognition can be determined from the performances of people with severe agrammatic aphasia on behavioural tasks, while the role of lexical knowledge can be established through cases of global aphasia where the system of word forms and meanings is itself profoundly impaired. Studies on theory of mind and causal reasoning in severe agrammatic aphasia have shown that the cognitive power of language lies not in the grammar (Varley 2002; Varley & Siegal 2000; Varley et al. 2001) as reasoning is retained in such instances. These studies prompt a shift in the language and thought debate from the relation of thought to an undifferentiated language faculty, to the more specific relation of the role of the lexicon in thinking.

Bloom sets out an agenda for future investigation of the numerical and mathematical abilities of people with aphasia. The challenge is to demonstrate, first, the extent to which the number faculty is retained in the absence of grammar, much as is the case for theory of mind and causal reasoning, and, second, to determine whether patients with number word processing problems are capable of dealing with numerical problems beyond the ability to estimate and discriminate small numbers that lie within the capacity of preverbal infants. Bloom's hypothesis of number words creating a capacity for mathematics is strictly developmental, with progression from small numerosities, to the acquisition of number words, leading in turn to increased mathematical understanding. In this respect, number concepts once acquired can be mapped to different surface symbolic representations. They can take the form of number words or other forms of numerical notation (such as Arabic or Roman numerals). In the established system, having

acquired numerical symbols, the language scaffolding (i.e., the number words) may be removed – as occurs in cases of aphasia – but the capacity for reasoning may be retained in the form of numerals that sustain calculation. A similar situation might be observed in the case of a dissociation in the domain of music between the ability to name a note and to understand its symbolic musical value (Luria et al. 1965). Just as Bloom concludes that people without words are capable of rich mental lives because of non-linguistic conceptual structures, so might already established number concepts sustain mathematical reasoning despite impairment of surface word forms.

Bloom's survey rightly emphasizes the role of language in the acquisition of abstract concepts such as numbers. While many object and artifact names correspond to things with vivid perceptual features, others are abstract and have little existence outside of the language faculty. "Bees" differ from "beliefs," and "dogs" from "democracy." The investigation of numbers and other abstract concepts in aphasia may provide a window on the role of word forms and concepts in cognition, and the sustainability of such concepts without the associated language form. Bloom shifts the language and thought debate from grammar to the lexicon, but also provides elegant illustrations of how grammatical structure provides one ingredient among the cues that support word learning and related conceptual development. However, once established, the role of grammar as a facilitator of cognition may diminish or "switch off." In our view, it is the facility to construct and manipulate surface symbolic representations such as words and numerals that characterizes the huge adaptive advantage of human cognition and cultural transmission. An issue that cries out for investigation is to determine whether the loss of such representational systems in global aphasia necessarily accompanies impairment in numerical reasoning.