CONCEPTUAL REVIEW ARTICLE

The Centrality of Language in Human Cognition

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The emergence of language—a productive and combinatorial system of communication—has been hailed as one of the major transitions in evolution. By enabling symbolic culture, language allows humans to draw on and expand on the knowledge of their ancestors and peers. A common assumption among linguists and psychologists is that although language is critical to our ability to share our thoughts, it plays a minor, if any, role in generating, controlling, and structuring them. I examine some assumptions that led to this view of language and discuss an alternative according to which normal human cognition is language-augmented cognition. I focus on one of the fundamental design features of language—the use of words as symbolic cues—and argue that language acts as a high-level control system for the mind, allowing individuals to sculpt mental representations of others as well as their own.

Keywords language and thought; categorization; perception; embodied cognition; Whorfian effects

Introduction

The emergence of language—a productive and combinatorial system of communication—has been hailed as one of the major transitions in evolution (Szathmáry & Smith, 1995). Just as the emergence of DNA enabled the faithful propagation of phenotype-coding units, the emergence of language allowed for faithful transmission of ideas by enabling a secondary inheritance system—symbolic culture. What was learned by one person or group could now be shared with others (Boyd, Richerson, & Henrich, 2011; Cangelosi, Greco,

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& Harnad, 2000). Ideas sufficiently useful (or captivating) could now enter the human *Umwelt* to be transmitted across generations.

Using language to transmit information means using language to learn. For example, a speaker could inform the listener that there is food nearby. The listener, having learned of the food (without ever directly perceiving it), could now pass on the knowledge to a third party (a design feature that Hockett [1960] called "total feedback"). A speaker could also say "I am hungry," allowing the listener to learn of the speaker's otherwise invisible mental state. Because the currency of language is *categories*, language is exquisitely well suited for promoting abstraction, categorization, and inference—processes essential to the creation of new knowledge (Murphy, 2002; Posner & Keele, 1968; Prinz, 2004). The compositional nature of language allows us to learn about novel items in terms of previously learned elements. Someone who already knows what unpeeled lychee fruit looks like can learn about rambutan by being told that it is like lychee, but hairy. Language can be used to instruct. Were it not for this, then running the simplest human behavioral study would have to be preceded by slow laborious training—operant conditioning—as is the case when experimenting with nonhuman animals. Language also allows us to ask questions. Simple questions—"What did you eat yesterday?" or "Who is your sister?"—can be usefully thought of as cues directing memory retrieval. As I argue in the section on language and memory, there is also some reason to think that language may play an important role in structuring long-term memory such that it can be reflected upon and shared with others (A. Clark, 1998; A. Clark & Karmiloff-Smith, 1993; Dennett, 1992; Luria, 1976; Rumelhart, Smolensky, McClelland, & Hinton, 1986).

What Is the Proper Place for Language in Human Cognition?

Few would disagree that language enables rapid and flexible transmission of knowledge and that much of the knowledge we acquire, we acquire through linguistic communication. But, as I discuss below, the impact of language may reach much deeper than contemporary cognitive science admits. Much of what we take to be "just" attention, "just" learning, "just" memory, "just" categorization, "just" perception may be importantly transformed by language such that the human form of these processes may rely on experience with and use of language.

What Is at Stake?

In comparing humans to other animals, one cannot help but be struck by the broad similarities of our sensorimotor capacities combined with enormous differences in our cognitive capacities and behavioral repertoires (Penn, Holyoak, & Povinelli, 2008). This observation is captured especially eloquently by Liz Spelke (2003):

> Although all animals find and recognize food, only humans developed the art and science of cooking. [A]ll animals need to understand something about the behavior of the material world to avoid falling off cliffs . . . but only humans systematize their knowledge as science . . . all social animals need to organize their societies, but only humans create systems of laws and political institutions to interpret and enforce them. (p. 277)

One reason it is so important to understand the proper place for language in human cognition is that it remains our best bet for understanding this difference between human and nonhuman minds (Bermudez, 2007; Bickerton, 2014; Carruthers, 2002; A. Clark, 1998; Dennett, 1996; Spelke, 2003).[1] To be clear, the idea that the unique aspects of human cognition can be explained by a single cause—whether linguistic or otherwise (e.g., a uniquely human ability for "relational reinterpretation"; Penn et al., 2008)—is probably overly simplistic. Yet And yet, the centrality of language to answering this question becomes clear as soon as we consider its role in shaping the human cognitive landscape.

To survive, we regularly depend on innumerable innovations made by our ancestors (Boyd et al., 2011). These innovations—encompassed by the general term *culture*—keep each human generation from starting from scratch. Culture includes not just tools and technologies (fire, bow and arrow, glass, the alphabet), but the very *idea* of their existence. Our ability to transmit such information means that we do not have to figure out on our own how to start a fire or melt sand to make glass. But what is culturally transmitted is not just the knowledge of how to start fires or how to cook food, but the very idea of controlled fire and that food can be cooked.

To further illustrate the notion of transmitting "the very idea of something," consider the idea that speech can be transcribed into a graphic form, that is, the *idea* of writing. Every child born into a literate culture benefits not only from not having to invent their own writing system, but from not having to reinvent the idea that spoken language can be written down. Sequoyah, a monolingual Cherokee, is rightly celebrated for singlehandedly inventing a writing system for Cherokee over a time span of about 15 years—a task that few people could accomplish in their lifetimes knowing only what Sequoyah knew. But although Sequoyah invented a new writing system for his language, he did not have to invent the *idea* that speech could be written down—an innovation so radical that it seems to have arisen only a handful of times in human existence (Fischer, 2001).

It may be tempting to think that the only aspects of culture that are transmitted through language are things that we talk *about*: objective entities that are *out there* for us to grasp with our preexisting sensory systems and intelligence. But as I discuss below, this intuition stems from the assumption that words map onto preexisting concepts that are either innately specified or acquired independently of language. I will argue that this assumption is incorrect. To foreshadow the argument, consider that many categories we name do not exist as discrete nameable chunks, but are themselves cultural innovations. For example, there is nothing cultural about the human ability to *distinguish* colors, and one certainly does not need words to distinguish red things from green things. But the ability to talk about a color category ("the red ones"), direct someone's attention to "just the red things," or simply ask a question like "what color is it?" are all cultural inventions. In being exposed to color words, we thus not only learn to map a range of colors to a common label, but learn the more general idea that colors are nameable entities. Once color is established as an abstract nameable entity, we can proceed to build it into our environment, color coding the world for our convenience. On this formulation, far more than just allowing us to communicate *about* things we already know, language plays a key role in imposing structure on the world and in doing so creates new types of representations.

The Strange Marginalization of Language

Given the importance of culturally transmitted knowledge to the human mind, and given the centrality of language in transmitting this knowledge, one might expect language to occupy a rather central role in cognitive science and related fields. But while there is no shortage of researchers who study language, it has tended to be strangely marginalized, standing apart from cognition. Typically, researchers work hard to argue that their field of study is as central as possible. For example, Wolpert (2012), in arguing for the centrality of motor control—his topic of study—makes a compelling case that the only reason animals have brains at all is to produce adaptable movements. Whether factually correct or not, such pushes for centrality are to be expected. If one spends a career studying something, they better come up with a good reason (if only for themselves) for its centrality.

Yet, when it comes to language, we see almost the opposite tendency. Take syntax. Rather than focusing on, for example, relating syntactic constructions to conceptual processes, syntacticians have sought to answer entirely language-internal questions such as why the sentence "I wanna meet Mary" is grammatical, but the sentence "Who do you wanna meet Mary" is not (see Bickerton, 2014, for discussion). Cognitive and developmental psychologists have likewise marginalized language by focusing on language internal processes such as sentence processing at the exclusion of understanding the possible role of language in memory, inference, categorization, and perception.

To be sure, there are many exceptions. The relationship between language and thought has long been a topic of philosophical inquiry (see Leavitt, 2011, for review), and a number of psychologists and linguistic anthropologists have taken interest in the relationship between language and the rest of cognition (Boroditsky, 2010; Bowerman & Levinson, 2001; H. H. Clark, 1996; Colunga & Gasser, 1998; Deák, 2003; Eckert, 2000; Elman et al., 1997; Gentner & Goldin-Meadow, 2003; Gumperz & Levinson, 1996; Luria, 1976; Sera, Johnson, & Kuo, 2013; Vygotsky, 1962; Whorf, 1956). By and large, however, rather than attempting to argue for the centrality of language in human cognition, empirical studies of language over the past 60 years have marginalized it. Consider the very term "language acquisition." Rather than inviting researchers to understand how *learning* language (and it is *learning* by any biological definition of learning) may be similar to or different from learning other complex skills (learning to walk, learning to sing, learning to play an instrument), we are instead informed that "language acquisition" is to be studied as a separate domain not connected to other kinds of learning.[2]

This marginalization of language has had a number of consequences. By focusing on language-internal processes, language researchers have often succeeded in marginalizing their own research (Pesetsky, 2013). It has also meant that researchers with primary interests outside of language tend not to appreciate the possible importance of language to their topics of study. If even people who study language do not think it is important to perception, categorization, reasoning, and memory, is it any surprise that people who focus on studying these latter processes conclude that they operate independently of language?

It is not an exaggeration to say that we currently know more about the mechanisms by which we use operant conditioning to shape the behavior of lab animals than the mechanisms by which words shape the human mind. And this seems odd indeed. In the sections that follow, I describe two reasons why we do not have better answers to this question. The first is an assumption that language learning is a mapping problem—an assumption that has closed the door on many questions regarding linguistic effects on cognition. The second reason is a methodological challenge of how to study such effects.

The "Language Learning as Mapping" Pitfall

A common assumption in linguistics and psychology is that learning a language involves mappings words to meanings. This view is clearly summarized by Papafragou (2005):

> [L]anguage acquisition essentially presents children with a mapping problem: the main task of the learner is to figure out which aspects of the input language correspond to which nonlinguistic conceptual primitive notions—or combinations thereof. (p. 257)

The language-learning-as-mapping assumption can also be seen plainly in titles like "Why is it hard to label our concepts" (Snedeker & Gleitman, 2004) and in statements like this:

> It is possible to suppose that these linguistic categories and structures are more-or-less straightforward mappings from a preexisting conceptual space, programmed into our biological nature: humans invent words that label their concepts. (Li & Gleitman, 2002, p. 266)

While this passage is unusual in being so explicit, it represents a fairly widespread view (Bloom, 2002; E. V. Clark, 2004; Pinker, 1994; Waxman & Gelman, 2009). The notion that learning a language is, to use Levinson's (critical) characterization of this position, "finding the local phonetic clothing for the preexisting concepts" (2003, p. 28), places some definite limits on the kinds of effects language can have. If we simply learn words for concepts we already have, the role of language is demoted from potentially transformative of cognition (e.g., Bowerman & Levinson, 2001) to being strictly a matter of communicative convenience.

The mapping assumption makes two broad predictions. If language maps onto preexisting concepts, we should (a) be readily able to identify and study concepts independently of language and (b) be able to easily find salient cross-linguistic similarities in the conceptual repertoire. But are these assumptions true?

In examining the literature on concepts and categories, one is struck by its utter dependence on lexical items. As Malt et al. (2015) have recently argued, "The prevailing assumption seems to be that many important concepts can be easily identified because they are revealed by words [such as] hat, fish, triangle, table, robin" (p. 292). One source of evidence for prelinguistic concepts comes from studies of young children who frequently behave in ways that suggest reliance on prelexicalized conceptual distinctions. For example, infants and toddlers show sensitivity to notions of spatial relations such as top/bottom/front/back (E. V. Clark, 1980; Kuczaj & Maratsos, 1975; Levine & Carey, 1982) and notions of physical support and containment (Hespos & Baillargeon, 2008; Hespos & Spelke, 2004) before they fully know the corresponding words. In one study, Levine and Carey (1982) examined whether children who did not reliably understand the words "front" and "back" could arrange toy object into a "parade" with all of them facing in one direction or to face them toward a doll who "wanted to talk to them." The results showed that, although children who were familiar with the words performed better on the toy arrangement tasks, fairly good performance was achieved even by children with poor knowledge of the corresponding words.

Such findings certainly demonstrate that young children are sensitive to the dimensions that constitute the meanings of words like "front" and "back", for example, that one usually faces toward the direction one moves in, and that the functional part of an object is often at the front (e.g., see E. V. Clark, 2004, for discussion), but we must be careful to not overinterpret such findings as indicating that the knowledge children bring to bear on these tasks is wholly independent of language. The child's performance in this experiment hinges on an experimenter demonstrating a rule (all toys face forward; all toys face the doll). But what enables the experimenter to construct a scenario that follows such a rule? If it turns If it were to turn out that the frontness/backness knowledge the children demonstrate can only be productively used when they are provided with just the right kind of inputs to model, then in what sense does the child "have" the corresponding concepts? More generally, we must be careful to not interpret evidence of certain abstract conceptual distinctions as indicating the "possession" of a concept that is identical to the kind of meaning activated by the corresponding word.

To be clear, I am not claiming that we cannot represent concepts for which we have no words. Rather, the argument is that *if* there were a rich well-specified repertoire of concepts onto which words map, one might expect that it would be easier to study this repertoire without appealing to lexical items. Put another way, how likely is it that an experimenter who spoke a hypothetical language with no lexicalized distinction of front/back would think to test whether children can distinguish front from back?

Not only are concepts psychologists study typically exemplified by words, the words used are typically *English*, as though "English nouns reveal the stock of basic concepts that might be innate" (see Malt et al., 2015, p. 292

and elsewhere for further discussion and references). Perhaps this is just a convenience. After all, most writers on the topic are English speakers, and we would hardly expect them to use terms from Lao or Dzodinka. But using English terms as indicating the existence of a universal nonlinguistic conceptual repertoire *presupposes* the existence of such a repertoire.

When we actually look at the lexicalization patterns of the world's languages, we see substantial differences. It would surprise no one that many languages lack words for derailleur or neoprene. What is surprising from the assumption of a universal conceptual repertoire is how much diversity one finds in the lexicalization patterns of domains that all humans share, for example, space (Haun, Rapold, Janzen, & Levinson, 2011; Levinson & Wilkins, 2006), time (Boroditsky, Fuhrman, & McCormick, 2011; Boroditsky & Gaby, 2010), common actions (Majid, Gullberg, van Staden, & Bowerman, 2007; Slobin, Ibarretxe-Antuñano, Kopecka, & Majid, 2014), kin relations (Kemp & Regier, 2012; Murdock, 1970), and of course colors (Berlin & Kay, 1969; Davidoff, 2001). Lexicalization of even the most embodied of domains—terms for body parts (Enfield, Majid, & van Staden, 2006)—varies from one language to another, a surprising finding if language simply maps onto preexisting concepts. One response to such claims of diversity is to suggest that the lexical repertoire of languages underspecifies our conceptual repertoire such that each language only lexicalizes a subset of the possible concepts. An analogy sometimes given is that of young infants being sensitive to all possible phonetic contrasts, but then homing in on the phonemes used by their language (E. V. Clark, 2004). The analogy only goes so far. It may be correct that in most cases languages build on existing discriminations rather than creating new ones. But this is very different from a claim that early sensitivity to varying phonetic contrasts implies a universal repertoire of phonemes from which languages pick and choose and, by analogy, that children come preequipped with all possible conceptual categories that languages simply pick from.

One may also protest that, even in the absence of strong lexical universals, all languages share a set of universal "semantic fields" (Tomasello & Merriman, 1995). For example, all languages might have some lexicalized terms related to eating. But what one observes here too are notable cross-linguistic differences (Newman, 2009). All humans eat, but any attempt to posit a universal lexical item of eating has to contend with the observation that the closest term in many languages does not neatly map onto the English meaning. For example, whereas the English "eat" excludes drinking and smoking, the Turkish word "içmek" is more general, including both eating and smoking, while Tzeltal

Mayan appears to lack a generic term for eating, instead using more specific terms depending on the food being consumed (Bowerman, 2005). It is not that speakers of Tzeltal Mayan cannot conceive a general category of ingesting food, but rather to highlight the problem with the assumption that there exists a universal set of concepts onto which the words map.

Cross-linguistic differences in lexicalization do not mean that all patterns of naming are equally likely. The lexicalization systems of different languages are far from arbitrary (Kemp & Regier, 2012; Majid et al., 2007). But on no theory *should* they be arbitrary given that humans the world over have similar brains solving similar problems. For example, languages tend to avoid disjunctions such as "blellow" meaning blue and yellow, but not the colors in between. But such constraints can be (and are) explained by more general cognitive constraints in perception and cognition (and in many cases reflect learning constraints that apply to animal learning) rather than being reflective of conceptual primitives. Even putting aside the separate question of what, if any, are the cognitive *consequences* of learning one system of lexical items versus another, the very existence of these differences is clearly problematic for any assumption of a preexisting conceptual repertoire.

To sumarize, there is a common assumption of a prelinguistic conceptual repertoire onto which words map. This assumption is at odds with findings of substantial cross-linguistic variability in just about every semantic domain (Evans & Levinson, 2009; Malt & Majid, 2013), which is unexpected and possibly inexplicable if words simply reflect preexisting (universal) categories, creating the distinct possibility that most research on putatively nonlinguistic concepts may have actually been concerned with concepts as realized through words.

From Words Mapping *Onto* Meanings to Words as *Cues* to Meaning

If one simply learns to label one's concepts, then the question of how words shape conceptual representations, much less perception itself, become nonsensical because those representations are assumed to exist prior to and independently of language.

An alternative to thinking of words as *mapping* onto preexisting meanings is that words, along with perceptual, affective, pragmatic, and other inputs, are cues that help people *construct* meanings. This position is best articulated by Elman (2004, 2009), who, drawing on earlier work by Rumelhart (1979), contrasts the view of words as cues to meaning to the standard position of words having (i.e., mapping onto) meanings:

> Rather than putting word knowledge into a passive storage (which then entails mechanisms by which that knowledge can be "accessed," "retrieved," "integrated" etc.), words might be thought of in the same way that one thinks of other kinds of sensory stimuli: they act directly on mental states. (Elman, 2004, p. 301)

We can thus start formulating a theory of language-augmented thought (Lupyan, 2012b). What *kind* of cues are words and larger verbal constructions? How does experience with language (as compared to experience with other domains) contribute to the representational capacities of the human mind? This framing clarifies much of the confusion that surrounds language-on-thought effects. All experience changes the brain. Language is a kind of experience. How does experience with language change the brain (mind)?

A poignant example of this type of reasoning put to work is Levinson's discussion of the consequences of having experience with a language that predominantly uses an absolute reference frame, thereby forcing speakers to always know which way they are facing:

> To drive a car, you need to acquire new motoric and cognitive skills. To speak Tzeltal, you'll need to be able to do base-20 math in your head, since it has a vigesimal number system, and . . . you'll constantly need to maintain a mental compass, since "downhill" denotes a quadrant based on N345°, for without that notion you can't describe where anything is.[3] (Levinson, Kita, Haun, & Rasch, 2002, p. 185)

Framed in this way, language becomes closer to a modality rather than just a way of communicating (Millikan, 1998). Just as we can talk about how visual input—as compared to tactile or auditory input—shapes our knowledge, we can ask how learning about something via language ("Hey, there's a dog") is similar to or different from learning about something via direct experience (seeing or hearing a dog). We can ask whether mental content about dogs, for example, is activated differently when it is cued by language as opposed to in other ways and ask if there are instances where language can yield mental representations that are unlikely to arise in the absence of language.

A Methodological Challenge to Studying the Role of Language in Cognition, and a Solution

One challenge to productively examining the proper place of language in cognition has been, as discussed above, the assumption that language simply maps onto preexisting concepts. This widespread (though by no means universal) assumption has had the effect of limiting the scope of inquiry. But beyond this issue of framing, there is also a methodological challenge that needs to be overcome. Because all normally developing humans are experts in at least one language, it is impossible to directly compare cognition between linguistic and "alinguistic" individuals. We simply cannot perform the ultimate experiment of comparing linguistic individuals with alinguistic but otherwise normal ones. Rare cases of language-deprived individuals are generally confounded by pathological socialization, as in the case of Genie (Curtiss, 1977). Cases of children born deaf and deprived of a conventional sign language—so-called homesigners (Richie, Yang, & Coppola, 2014)—perhaps bring us closest to understanding what a human mind without language would be like (see Sacks, 2000, for a history). But, although such individuals lack a full language model, they are exposed to language indirectly by interacting with people who do use language. If language is as important to understanding the functioning of the human mind as I claim, its effects will permeate our environment through the artifacts and cultural institutions that could not exist in the absence of language. How to proceed then?

One solution is to train nonlinguistic animals in the rudiments of language in an attempt to see what if any cognitive changes can be traced to such linguistic enculturation. Although often dismissed as abject failures (Chomsky, 2007), experiments in linguistic training of nonhuman animals have taught us much about the (latent) capacity of some animals to learn words and perhaps rudimentary grammar (Kaminski, Call, & Fischer, 2004; Lyn & Savage-Rumbaugh, 2000; Pepperberg, 2013; Pilley & Reid, 2011; Rumbaugh & Savage-Rumbaugh, 1994; Thompson, Oden, & Boysen, 1997). An important lesson to draw from these studies is that the factors most responsible for limiting language learning in a range of nonhuman animals may lie much closer to factors of cooperation and motivation to share information with others (e.g., Tomasello, 2014) rather than resulting from insufficient memory, motor control, or a lack of a putative language acquisition module. But, while valuable, relying on such studies to learn about the impact of language on the mind presents substantial methodological challenges such as limited sample sizes and the need for exhaustive training before data collection.

Another solution is to study young children under the assumption that doing so enables us to glimpse what human minds are like prior to, or as they are being molded by, language. Indeed, there is a long and productive history of examining the impacts of language on cognitive development in domains such as categorization (e.g., Balaban & Waxman, 1997; Casasola, 2005; Colunga & Smith, 2005; Katz, 1963; Landau & Shipley, 2001; Lucy, 1992; Nazzi & Gopnik, 2001; Plunkett, Hu, & Cohen, 2008; Robinson, Best, Deng, & Sloutsky, 2012), relational reasoning (Christie & Gentner, 2014; Ferry, Hespos, & Gentner, 2015; Gentner & Loewenstein, 2002; Loewenstein & Gentner, 1998; Walker & Gopnik, 2014), spatial cognition (Casasola, 2005; E. V. Clark, 1980; Haun et al., 2011; Levine & Carey, 1982), executive function (Deák, 2003; Karbach, Kray, & Hommel, 2011; Vygotsky, 1962), and theory of mind (Astington & Baird, 2005; Hale & Tager-Flusberg, 2003; Slade & Ruffman, 2005).

Despite the productivity of the developmental approach, it has a number of shortcomings. First, it is difficult to make strong conclusions about the impact of specifically linguistic experience on cognitive development given that children are simultaneously developing in so many domains. Our ability to test the causal role of language on cognition is limited by our ability to experimentally modify the linguistic environment of children (although, as discussed below, even small linguistic manipulations may be useful for making inferences about the causal role of language in various mental processes). Second, relying on measures like preferential looking and dishabituation to make strong inferences about conceptual structure (rather than about discrimination abilities, etc.) is not without controversy (Aslin, 2000; Haith, 1998) and so claims about infants having or not having a concept independently of linguistic support are quite difficult to evaluate both because it is not straightforward to measure what it means to have a concept (Casasanto & Lupyan, 2014) and because children become sensitive to aspects of word meanings far earlier than they start producing the words (Bergelson & Swingley, 2012).

An alternate solution that I have favored in my own work is to experimentally manipulate some aspect of language and observe the outcome of this manipulation on various tasks of interest. This approach allows the researcher to test adult participants and to make full use of the well-validated toolkit of cognitive psychology. The logic is simple: Insofar as language is causally implicated in some cognitive or perceptual process, linguistic manipulations ought to change performance on that task. If language helps process X, then down-regulation of language may hinder performance on tasks relying on process X while up-regulation may enhance it. This up- and down-regulation can occur on varied timescales: from highly transient trial-by-trial effects, to longer-term effects produced by training or certain kinds of linguistic instruction.

Some examples of linguistic up-regulation include using a linguistic cue to label an ambiguous or otherwise underdetermined image thereby helping a viewer see it as an example of a known category (Bower, Karlin, & Dueck, 1975; Lupyan & Spivey, 2008). Further examples can involve teaching participants a novel word for a category of objects, for instance, with the goal of comparing how people learn the category when it is labeled versus when it is learned through perceptual experience alone (Lupyan, Rakison, & McClelland, 2007). Linguistic up-regulation can be as subtle as overtly labeling a familiar item with the expectation that whatever the effect of having a label for something is, activating it extrinsically will exaggerate whatever effect the label normally has (e.g., Lupyan, 2008b).

To down-regulate language, we can use not only linguistic interference paradigms, but also noninvasive neural stimulation (transcranial direct current stimulation, transcranial magnetic stimulation) of cortical regions known to be involved in verbal processes such as labeling (see Perry & Lupyan, 2013, for discussion). Although it is commonly assumed that verbal interference works simply by disrupting overt naming, the fact that it affects performance on tasks in which overt naming is not practical (e.g., Gilbert, Regier, Kay, & Ivry, 2006) suggests that a better way of thinking about verbal interference is that it interferes with otherwise automatic (and largely covert) linguistic processes (Lupyan, 2012b). Another form of linguistic "down-regulation" (of a rather more drastic kind) is brain injury. By studying individuals with acquired language deficits (typically stroke-induced aphasia) and comparing their cognitive profiles to appropriate controls, we can make inferences regarding the dependence of affected abilities on language (see below). Of course, this last method requires a special population and because brain lesions do not respect functional boundaries (i.e., lesions are messy), making it a rather coarse tool.

The use of these methods neither implies nor requires language processes to be modular or fully separable from the rest of cognition. A useful metaphor is to think of the manipulations as turning a series of knobs. Teaching someone a word, overtly naming a known object, stimulating a particular cortical region, or having a person engage in a secondary verbal interference task while completing an unrelated task all have the effect of turning certain knobs linked to (some subset of) language processing. Insofar as turning these knobs produces predictable changes to performance on putatively nonlinguistic tasks, we can make inferences about the impact of language on processes underlying performance on those tasks. A key assumption of this approach, as elaborated below, is that many of the most interesting effects of language on thought are *online* effects (Lupyan, 2012a).

How Language Impacts Cognition and Perception: A Sampling

In a provocatively titled chapter, "From the Jurassic Dark: Linguistic Relativity as Evolutionary Necessity," Hays (2000) makes the following argument:

> The use of language cannot change reality, but it can change the perception of reality. Parents bringing up offspring can use language to mold the cognitive structure of children in ways that promote survival. This molding of the cognitive or conceptual structure only works as an evolutionary advantage if we see a strong form of linguistic relativity at work in language acquisition. The process becomes one of structuring perception by using the acquisition of vocabulary and grammar to modify perceptual categorization. (p. 159).

How do we make sense of claims like Hays'? Is there any evidence for language effects on categorization (perceptual or otherwise)? In the sections that follow, I describe some evidence to the affirmative for such effects.

What Is Special About Linguistic Experience?

All experience changes the brain. Languages is a kind of experience. But how is it different from other kinds of experiences? Assuming a highly simplified model of language, we can treat words as cues of the same sort as other perceptual inputs. But are words just like other cues? And if not, what makes them different? What is the difference between some information being conveyed (i.e., constructed; Reddy, 1979) through language versus conveyed in other, nonlinguistic ways? And are there certain types of information that can only be conveyed through language?

A comparison of how words differ from other cues reveals a few key differences: *Words are discrete*. This is in contrast to other communicative signals such as facial expressions and nonverbal vocalizations (what Burling [1993] called the gesture-call system), which are largely analog. A smile can grade into a laugh; the words "smile" and "laugh" do not because they are discrete. *Words are categorical* in that a word is associated with a category. This stands in contrast with all other perceptual cues. Any dog we come across is a particular dog. Any thunderclap we hear, coffee we smell, or a shade of mauve we see are all particulars. The corresponding words, on the other hand, denote entire categories.

It may be pointed out that words are largely used by intentional agents to *communicate* whereas many other perceptual cues are not communicative; they are just there. But even if one were to use these nonverbal cues in a communicative way, they would still cue a more specific representation than words. Consider a question like "How many chairs are there?" How would one convey such a question in the absence of words? What, other than words, can be used to cue knowledge about chairs in general?

This categorical property holds across levels of abstraction. It is true at the superordinate level: "mammal," "furniture"; at the basic level: "dog," "chair"; and at the subordinate level: "poodle," "armchair." And, perhaps more controversially, even proper names denote categories. There may only be one *real* Eiffel Tower, but the label "Eiffel Tower" denotes the category of entities that are sufficiently similar to the Eiffel Tower to warrant being called that; this may include scale model, a photograph, and so on. That they have an original referent that occupies one place in the world is a difference in generality (there are lots of dogs, but only one real Eiffel Tower) rather than in kind. Strictly speaking, words are not the only communicative signals that have this categorical property. Systems of alarm calls are categorical in the sense that a vervet monkey's leopard alarm call is associated with an entire category of (presumably distinguishable) experiences of being hunted by a leopard (Seyfarth, Cheney, & Marler, 1980). Verbal cues take such categoricality to new heights by providing the ability of denoting categories at different levels of abstraction and importantly by being composed to form new categories such as "the worn green armchair" or "apartment dog" (Murphy, 1988).

It is sometimes pointed out that words are arbitrary. That is, the word "dog" does not iconically depict a dog (in a way that a picture of a dog would). Arbitrariness, however, is not the unique province of language. That dogs bark is arbitrary as far as human learners are concerned. If dogs meowed, that's what we would learn. A related, but distinct design feature, however, is that *words are unmotivated*. I mean something very particular by this. Much of our perceptual world is motivated in that one set of changes is correlated with other changes. For example, the pitch of the sound made by a dropping object is correlated with (i.e., predictable from) the size of the object (e.g., Kunkler-Peck & Turvey, 2000). Similarly, although a dog's bark is arbitrary, it is not *unmotivated* in that the acoustic properties of the bark are correlated with aspects of the dog. Deeper barks predict larger dogs, for example. In comparison, although the manner in which the word "dog" is uttered indexes various properties of the speaker, it does not (in general) correlate with any properties of the dog (Edmiston & Lupyan, 2015b; Lupyan & Bergen, 2015). We can, of course, be quite specific with language. We can say "poodle" rather than "dog" and we can try to paint with words ("an unusually small poodle wearing a circular red hat") to approximate the kind of experience one might have while actually viewing the animal. But we can also just say "dog"—a categorical experience that *cannot*—I claim, be instantiated without words.

Language and Categorization

The processes of categorization—and its close cousin recognition—are among the most fundamental cognitive operations. Categorization can be thought of as the process by which a stimulus comes to be represented as a member of a larger class, thereby inheriting some of the (possibly unobserved) properties of that class. In categorizing, one represents task-relevant similarities while overlooking (abstracting over) detectable differences. By learning to categorize different exemplars into a common category, we can learn what the most diagnostic dimensions of that category are (for discussion, see Margolis & Laurence, 1999; Murphy, 2002; Prinz, 2004), inferring those properties in instances when they are not directly observed—a key way in which we create new knowledge.

Even those skeptical of the idea that language shapes cognition admit that, of course, language is an important guide to which of the many possible things in our environment are important and worth categorizing and, more generally, worth caring about (Bloom & Keil, 2001). Curiously, this function of language is sometimes seen as trivial as when Devitt and Sterelny (1987) remarked that "the only respect in which language clearly and obviously does influence thought turns out to be rather banal: language provides us with most of our concepts" (p. 178). Pullum (1989) famously ridiculed the notion that having more words for something is anything but a mundane reflection of cultural preoccupations: "Horse breeders have various names for breeds . . . botanists have various names for leaf shapes; interior decorators have names for shades of mauve" (p. 278). This reasoning demonstrates the now-familiar language-as-mapping assumption. That the vocabularies of different cultures/languages reflect the interests and needs of the speakers is true. The question is: what are the consequences of learning these words? If, as Hays argues, the outcome is that the words of our language mold the cognitive structure of children, the consequences are far from trivial.

The first way in which language shapes categorization is by providing targets for learning. If it were the case that the world came in discrete and unambiguous chunks, providing added targets would be unnecessary. But, although the world may contain cats, dogs, and rocks independently of their being labeled, the world does not contain "in" and "on" events, reds and blues, instances of empathy and depression, all floating in a platonic ether waiting to be categorized (recall the earlier discussion of inventing the very idea of labeling something). Even a seemingly concrete thing like a rock—what's more concrete than a rock!—is a kind of construct. The *individual* rocks are out there whether we categorize them as such or not. But the concept of rocks is a construction. In what sense is a rock that I can pick up and throw in the same category as one firmly embedded in the ground or one jutting out of a side of a cliff? English guides us to categorize all these rocks as being in the same category. This does not mean that we cannot think otherwise. Indeed in a context where the desired category is, say, something I can throw, the different kinds of rocks readily come apart. But what language is doing is ensuring that every speaker of English learns a roughly similar concept of rocks—one that might take on a very different form were it not for learning a common set of labels. Despite the many joints of nature that humans and other animals are predisposed to detect (both through innate mechanisms and general learning systems), these joints massively underdetermine the conceptual structure that humans possess. Language (and cultural institutions built on language) carve joints into nature (Lupyan, 2012a, 2012b; Lupyan & Bergen, 2015).

Levinson (2003) makes a similar argument for the role of language in creating chunks:

> We don't have to think about a hundred as "ten tens" when doing mental arithmetic, or aunt as "mother's sister, or father's sister, or father's brother's wife, or mother's brother's wife" when greeting Aunt Mathilda. Composing complex concepts gives enormous power to our mental computations, and most of those complex concepts are inherited from the language we happen to speak. (p. 56)

Beyond providing the targets for category learning, verbal labels appear to augment the learning process itself. In associating a common label with a range of discriminable examples, our representation of those exemplars becomes more categorical than when people perform the very same categorization task without learning names for those categories. When people were asked to learn to categorize new items—"aliens"—into those that should be approached and those that should be avoided, learning the *names* of the two categories (that one kind of aliens was called "grecious" and the other "leebish") led to about a doubling in learning speed (Lupyan et al., 2007; Lupyan & Casasanto, 2015). Pullum (1989) dismissed as trivial the idea that having a name for a distinction should matter. Here we have an empirical rebuttal. Participants learned categories associated with discrete labels considerably faster than participants trained in exactly the same way but without learning the category names. Further discussion accompanied by a neural network model that fleshes out the claims in more computational detail can be found in Lupyan (2012b).

Beyond affecting the learning of novel categories, verbal labels affect how familiar knowledge is activated. Treating words as cues allows us to ask a simple question: Does knowledge cued by labels differ in some way from ostensibly the same knowledge cued in a nonverbal way? In an initial attempt to answer this question, Lupyan and Thompson-Schill (2012) used a series of simple behavioral studies to examine how visual knowledge (i.e., one's knowledge of what something looks like) is activated by hearing its name (e.g., "dog," "motorcycle") versus hearing characteristic sounds (e.g., <dog bark>, <motorcycle engine revving>). The sounds were normed to be highly recognizable and familiar. We observed a highly robust label advantage. Label cues activated visual knowledge more effectively than nonverbal cues. This label advantage persisted for new categories of "alien musical instruments" for which participants learned to criterion either names or corresponding sounds—further evidence that the advantage did not arise from the nonverbal cues being less familiar or inherently more difficult to process. Labels were not simply more effective at activating conceptual representations, but the representations activated by labels were systematically different from those activated by nonverbal sounds. Specifically, labels appeared to preferentially activate the most diagnostic features of the cued category as inferred by analyzing response patterns for different category exemplars. Thus, hearing "dog" appeared to selectively activate the features most central to recognizing dogs. As subsequent studies made clear (Edmiston & Lupyan, 2015b), while nonverbal cues such as dog barks activated representations of specific dogs (and at specific times), verbal labels appeared to activate a more abstracted and prototypical representation.

The role of language in categorization processes is further demonstrated by turning to neuropsychology. It has been long known that aphasia—a rather drastic form of linguistic down-regulation, to use the term from a previous section—is accompanied by impairments in seemingly nonverbal categorization tasks (e.g., Cohen, Kelter, & Woll, 1980; Davidoff & Roberson, 2004; Hjelmquist, 1989; see Gainotti, 2014, for a review). In a recent study (Lupyan & Mirman, 2013), we tested a group of individuals with aphasia selected on the basis of having impairments in confrontation naming (e.g., trouble with naming familiar pictures). Participants were shown arrays of pictures and asked to select ones that matched a particular category, for instance, birds, things with handles, things found in a kitchen, orange items, and so forth. The individuals we tested were quite high functioning and had generally good comprehension abilities; following the instructions did not present considerable difficulty. Indeed, their performance on some items was equal to age- and education-matched controls. Their performance on other items was markedly impaired and correlated with their naming impairments. What distinguished between success and failure was the *structure* of the category being requested. Individuals with aphasia were impaired when asked to group items into what we called low-dimensional categories (e.g., "click on the orange things") but had normal performance when asked to group items into high-dimensional categories (e.g., "click on all the things you find in a kitchen"). This result largely confirms earlier observations that individuals with aphasia are "deficient if the task requires isolation, identification, and conceptual comparison of specific individual aspects of an event," but are equal to controls "when judgment can be based on global comparison" (Cohen et al., 1980, p. 343).

Making inferences from brain lesions is never straightforward, however, so it is useful to experimentally down-regulate aspects of language processing to see if such manipulations roughly simulate categorization deficits in aphasia. We have done this in several ways. First, we have used a form of verbal interference such as asking participants to repeat a string of numbers while performing the task of interest. Using an odd-one-out task modeled after a task used to test an individual with profound anomia (Davidoff & Roberson, 2004), we showed that, just like this anomic individual, people undergoing verbal interference were selectively impaired in categorizing objects on specific dimensions of size and color, but not in categorizing them in a more holistic functional/thematic way (e.g., grouping together a jacket and a suitcase on the basis of being able to put one inside the other). Second, we have used a form of noninvasive neural stimulation to up- and down-regulate cortical excitability of Broca's and Wernicke's areas—two regions classically associated with language and stimulation of which we have shown to produce changes to speed of covert labeling (see Perry & Lupyan, 2013, for discussion). Cathodal stimulation of Broca's area produced a pattern of impairments in college undergraduates similar to that demonstrated by individuals with aphasia. In another study, Perry and Lupyan (2014) investigated categorization of simple visual stimuli (Gabor patches of varying orientations and spatial frequencies) that could be categorized in a one-dimensional or two-dimensional way (i.e., both solution types could yield equal accuracy). Control participants had a strong bias to categorize in a unidimensional way; individuals undergoing cathodal stimulation of Wernicke's area were considerably more likely to use two-dimensional categorization. These results further show that the type of categorization processes most affected by language are those requiring flexibly representing items along task-relevant dimensions—an ability which, as discussed below, is central to what is often called intelligence.

Language and Visual Perception

In a previous section, I discussed the idea that words are cues to meaning. Another set of cues to meaning are, of course, our perceptual systems and, for most of us, the visual system in particular. In affecting how something is mentally represented, are effects of language limited to "cognitive" processes like categorization, memory, and reasoning (see below) or can language change how something is actually processed at a perceptual level? The answer is that language has now been shown to affect a range of decidedly *perceptual* processes from visual search efficiency (Lupyan, 2008b; Lupyan & Spivey, 2008) to attentional deployment (Lupyan & Spivey, 2010; Salverda & Altmann, 2011), color discrimination (e.g., Roberson, Pak, & Hanley, 2008; Thierry, Athanasopoulos, Wiggett, Dering, & Kuipers, 2009; Winawer et al., 2007), and motion discrimination (Dils & Boroditsky, 2010; Meteyard, Bahrami, & Vigliocco, 2007). Simply hearing a word such as "pumpkin" can even make the difference between a picture of a pumpkin being qualitatively invisible and visible (Lupyan & Ward, 2013).

Posing the question in the way that I did (namely, does language affect the construction of *perceptual* representations rather than merely cognitive representations?) implies that there is a strict distinction between perception and cognition. This distinction is challenged by a rapidly growing body of literature showing that the representation of perceptual knowledge (e.g., that carrots are orange, nails sharp, and ice cream tasty) involves perceptual systems broadly construed (Amsel, Urbach, & Kutas, 2014; Edmiston & Lupyan, 2015a; Pulvermüller, 2005; Simmons et al., 2007; Yee, Chrysikou, Hoffman, & Thompson-Schill, 2013). On these accounts (often called "embodied"), meaning is distributed across modal systems. For example, the representations that constitute the knowledge of what "zebras" and "pumpkins" look like, rely on the visual system. The perceptual representations of zebras and pumpkins can be activated in a variety of ways, the primary being, of course, actually seeing them. What is different about activating these representations via language is that words activate a particular *kind* of mental state, a state that is more discrete and categorical by selectively highlighting category-diagnostic dimensions (Lupyan, 2012b).[4] In work following up on the "dog" versus bark cuing experiments discussed above (Lupyan & Thompson-Schill, 2012), Boutonnet and Lupyan (2015) showed that the difference between the verbal and nonverbal cues arose within the first 100 milliseconds of target picture onset and measurable in the P100 component, consistent with the hypothesis that the two cue-types were activating different visual representations and, more specifically, that labels were more effective at activating categorical visual representations. That hearing or saying a word can affect visual processing should not be thought of as a separate phenomenon, but simply part of the mechanism by which words activate mental representations, which (when visual appearance is involved) include visual representations.

Language and Attention

In discussing effects of language on perception, a question that sometimes arises is whether such effects are *perceptual* effects or merely attentional ones. As in the case above, formulating the question in this way assumes a clear boundary between perception and attention. Because attention appears to operate by changing perceptual representations (Bressler, Tang, Sylvester, Shulman, & Corbetta, 2008; Ghose & Maunsell, 2002; O'Connor, Fukui, Pinsk, & Kastner, 2002; see Lupyan, 2015, for a more detailed discussion), this distinction is arguably a false one. Attentional effects on this view are a subclass of perceptual effects.

Effects of language on attention can be quite profound. Consider a recent study by Çukur, Nishimoto, Huth, and Gallant (2013) in which participants viewed a series of short video clips either passively or while attending to vehicles or people. The attentional prompts were shown to shift neural representations throughout the brain (including primary visual cortex) such that a prompt to attend to vehicles expanded the neural representations of vehicles and semantically related entities, while collapsing semantically distant categories, and vice versa when attending to humans. These modulations—a form of categorical attention—were elicited through words. Are words serving as mere conveniences? Consider the alternatives. Any picture of a car is a picture of a particular car; a picture of a person (or any other nonverbal cue such as a person's voice) necessarily carries information about specific exemplars. Language allows us to abstract away from these specifics.

It is telling that even in cases where people are instructed to treat a pictorial cue in a categorical way (e.g., a picture of a cow means you should search for any cow), people can't help but be biased to find the cow similar to the cued one (Hout & Goldinger, 2015) even though they could easily label it themselves. In contrast, labels by virtue of their categorical and unmotivated status (as discussed above) appear to be uniquely effective in activating a categorical attentional state (e.g., Boutonnet & Lupyan, 2015).

Memory and Intelligence

In the remaining two subsections, I discuss effects of language on memory, intelligence, and reasoning. This discussion will be more speculative and less empirically grounded because relatively little directed research has been done on the subject.

Language and Memory

Certain effects of language on memory are well known. We can and do regularly use language to influence memory. For example, memory for an event such as a car accident can be altered by asking people differently worded questions (Loftus, 2003). These effects can be framed more generally as arising from language cuing information (perceptual and otherwise) in a particular way, distorting what has been originally encoded (Lupyan, 2008a).

We can also use language to ascribe meaning to otherwise meaningless items, thereby rapidly assimilating them into existing semantic networks. In a classic study, Bower et al. (1975) tested participants' memory for "droodles"—seemingly meaningless drawings. Memory for these apparently meaningless collections of lines and squiggles was considerably better when they were described in such a way as to make them meaningful during study. Simple mnemonic devices and highly developed mnemonic strategies such as the method of loci that allow people to perform astonishing feats of memorization (Foer, 2012) are further examples of using language to massage arbitrary collections of items into a more memorable form.

The role of language in memory becomes clearer still when we consider that capacity limits on short-term memory—whether limited to the famous $7 +/- 2$ (Miller, 1956) or to 4 (Cowan, 2001)—are measured in "chunks." Where do chunks come from? To a large extent, they may come from the processes of categorization, which, as I have argued, is importantly augmented by language. Recall the example mentioned above of Aunt Mathilda (Levinson, 2003); the word "aunt" seems to be half the number of chunks compared to "mother's sister." The process of chunking is related to the sorts of memory distortions mentioned above. As discussed by Miller (1956), "[t]he inaccuracy of the testimony of eyewitnesses is well known in legal psychology, but the distortions of testimony are not random—they follow naturally from the particular recoding that the witness used" (p. 95). The process of chunking is certainly not the exclusive domain of language, but, as recognized by Miller himself, "language is tremendously useful for repackaging material into a few chunks rich in information" (p. 95). It bears mention that dismissing chunking as being "just" strategic is to beg the question. In what sense is human memory ever free of such "strategies"? Perhaps in infancy, but infant memory is not very good, is it?

A final effect of language on memory is the most speculative, but also potentially most important. In its strongest form, the claim is that without language we may continue to have excellent memories for certain kinds of information, but may nevertheless lack a remembered self. I am referring here to autobiographical or recollective memory—the episodic memory of our lives (see Brewer, 1996, for a more elaborated definition). Traditionally, autobiographical memory has been viewed as developing organically after a child passed the barrier of infantile amnesia (e.g., Howe & Courage, 1993). The existence of autobiographical memory was taken as a given and what was puzzling was the barrier. As Fivush and Nelson (2004) point out, subsequent research showing substantial differences in autobiographical memories across individuals and cultures suggests that "what is in need of explanation is the presence of autobiographical memories at all . . . [h]ow and why do humans have autobiographical memory, and what is the process by which it develops?" (p. 573).

Provocatively, the memory of a continuous and unified self may be a sociocultural construction (Luria, 1976), with language acting as a "fundamental soc[io]-cultural tool in the development of an autobiographical memory system" (Reese, 2002, p. 489). Summarizing a handful of studies (the literature is admittedly quite small), Nelson and Fivush (2004) argue that, although memories for preverbal experiences can be sometimes demonstrated through actions, they do not become accessible for verbal recall as children learn more sophisticated language, and thus "it does not seem to be the case that language simply allows children to express what they may remember . . . [r]ather, language actually supports the development of a verbally accessible autobiographical memory" (p. 493).

Although our knowledge may take on a variety of forms—an event certainly need not be verbally describable in order to be remembered—when it comes to autobiographical memory, the *retrieval* cues are frequently verbal. For example, it is only using language that one can ask questions like "Where were you born?" or "Who was your first kiss?" or "Did you have many friends in school?" Absent the ability to formulate such questions (posed either to others or to oneself), the knowledge that constitutes their answer, even if available, may remain—to use a phrase coined by Simon Thorpe (2011)—cortical dark matter.

Language, Reasoning, and Intelligence

For better or worse, over the past century, we have sought to put a number on people's intelligence. This desire led to the proliferation of tests purporting to measure it. Contemporary intelligence tests distinguish between two broad factors. Crystallized intelligence, typically measured using verbal and culturally relative assessments and designed to assess a person's ability to access and use previously stored information. Fluid intelligence, measured in a putatively more culturally and language-neutral way and designed to tap into real-time problem solving (Cattell, 1971). A common test of fluid intelligence is Raven's Matrices (e.g., Raven, 2000), in which participants see a matrix of patterns that proceed in some order and need to choose a missing pattern from a list of options.

The factors of crystallized and fluid intelligence are often mapped onto "verbal" and "nonverbal" intelligence (Sternberg & Kaufman, 2011). Insofar as crystallized intelligence measures largely linguistically acquired knowledge, it is sensible that it should correlate with such verbal measures as vocabulary and amount of reading (Stanovich & Cunningham, 1992).[5] But in what sense is fluid intelligence "nonverbal?" The tests designed to measure fluid intelligence have a nonverbal format, using patterns, for example, rather than words. But does that mean that performance on such tests is independent of language? Solving Raven's matrices (especially the more difficult problems) appears to be a process of discovering relevant dimensions of variation in a way that certainty *feels* quite verbal (Carpenter, Just, & Shell, 1990). The ability to abstract the dimensions may importantly depend on relating them through names (e.g., "dots decreasing along the horizontal; lines decreasing along the vertical"). A unique feature of Raven's Matrices is its progressive nature: The early problems introduce the test taker to the patterns and dimensions by presenting them in relative isolation, thus inviting them to be labeled. Later problems make use of these primitives in more complex contexts requiring greater abstraction and compositionality. Someone who is better able to selectively attend to the earlier isolated pattern—a process sensibly aided by having labeled the pattern—will tend to do better. It is of note then that among the best predictors of performance is, of all things, vocabulary (Raven, 2000; Stankov, Horn, & Roy, 1980; Stanovich & Cunningham, 1992)! It is possible that the causality runs in the other direction and whatever abilities that matrix reasoning measures lead to greater vocabularies, but it is curious that, when it comes to predicting real-world outcomes such as income and academic success, crystallized/verbal intelligence tends to be a better predictor than fluid intelligence (Ceci & Williams, 1997; Sattler, 2001)—a somewhat puzzling result if fluid intelligence is the driver of verbal abilities. As McGrew and Flanagan (1998) write, "nonverbal IQ" is not a valid construct: “There is no such thing as ‘nonverbal’ ability—only abilities that are expressed nonverbally” (p. 25).

What about dissociations between language and intelligence? Consider the construct of specific language impairment (SLI), a disorder said to be characterized by poor verbal skills combined with normal nonverbal intelligence. It is true that one finds a population of individuals who demonstrate language abilities far below that of their peers, but who score in the normal range on measures of fluid intelligence. But the existence of such individuals does not in itself show a dissociation between intelligence and language. First, the existence of such individuals is a statistical truism—they are just the people who lie within one of the quadrants of the bivariate distribution (Reilly et al., 2014). Yes, there are children who have a verbal IQ of 70 accompanied by a nonverbal IQ of 95. But what might their so-called nonverbal IQ be if their language abilities were improved? Second, children diagnosed with SLI often *do* indicate systematic impairments on putatively nonlinguistic tasks, such as those requiring categorization and hypothesis testing (Leonard, 2000).

Given the size of the literature on intelligence testing and the predictive power of language measures, one might imagine that there is a large body of work examining how such measures correlate with performance on analogies, logic, and pattern completion—problem types that have been elevated to the realm of intelligence. But at present, such work is scarce. The arguments in this section are admittedly speculative, but they are worth keeping in mind. As we now know, there are drastic differences in the linguistic environments of children (Hart & Risley, 1995; Lee & Burkam, 2002; Weisleder & Fernald, 2013), differences that appear to have substantial effects on, for example, academic achievement (Baumann, 2009; Hurtado, Marchman, & Fernald, 2008; Stanovich & Cunningham, 1992). In a recent longitudinal study of nearly 2,000 pairs of identical twins, Ritchie, Bates, and Plomin (2015) found that differences in reading abilities between the twins predicted differences not only in verbal, but also nonverbal intelligence in later childhood. A better understanding of the link between language skill and intelligence—however defined—can help us get a much better handle on what such relationships mean and the mechanism that gives rise to them.

Conclusion

I began by arguing for the centrality of language to culture and human intelligence. This argument is certainly not new (Darwin, 1871/2004) and similar sentiments form a common rhetoric in writings about language. For example, Poeppel, Emmorey, Hickok, and Pylkkänen (2012) describe language as “the mental faculty considered to be at the very core of human nature" (p. 14125). This admission of the centrality of language stands in stark contrast to research programs in both linguistics and psychology—fields full of researchers who care deeply about language, but who have marginalized it by studying it as a standalone system.

One reason for this marginalization may lie with the deeply entrenched assumption that words simply map onto preexisting concepts—an assumption that tends to undercut the potential import of language in cognition. Another roadblock is methodological. It may appear that it is not possible to productively study the role of language in the human mind in the absence of an alinguistic control group.

I have argued that the notion that language simply maps onto a preexisting conceptual space has severe problems. Rather than viewing language as mapping onto preexisting meanings, it is more productive to view language as acting in concert with other cues to *construct* meaning. The unique design features of language such as its categorical and discrete format allows it to augment basic cognitive and perceptual processes. This augmentative function can be productively studied using methodologies that transiently up- and down-regulate language and observe the consequences of such regulation. On the view put forward here, language attains a new centrality. Normal human cognition is language-augmented cognition.

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Notes

1 As the subsequent sections should make clear, my view concerning the way in which language feeds into human intelligence is substantially different than previous proposals, e.g., that natural language provides an interface between the outputs of domain-specific core systems (Spelke, 2003) or that it serves as the representational medium of domain-general thought (Carruthers, 2002).

2 The distinction between learning and acquisition is sometimes described as being the difference between conscious and unconscious processes (Krashen, 1982). This distinction is intuitive but empirically questionable. Much of what we learn when learning motor or perceptual skills is not consciously accessible, yet we continue to (correctly) call these processes "motor learning" and "perceptual learning."

3 Here is an example of the kind of confusion one sees in popular discourse on the relationship between language and thought. In a recent review of John McWhorter's critique of Whorfian-type effects (2014), the *New Yorker* writer Adam Gopnik (2014) cites McWhorter as saying that it is no more surprising that a tribe speaking a language without numbers cannot do math, than that a tribe without cars does not

drive. The irony is that, while people take as obvious the notion that technologies and cultural practices enable all manner of new behaviors, the most ubiquitous cultural artifact of all—language—is deemed by writers like McWhorter (2014) as well as Pinker (1994, 2007) as somehow immune from exerting such influences (Boroditsky, personal communication).

4 An additional property I am not discussing much here is that words may activate mental states in a format that allows for greater compositionality. For instance, we can use language to activate a mental state corresponding to a square, a purple square, a purple square with a red circle on top, and so on.

5 Some may be surprised to learn (as I was) that reading experience correlates strongly with performance on cognitive tasks such as semantic fluency (e.g., list as many animals as you can in 30 seconds). This is because even in such seemingly basic tasks, the knowledge tested is often linguistically acquired. I have never seen a mole rat or a narwhal, but I have read about them.

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