Steve Pinker put it best when he described Paul Bloom's book as a "tour de force" on the subject of word learning. For centuries, scholars pondered the nature of early word learning. In *How Children Learn the Meanings of Words* (*HCLMW*), Bloom articulates how this seemingly simple task "requires rich mental capacities – conceptual, social and linguistic – that interact in complicated ways" (Bloom 2000, p. 1). The book is a beautifully written, scholarly treatment of early language learning that draws on the author's rich command of psychology, philosophy, and linguistics.

At the core of Bloom's theory is a solution to the "mapping problem." How do infants map the words that they hear onto the objects, actions, and events in their environment? How do infants learn that the word "dog," signifies the category of canines? Philosophers, like Quine (1960), note that this is an intractable problem. What allows a child to learn that the word "dog" refers to the whole dog and not to dog parts? There have been many proposed solutions for the indeterminacy of word mapping. Some hold that infants operate with a set of constraints that limit the possibilities for word mapping (Golinkoff et al. 1994; Markman 1989). Others argue that infants have no internal working hypotheses, but rather associate the word heard with the most salient feature in the environment (Plunkett 1997; Smith 2000).

Bloom aligns himself with yet a third alternative, social pragmatics. Children are bathed in social environments, constantly interacting with others. Infants, keenly aware of their social surroundings, "read" the speaker's intent. When a speaker says the word "dog" while looking at the dog, the problem of reference fizzles away. Attention to the speaker's perspective narrows alternatives for word mapping, allowing children to apprentice with master word users (Baldwin & Tomasello 1998; Tomasello 1995b). Bloom writes,

> How do children make the connection between words and what they refer to? . . . they do so through their understanding of the referential intentions of others . . . children use their *naïve psychology* or *theory of mind* to figure out what people are referring to when they use words. (*HCLMW,* pp. 60–61, emphasis in the original)

Bloom contends that this ability to infer others' intentions is available from the outset. Even by 6 months of age, infants follow another's gaze (Butterworth 1991; Carpenter et al. 1998). This fact, Bloom suggests, is evidence that infants have a "broad" theory of mind. It is this early ability to read intent that paves the way for word learning:

> it is impossible to explain how children learn the meaning of a word without an understanding of . . . how children think about the minds of others. (*HCLMW,* p. 2)

We generally agree with Bloom's position. Speaker intent is a hallmark of word learning. We beg to differ, however, with two of Bloom's central tenets. First, attention to social information in the environment need not imply social intent. Second, infants are not sensitive to social intent at the very beginnings of word learning.

Social* attention *need not equal social intention. Social pragmatic theories regard attention to social cues as synonymous with social intent. Yet, the two must be distinguished. Six-month-olds who follow a speaker's eye gaze are attracted to social cues, but may not use them to infer speaker intent. Similarly, acts of joint attention, central to early word learning, might be just that – two people attending to an object. Indeed, in a joint attention task infants fail to learn novel words when the task requires that they shift attention from the object in *their* view to that which the mother indicates (Dunham et al. 1993; Tomasello & Farrar 1986). They are socially attentive to the mother, but do not use her intent as a platform for word learning. It seems a stretch to assume that because social objects command infant attention, the infant is blessed with the ability to attribute intent. Research in our laboratories is exploring this distinction in children with autism. Recent findings suggest that these children, who do learn some words, *are* aware of attentional social information (Leekham et al. 2000) but *cannot* read social intent (Baron-Cohen 1995; Bloom 2000).

Infants are not initially sensitive to social intent: Development proceeds from social attention to social intent. Bloom contends that infants are sensitive to social intent in word learning from the outset. Evidence suggests otherwise. In one study, infants 10 to 24 months old heard novel words uttered in the presence of an unfamiliar interesting object and an unfamiliar boring one. Speakers used eye gaze and pointing to indicate the intended referent. All infants attended to the speaker's gestures. Only 19- and 24-month-olds, however, used speaker intent to map the word onto the boring object (Hollich et al. 2000). Ten-month-olds did what Bloom argued "never happens" (p. 59). They mismapped – assuming that the label referred to the most interesting object regardless of the speaker's intent (Hennon et al. 2001). Preliminary data suggests that children with autism respond more like 10-month-olds than like their older counterparts. These findings accord well with others in the literature. Before 18 months of age, infants do not use social intent in a word learning task (Baldwin & Tomasello 1998).

One way to reconcile these findings with Bloom's is to suggest that when infants begin to learn words, people serve as salient perceptual objects that draw attention to, or highlight, word-to-world mappings. At around 18 months of age – around the time of the naming explosion – infants begin to note speaker intent and their word learning strategies shift. The Emergentist Coalition Model of word learning makes this prediction, offering a theoretical justification for the shift in word learning strategy (Hirsh-Pasek et al. 2000; Hollich et al. 2000). Under this scenario, children learn some words or "arbitrary signs" (p. 17) without social intent, but become more efficient word learners when social intent comes on-line for language learning. The challenge for those of us in the field becomes explaining how children who learn words like "Fido" transform into those who learn words like "Fred."

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Vocabulary and general intelligence

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Abstract: Acquisition of word meanings, or vocabulary, reflects general mental ability (psychometric *g*) more than than do most abilities measured in test batteries. Among diverse subtests, vocabulary is especially high on indices of genetic influences. Bloom's exposition of the psychological complexities of understanding words, involving the primacy of concepts, the theory of mind, and other processes, explains vocabulary's predominant *g* saturation.

The main message of Bloom's extraordinarily detailed and probing analysis, which I found completely convincing, is the primacy of conceptual thinking in the acquisition of vocabulary. The essential direction of causality is concept to word rather than word to concept, as is so commonly and mistakenly believed. The acquisition process is as different psychologically from the stimulus-response paradigm for paired-associate rote learning as one could imagine. Vocabulary is acquired when words fill conceptual "slots" that form in the course of mental development and seek to be filled. The wide range of individual differences in vocabulary reflects differences in the number "slots" much more than differences in the amount of exposure to words. The causes of the available number of "slots" are still largely unknown but are certainly related to chronological age and Spearman's *g* factor. The probability that an individual will know the meaning of a given word is mainly a multiplicative function of that individual's level of *g* and the frequency of that word in the individual's past experience.

I was first attracted to Bloom's book by my prior interest in vocabulary tests and in the fact that they are so strongly correlated with IQ, while individual differences in the paired-associates learning of words, nonsense syllables, or paralogs have such a relatively weak correlation with IQ and even with vocabulary. Although Bloom briefly alludes to this fact (p. 193 of *HCLMW*), I think much more should have been made of it, as it not only supports his thesis but extends it to psychometric findings and to the information processing theory of general intelligence. In combination with Bloom's conclusions, the psychometric and behavior-genetic facts about vocabulary should give pause to many psychologists and educators.

For a starter, consider the following observations. Recall that a factor in psychometrics is a source of variance (individual differences) common to a number of different tests; a test's *g* factor loading is its correlation with the one factor that is common to all of a number of diverse tests whose intercorrelations have been subjected to a factor analysis. In the national standardization sample of the Wechsler Intelligence Scales for Adults (WAIS), vocabulary has the largest *g* loading (.87) among the eleven diverse subtests. What may seem more surprising, however, is that when vocabulary is factor analyzed among only the six completely nonverbal subtests, its largest loading is only slightly lower (.82). Its loading among just the verbal subtests is .92. Vocabulary therefore reflects *g* much more than it reflects verbal ability residualized from *g*.

Bloom emphasizes, rightly, that the "theory of mind" plays an important part in the child's acquisition of word meanings. This leads one to predict that, among nonverbal tests, vocabulary should have its highest correlation with Picture Arrangement (PA). Wechsler (1944, p. 88) described PA as a form of social intelligence, involving human, practical situations, and inferring what the cartoon characters in a disarranged series of pictures are trying to do. The correlation of PA with vocabulary is .65, a value that is entirely predicted from these two tests' *g* loadings. The same results are found at every age level in the Wechsler Intelligence Scale for Children (both in the American and Japanese versions) and in the British Intelligence Scales. A factor analysis of a much larger number of diverse subtests, performed to examine Carroll's (in press) 3-stratum model of the factor structure of cognitive abilities, allows a detailed analysis of Oral Vocabulary, showing its percentages of variance in each of the three strata of an orthogonalized hierarchical factor analysis: (1) Verbal Ability (V), (2) crystallized intelligence (Gc), and (3) general intelligence (*g*). The test's specificity and measurement error are the residual (Res), that is, components of variance not common to other tests in the battery. The averaged results of two batteries (of 29 and 16 subtests) are: $g = 61\%$, $Gc = 16\%$, $V = 8\%$, $R = 15\%$. A similar hierarchical analysis of another large battery containing many nonverbal tests (Gustafsson 1988) shows the factor composition of vocabulary as $g = 55\%$, $Gc = 34\%$, $Res = 11\%$.

Although the acquisition of vocabulary naturally depends on exposure to words in some meaningful context, such exposure interacts strongly with innate biological factors, as indicated by the high degree of heritability of vocabulary tests. On a test of vocabulary, monozygotic (MZ) twins are more alike than dizygotic (DZ) twins (Newman et al. 1937). Vocabulary scores (with age partialed out) are correlated .86 for MZ twins and .56 for DZ twins; the broad heritability of vocabulary therefore, is estimated as $2(.86 - .56) = .60$. In this same data set, the heritability of Binet IQ is .50, of height, .57.

As a result of natural selection, advantageous traits typically show genetic dominance, a component of the trait's broad heritability. Dominance can be detected by the effect of inbreeding on the trait, a quantitative phenomenon known as inbreeding depression (ID), which is manifested in the offspring of parents who are closely related genetically, such as siblings or cousins (Jensen 1978; 1983). ID is measured as the percentage of depression of the trait among inbred offspring compared with the mean of an outbred group (i.e., offspring of genetically unrelated parents) that is matched (or statistically controlled) for parental socioeconomic and educational variables. The largest study of the effects of inbreeding (cousin matings) on children's mental test scores found that among the eleven subtests of the Wechsler Intelligence Scale for Children, vocabulary had the highest index of ID (11.45%) as compared with the average of ID of 6.58% for the other ten subtests (Schull & Neel 1965). The inbreeding effect on the various subtests was correlated about +.80 with the subtests' *g* loadings (Jensen 1983).

Bloom's book describes, more thoroughly than any other analysis I have read, the purely psychological processes crucially involved in children's acquisition of word meanings. This fascinating array of behavioral phenomena and its social-environmental context accounts for why measures of vocabulary reflect so much of the brain's power that is represented psychometrically by the encompassing, and still causally unfathomed, *g* factor (Jensen 1998). The aim of reductively understanding the causal mechanisms of individual differences in vocabulary is essentially the same as that of discovering the physical basis of g, its predominant latent trait.

Good intentions and bad words

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Abstract: Bloom makes a strong case that word meaning acquisition does not require a dedicated word learning system. This conclusion, however, does not argue against a dedicated language acquisition system for syntax, morphology, and aspects of semantics. Critical questions are raised as to why word meaning should be so different from other aspects of language in the course of acquisition.

The failure of attempts to explain or model the acquisition of language in terms of an all-purpose general learning system has been taken as supporting arguments that humans have a domain specific language acquisition system, variously thought of as a mental organ (Chomsky 1965), a module (Fodor 1983) or a specialized instinct (Pinker1994b). Children seem to be innately predisposed to prefer certain families of language structures over others, preferences that apparently cannot be explained by general principles of association, problem solving, or massive parallel processing. In addition, it has been difficult to expand the scope of this capacity beyond language to a somewhat larger domain such as hierarchically organized relations, temporal strings, or symbolic relations. Language in particular seems to be matched to specific mental faculties.

While this view remains convincing to many more than forty years after Chomsky proposed it, there is far less consensus on what aspects of language are innately determined and how that determination takes place. Paul Bloom's book offers an extraordinary re-examination of the claim that part of the language faculty involves a capacity to acquire the meanings of words. At first blush, it seems that learning words is surely near the center of the faculty. Children acquire words quickly and effortlessly; and they seem to rule out all sorts of alternative meanings that, on associative grounds, should be quite compelling. There seems to be a Word Acquisition Device (WAD), full of constraints that narrow down the extraordinary range of possible meanings that could be mapped onto words. Indeed, the impossibility of divining from scratch the meanings that another person attaches to their words is more striking on the surface than comparable arguments for syntax. The ease of laying out the indefinitely large set of logically possible alternative meanings for a word makes inescapable the conclusion that something must be profoundly limiting the child's conjectures (Quine 1960).

Bloom's book convincingly shows that there is no WAD as such. Fast mapping of words works for non-words equally well. There